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Digital Learning Object Based on Transition Design Methodology to Promote the Energy Efficiency Culture: An Interdisciplinary Development for STEAM Education

Gloria Janeth Murillo-Aviña, CETYS Universidad, Mexico
Sialia Karina Mellink-Méndez, CETYS Universidad, Mexico
Josué Aarón López-Leyva, CETYS Universidad, Mexico
Paola Monet Cañedo-Bobadilla, CETYS Universidad, Mexico

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Abstract
This paper presents the design, development, and quantitative and qualitative evaluations of a digital learning object based on the Transition Design methodology and the ISO-50001 standard (i.e., Energy Management System). To clarify, Transition Design addresses complex problems, called wicked problems, such as climate change, the global pandemic, and lack of access to affordable education, among others. In particular, the problem addressed in this paper is the lack of knowledge of general and standardized aspects related to energy efficiency in the secondary education curriculum design & development in Mexico. Therefore, obtaining good results in the energy efficiency context turns out to be very complicated, since there is no standard framework, and the activities or learning objects used, are not generally appropriate to the expected learning outcomes. In this way, through social immersion, focus groups, creativity techniques, and digital design tools, a market study was carried out considering a sample of 208 students distributed into 6 groups from different subjects, where the subjects are related to natural & exact sciences and social sciences & humanities. The aforementioned is for assessing the student's learning styles to determine the most adequate digital learning object for them. As a result, a digital learning object was developed in an interdisciplinary manner considering the Kolb learning styles., i.e., concrete experience, reflective observation, abstract conceptualization, and active experimentation. Finally, this project has implications for the future development of the secondary education curriculum, but the learning object can also be adapted to existing educational programs and models.

Keywords: Digital Learning Object, Energy Efficiency, Interdisciplinary Development

Introduction

Nowadays, there are many wicked problems around the world, such as extreme poverty, climate change, among others. These problems cannot be approached like traditional problems, that is, in a linear way (Lönngren and van Poeck, 2021). Among those wicked problems is environmental pollution related to energy efficiency in society. Considering the above, the energy efficiency culture must be strengthened in all sectors of society, mainly in educational centers of different levels, to strengthen soft and hard skills regarding the efficient use of energy resources. In support of the above, there are digital learning objects (DLO) that you can help to promote the energy efficiency culture on a Science, Technology, Engineering, Arts, and Mathematics (STEAM) education framework. In this way, this article shows the design of the DLO based on the transition design methodology to address this wicked problem (Cabero-Almenara and Palacios-Rodríguez, 2021).

Theoretical framework

Standard ISO-50001

ISO-50001 is an international standard developed by the International Organization for Standardization (ISO). This standard is of voluntary application, that is, companies, organizations, and institutions are not obliged to comply with them, but they can promote their compliance and consideration. In general, ISO-50001 provides organizations with an internationally recognized and approved reference framework to manage and improve energy performance. The standard is broad, but in particular, it covers the following, 1) the efficient use of energy in all activities of an organization, 2) the measurement, documentation, and reporting of energy uses, 3) the design and practices procurement for equipment, systems, and processes that are energy efficient, 4) the development of an energy management plan, among other factors that affect energy efficiency. In this way, the adoption of ISO-50001 by the organization allows reducing the carbon footprint of the products and services offered, which is part of sustainable business development. As mentioned, although the standard is indeed made up of many stages and sub-stages, it is not the objective of this document to explain it in detail. Therefore, the stages and sub-stages that make up the standard will be disclosed within the DOL, which are based on the Deming cycle, Do-Check-Act-Plan (Marimon and Casadesús, 2017).

Learning styles

David A. Kolb's learning styles model states that learning is based on experimentation and processing of the information that is received. This model contemplates four stages for optimal information processing, which are: a) concrete experiences (feelings); b) reflective observation (watching); c) abstract conceptualization (thinking); and d) experimentation (do). People tend to focus on one of these phases, which is preferable in terms of learning. Therefore, four learning styles are established according to how they prefer to process the information received. It is classified as 1) Divergent, associated with experience and observation; 2) Convergent, based on abstract conceptualization and active experimentation; 3) Assimilators, related to abstract conceptualization and reflective observation; and 4) Accommodators, based on concrete experience and active experimentation (Newton and Wang, 2022).

Transitional design methodology

The transitional design is a methodology that allows for solving systems and complex problems such as climate change, crime, forced migration, loss of biodiversity, poverty, and water security. These problems are challenging because: 1) they involve multiple stakeholders with conflicting agendas; 2) straddle disciplinary boundaries; 3) are ill-defined and stakeholders rarely share an understanding of the problem; 4) the problem is continually changing and evolving; 5) problems exist at multiple levels of scale and are interdependent and interconnected; 6) any intervention (attempted solution) in one part of the system, ramifies elsewhere in unpredictable ways; 7) interventions take a long time to evaluate, and problems, a long time to resolve (Costa and Irwin, 2018).

Methodology

Research of teaching resources

To optimize project resources and generate an updated and easily accessible learning object for students, it was decided to use an online platform for its creation. In this way, an investigation of different digital platforms, that could be used for the development of the learning object, was carried out. Below is a compilation of the most relevant platforms found online. The advantages and disadvantages of each one were considered to determine the platform that was selected for the creation of the learning object.

Open edX

It is an open-source digital learning platform for creating, providing, and analyzing online courses developed by Harvard University and the Massachusetts Institute of Technology, currently managed by the non-profit organization, The Center for Re-Imagining Learning, formerly known as edX Inc. (Open edX, 2023). The advantages of Open edX are, 1) It is a free platform, 2) It allows you to create units, sections, and discussions and has a wide variety of reagent options, and 3) It handles certificates, exams, and study activities. While the disadvantages are, 1) For the more advanced aspects of the course you need knowledge of the HTML programming language and 2) customization in terms of design is limited.

Google Classroom

It is the tool that Google offers for education, it allows you to manage a classroom online and collaboratively. The platform is linked to the user's Gmail account, which allows the use of different Google extensions, such as creating documents, working simultaneously, generating online meetings, and sharing information in different formats (Google, 2023). The advantages of Google Classroom are, 1) It is very easy and intuitive to use, 2) It is a platform with recognition and positioning, 3) It allows you to create exams, surveys, announcements, and units, and 4) It shows graphs with the results of the exams and surveys. While the disadvantages are, 1) The types of reagents are limited, 2) It is currently not considered a novel platform, and 3) The freedom of customization of the design is of an intermediate level.

Moodle

It is an online learning platform created to provide educators and students with a safe tool for the generation of learning environments that can be personalized (Moodle, 2022). The advantages of Moodle are, 1) It offers a wide range of activities: quizzes, surveys, wikis, glossaries, and more, 2) Its interface and design are nice and modern, and 3) It is constantly updated. While the downsides are, 1) Moodle is free to download, but server hosting costs extra, and with the free plan you have to find a provider or contract from the same page, and 2) Being open source, knowledge of HTML is required to perform certain functions.

iSpring Learn

iSpring Learn is an LMS aimed primarily at companies that want to train their employees. It works as a simple corporate platform for the creation of advanced courses where administrators can publish content, generate activities and track the results of their employees (ispring, 2023). The advantages of iSpring Learn are, 1) Its interface and design are friendly, modern, and intuitive, 2) It allows students to be awarded points and rewards for correctly completing an activity or unit, and 3) It is updated. While the disadvantages are 1) The yearly subscription depends on the number of active learners and starts from $3.66/user/month for up to 100 active users, and 3) It is mainly aimed at businesses.

Curriki

It is a non-profit organization founded in 2004 by Sun Microsystems, which manages an online learning platform focused on providing a wide range of interactive activities and revolutionizing online learning (Curriki 2022). The advantages of Curriki are, 1) Clean, friendly, and intuitive design for the student, 2) It is completely free, and 3) It has a great variety of types of activities. While the disadvantages are, 1) It can be linked with other LMS like Google, but it doesn't return results, and 2) The creation of activities is not very intuitive, especially the ones with a higher level of complexity and length.

Other very complete platforms were found in terms of an LMS. However, they were discarded due to their high costs, which were around $29 per month. Some of the platforms were Learndash and Appsembler. Considering the analysis of the different online platforms found, it was decided to use Curriki for the development of the Learning Object due to its large number of interactive reagents, interface, and updating.

Classification of Curriki teaching activities

Considering the Curriki platform, a classification of the activities was carried out according to Kolb's learning styles; adapter, divergent, assimilator, and convergent. Likewise, the activities that could function as a review for the students as well as to present and conclude the information seen in each unit were identified.

Accommodators

In this learning style, the student performs better by doing things kinesthetically and engaging in new experiences (Poch, 2023). After an analysis, it was determined that the activities related to this learning style considering the Curriki platform are:

- ✓ Branching Escenario: The student will experience different scenarios according to the answers they choose.
- ✓ Drag and Drop: Identify and drag the concepts with their corresponding images.
- ✓ Collage: Composition of different images on one or several themes.

- ✓ Guess the Answer: The student will have to identify the correct answer to the question posed.
- ✓ Image Hotspot: It will be possible to navigate in an image with interactive hotspots that will contain information, images, or a video.
- ✓ Interactive Book: A digital book with animations and transitions.
- ✓ Virtual Tour: It allows to navigate in a virtual space with explanations, videos, sound, and presumed interactions.
- ✓ Personality Quiz: Multiple choice quiz returns a result depending on the options selected.

Divergent

The strongest point of people who present this learning style is their imaginative capacity (Poch, 2023). After an analysis, it was determined that the activities related to this learning style considering the Curriki platform are:

- ✓ Image Juxtaposition: Overlapping images that can be displayed interactively through a slider.
- ✓ Agamotto: Image transition.
- ✓ Find the Hotspot: Find the correct option that completes the image.
- ✓ Flash Cards: Cards with pictures and open questions.
- ✓ Image Pairing: Select the corresponding images.
- ✓ Immersive Presentation: Presentation with interactive elements.
- ✓ Mark the Words: Underline the requested concepts of a text.
- ✓ Timeline: Graphic representation of a chronological sequence of events.
- ✓ Word Find: Find and mark certain words within a series of letters arranged in columns and rows.

Assimilators

People with this type of learning are characterized by their ability to create theoretical models (Poch, 2023). After an analysis, it was determined that the activities related to this learning style considering the Curriki platform are:

- ✓ Column Layout: Display of information in the form of columns.
- ✓ Dialog Cards: Virtual cards with information, sound, and images.
- ✓ Documentation Tool: Add a document.
- ✓ Questionnaire: Open-ended and multiple-choice question series.
- ✓ Quiz: Questionnaire with different types of reagents.
- ✓ Essay: The student generates his argued opinion based on a question.
- ✓ Image Slider: Display of an image series with description.
- ✓ Immersive Reader: Reading with audio and other immersive elements.
- ✓ True & False: Choose whether the statement is true or false.

Convergent

They stand out for learning through the practical application of ideas (Poch, 2023). After an analysis, it was determined that the activities related to this learning style considering the Curriki platform are:

- ✓ Advanced Fill in the Blanks: Select the correct answer from a series of options.
- ✓ Chart: Answer questions based on graphs.
- ✓ Drag Text: Put the words that correspond to the concept.
- ✓ Fill in the Blanks: Complete the sentence with the correct answers.
- ✓ Image Sequencing: Image series.
- ✓ Interactive Video: Video with questions and presentation of concepts.
- ✓ Memory Game: memory game with cards.
- ✓ Single Choice Set: Multiple choice quiz with only one correct answer.

Review activities such as Accordion, Summary, Column Layout, Course Presentation, and Frame Embedded were also identified.

Survey

To find out how students learn at the upper secondary level, a survey was developed with the Google Forms digital tool consisting of 13 questions/statements related to learning styles and 4 according to the user's personal information, such as age, gender, level academic and sector, to use it for statistics. The sample size was 208 high school students from 6 groups from different subjects, where the subjects are related to natural & exact sciences and social sciences & humanities. Multiple choice questions were implemented for personal data, and the Likert scale was for questions related to learning style. The Likert scale was categorized and quantified as follows: 1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly agree. The survey questions were the following:

A. Adapters or Accommodators

- S1. You prefer to implement solutions, so you take risks and are open to options. Also, you prefer teamwork.
- S2. You are comfortable with the need to obtain the necessary resources to achieve your goals related to a particular project.
- S3. You prefer multitasking, that is, carrying out several activities simultaneously.

B. Convergent

- S4. You need the practical application of ideas to test theories or solve problems.
- S5. You lose yourself when there are many alternatives.
- S6. You are exceptional in situations where there is only one way to be resolved.

C. Divergent

- S7. You enjoy analyzing (critiquing) problems as a whole and working with other people (multiplicity).
- S8. You are empathetic (open-minded), emotional, and witty (creative).
- S9. You generate a large number of ideas (brainstorming), that is, you are very creative.

D. Assimilators

- S10. You participate in the creation of theoretical models and the clear definition of problems.
- S11. You are more interested in projects related to abstract ideas (exact and natural sciences) than those projects directly related to people (social sciences and humanities).
- S12. You prefer individual work to group work.

Results

Statistics of Styles and learning objects

The results of the survey are shown in Table 1. In general, it is concluded that learning style C (Divergent) is the predominant one in the analyzed sample. In particular, the average value and standard deviation of this learning style are 3.96 and 0.96, respectively. While the least predominant learning style is D (Assimilator), with an average value of 3.42 and a standard deviation of 1.12. Now, considering the predominant learning style and their statements, the S8 has the best score, an average value of 4.33, and a standard deviation of 0.84. In this way, the results shown in Table 1 allow for establishing the assignment rule for the didactic activities in proportion to the learning styles qualification. That is to say, the learning object proposed in this research will give priority to learning activities related to learning style C, then to A and B (because they have similar expected values and standard deviation), and finally to learning style learning D.

<table>
<tr><th></th><th></th><th>Average (S)</th><th>S.D (S)</th><th>Average (LS)</th><th>S.D (LS)</th><th>Ranking (A)</th></tr>
<tr><td rowspan="3">A
Adapters or Accommodators</td><td>S1</td><td>3.78</td><td>0.99</td><td rowspan="3">3.62</td><td rowspan="3">1.05</td><td rowspan="3">2</td></tr>
<tr><td>S2</td><td>4.01</td><td>0.90</td></tr>
<tr><td>S3</td><td>3.08</td><td>1.27</td></tr>
<tr><td rowspan="3">B
Convergent</td><td>S4</td><td>3.96</td><td>0.99</td><td rowspan="3">3.60</td><td rowspan="3">1.05</td><td rowspan="3">3</td></tr>
<tr><td>S5</td><td>3.08</td><td>1.22</td></tr>
<tr><td>S6</td><td>3.75</td><td>0.94</td></tr>
<tr><td rowspan="3">C
Divergent</td><td>S7</td><td>3.77</td><td>1.06</td><td rowspan="3">3.96</td><td rowspan="3">0.96</td><td rowspan="3">1</td></tr>
<tr><td>S8</td><td>4.33</td><td>0.84</td></tr>
<tr><td>S9</td><td>3.78</td><td>0.97</td></tr>
<tr><td rowspan="3">D
Assimilators</td><td>S10</td><td>3.58</td><td>0.94</td><td rowspan="3">3.42</td><td rowspan="3">1.12</td><td rowspan="3">4</td></tr>
<tr><td>S11</td><td>3.44</td><td>1.21</td></tr>
<tr><td>S12</td><td>3.25</td><td>1.20</td></tr>
</table>

Table 1. Statistics of Styles and learning objects.

Digital learning object development in Curriki

Below is evidence of the development of the DLO on the Curriki platform. It is essential to mention that the DLO was developed in Spanish. Figure 1 shows the sections of the DLO. Figure 2 shows the learning activities from Section 1, Introduction. Regarding the learning activities used, the results of Table 1 and the classification of Curriki's learning activities based on Kolb's learning styles were considered.

Figure 1: Digital learning object structure in Curriki platform.

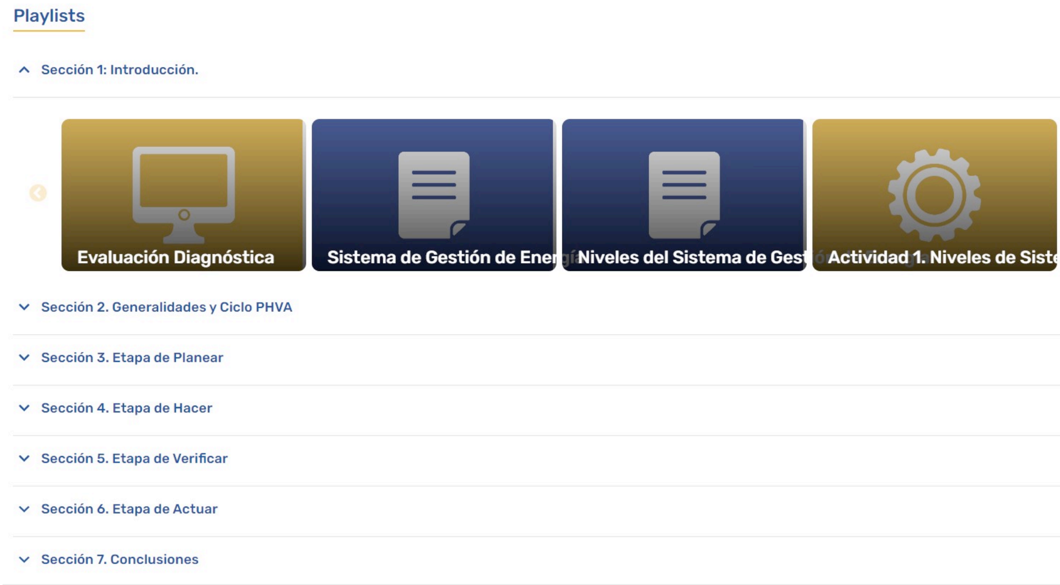

Figure 2: Didactic elements of Section 1.

Figure 3: Example of learning activity as a review of Section 1.

Figure 3 shows an example of a review activity for Section 1. In fact, each section of the DOL consists of review and assessment activities.

Evaluation of the Digital Learning Object

An evaluation of the Digital Learning Object was carried out with the participation of 21 students. In general, the figures in this section show the distribution of the responses for each parameter evaluated. In particular, the average value of each parameter was: 1) The didactic resources used are attractive (4.19), 2) The technical information is understandable (3.9), 3) The presentation of the information is correctly organized (4.09), 4) The digital tool allowed me to recognize the general elements of the ISO-50001 standard, referring to energy management (3.71) and, 5) The digital tool helped me to better understand energy efficiency issues and methodology to address real problems in the industrial sector (3.71).

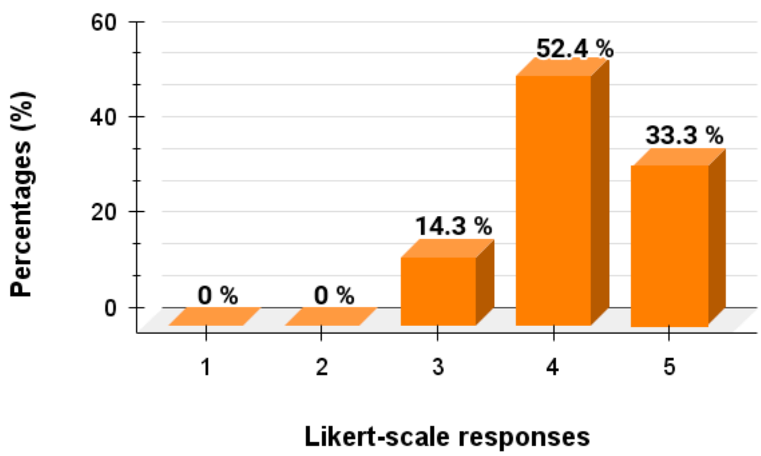

Figure 4: Results of Parameter 1, The didactic resources used are attractive.

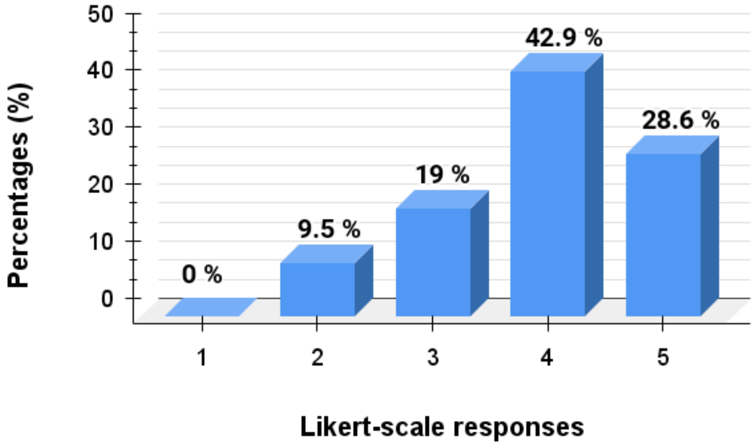

Figure 5: Results of Parameter 2, The technical information is understandable.

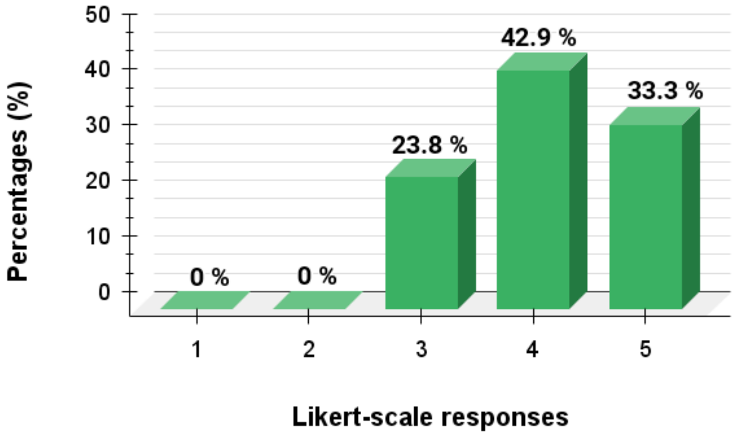

Figure 6: Results of Parameter 3, The presentation of the information is correctly organized.

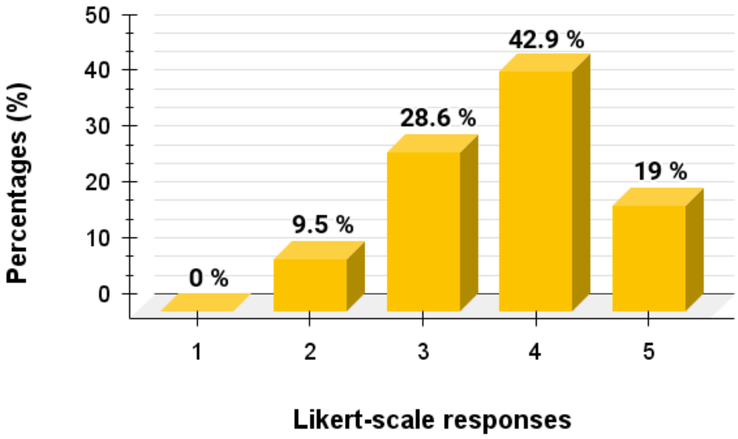

Figure 7: Results of Parameter 4, The digital tool allowed me to recognize the general elements of the ISO-50001 standard, referring to energy management.

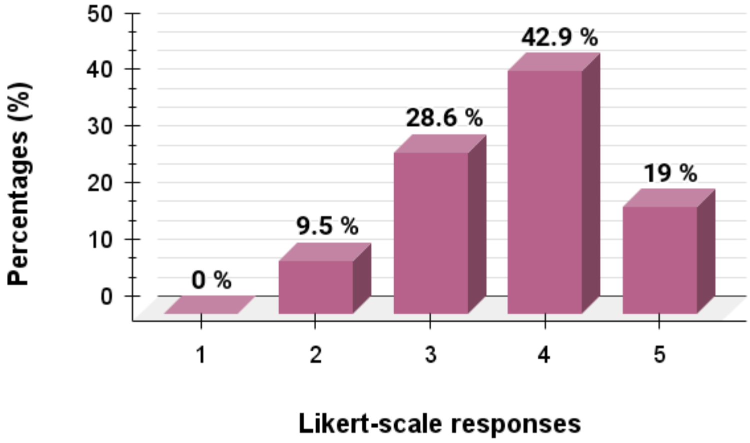

Figure 8: Results of Parameter 5, The digital tool helped me to better understand energy efficiency issues and methodology to address real problems in the industrial sector.

Conclusions

The developed Digital Learning Object has adequate ratings, generally between 4 and 5, on the Likert scale. Also, the Digital Learning Object presents some improvement aspects, mainly related to the presentation of the technical information of the ISO-50001 standard. Some questions for further investigation are: What learning activities improve the DLO assessment? What is the validity period of the DLO? What is the evaluation of DLO in the public sector?

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Contact email: josue.lopez@cetys.mx

Analysis of Time Management, Problem-Solving Ability and Automotive Electrical Competence

Heru Arizal, Universitas Negeri Surabaya, Indonesia
Suparji, Universitas Negeri Surabaya, Indonesia
Marniati, Universitas Negeri Surabaya, Indonesia
Bambang Suprianto, Universitas Negeri Surabaya, Indonesia
I Gusti Putu Asto Buditjahjanto, Universitas Negeri Surabaya, Indonesia
Ali Hasbi Ramadani, Universitas Negeri Surabaya, Indonesia

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Abstract
In the 21st century, the industrial revolution 4.0 and regulations limiting fossil fuel use have caused the automotive industry to compete to create environmentally friendly vehicles. Electric-based vehicles are the right solution for future vehicles. Therefore, the workforce's ability in the electricity field is urgently needed. Therefore, there is a need to improve the quality of human resources, especially in the field of automotive electronics. The quality of human resources can be seen from their competence in working. Researchers want to identify internal factors that affect competence, especially in automotive electricity. The internal factors observed in this study are problem-solving ability and time management ability. The research sample is mechanical engineering education students of 2019-2021 who have taken automotive electrical practice courses. Before data collection, validation and reliability of the instrument are carried out. Data analysis of this study used a simple double regression analysis. The results showed that problem-solving ability significantly affects competence, while time management does not. Therefore, to improve student competence in the field of automotive electricity, it is necessary to enhance problem-solving skills.

Keywords: Time Management, Problem-Solving Ability, Automotive Electrical Competence

Introduction

The 21st century, characterized by Industrial Revolution 4.0, is a period of rapid technological progress, requiring all elements to transform every aspect of human life. (Ali et al., 2020). The existence of the industrial revolution 4.0 and the impact of technological disruption are certainly very influential in the world of education. Education is fundamental in building each individual's character, so education is expected to optimize students to become competent human beings. Increased competence can bring a person into the world of associations, which can be done in the world of business, industry, social environment, management, and media technology.

In answer to 21st-century challenges, the key to the success of professional and continuous vocational education is determined by three aspects: teachers, curriculum, and learning(Nurtanto et al., 2020). The main goal of TVET is to produce graduates who must be able to produce graduates who are ready and capable of entering the world of work and industry. (Ali et al., 2020). In Indonesia, vocational education is undergoing a curriculum transition from initially based on the 2013 curriculum to an independent learning curriculum.

Educational institutions produce graduates who are not ready for work, causing a lot of unemployment; this is currently happening in Indonesia(Sarjono, 2019). We must take concrete and comprehensive steps to solve these problems to produce graduates who are ready to use, competent in the field of work, competitive, and have high selling points to compete in the global era.

Vocational school students tend to learn more functional and social competencies, such as technical skills and job-appropriate(Behle, 2017). Competence is a unified set of knowledge, skills, and attitudes that acquire meaning in the context (work) or task in which competence is used(Misbah et al., 2020). Höglund distinguishes between competence and qualification. The difference is that an individual has competence, while stuff is related to a work task(Backa & Wihersaari, 2014). Granberg defines competence as a formal qualification for a job assignment or position. According to Granberg, there are several competencies, one of which is legal competence. As a rule of proper competence related to the education that has been carried out by the individual(Backa & Wihersaari, 2014). Competence is defined as self-efficacy for a task or the degree to which a person believes they can complete a task successfully(Deci & Ryan, 2008).

Teachers do many things to improve student competence, one of which is by enhancing problem-solving skills. These capabilities can be applied, one of which is a problem-based learning model. Barrows and Tamblyn first introduced PBL in a medical class at McMaster University, Canada. (Engle, 1981). According to Barrows and Tamblyn, learning through problem-solving is much more effective than acquiring a large amount of practical knowledge, and problem-solving skills are more important to physicians than memory.(Engle, 1981).

Andis research shows that using PBL in large classrooms without tutors (thus avoiding additional costs) leads to a statistically significant improvement in students' general problem-solving skills(Klegeris et al., 2013). Hosseinzadeh teaches PBL in electrical engineering and is concerned about the breadth of content being discussed without detracting from the content topic. (Hosseinzadeh & Hesamzadeh, 2012). Problem-based learning is a constructive learning paradigm in which learners select and transform information, generate ideas, and make decisions based on current or past knowledge. (Yoo & Park, 2015).

In general, problem-solving researchers usually define the term problem as a task or question that an individual or group does not immediately know how to answer. (Haavold & Sriraman, 2022). But this definition says little about how individuals can be trained to be better at problems. (Haavold & Sriraman, 2022). Therefore, several problem-solving models have been developed to describe and explain the factors and processes involved in problem-solving. Most were interested in relying heavily on Poriya's famous four-step problem-solving model. Hesse et al. problem solving involve students recognizing the difference between the current state and the desired state of the goal, acknowledging that there is no simple or routine solution to this difference, and responding to specific situations. Define it as the activity you are trying to accomplish. This goal involves several mental and behavioral processes that do not always occur sequentially but can occur in parallel. (Guaman-Quintanilla et al., 2022).

Problem-solving is the process of eliminating the gap between the desired state and the existing mind. Several indicators are included in problem-solving, such as finding a problem, describing a problem, creating several alternative solutions, evaluating alternatives, and choosing the best option(Zhang et al., 2021). Problem-based learning empowers students to respond appropriately during the first and second stages of learning and teaching and to successfully identify, analyze, and solve communication problems [(Jonassen & Hernandez-Serrano, 2002)(Allchin, 2013).

The ability to solve problems is influenced by several factors, namely internal and external factors. Internal factors come from the individual, e.g., motivation, interests, self/time management, etc. At the same time, external factors are conditions that are influenced outside the individual, for example, the environment, infrastructure, etc. The research discussed in this article is an internal factor: student time management in carrying out activities, especially in learning.

Work-based learning in groups is the largest consumer despite being distributed relatively homogeneously. In addition, students spend too much time in almost all activities, which causes general overloads to be handled correctly(Ruiz-Gallardo et al., 2016). It is known that time management is a technology to increase efficiency in the use of time for the implementation of tasks. Time management supposes conscious control over the amount of time spent on a particular type of work, thereby increasing the efficiency and product quality of the activity(Vladimirovich Kirillov et al., 2015). Numerous studies have identified the positive impact of time management. Time management skills have been shown to impact student learning and student outcomes[19] positively. (Krause & Coates, 2008) reports that the capacity to successfully manage their time is the basis on which students develop good study habits and strategies for success. In the study, Adam and Blair found students' understanding of time management behavior in contributing to students' academics(Adams & Blair, 2019).

Based on the above background, this research analyzes time management and problem-solving skills in expertise, especially in automotive electrical competencies. The formulation of the problem discussed in this article is:

1. How time management affects automotive electrical competence
2. How problem-solving ability affects automotive electrical competence

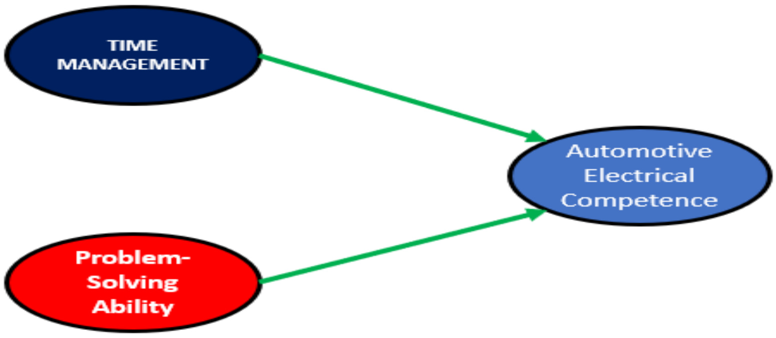

Figure 1. Skeleton Conceptual

Method

Design

The design of this study examines the factors that affect automotive electrical competence. Where researchers look at time management and problem-solving skills in undergraduate students of Mechanical Engineering Education, Surabaya State University, this study aims to obtain information on the effect of time management and problem-solving ability on automotive electrical competence. The research uses a quantitative approach *to ex post* facto survey methods.

Population and Sample

Where the population in this study is mechanical engineering education students who participated in the automotive electrical practices class of 2019 and 2021, the samples taken were 143 mechanical engineering education student class of 2019 and 2021 who had participated in automotive electrical practice activities.

Research Instruments

Data or information collection is a procedure and prerequisite in solving the construct research problem being tested. Then the data collection instrument is compiled into questionnaires and tests. Questionnaires are used to obtain time management data, while tests collect data on problem-solving ability and automotive electrical competence.

Multiple experts in the field have validated this tool: instructors and auto mechanics. Some devices are validated by validators and continue to be tested on equipment. The agency was tested in a non-research sample of vocational high school students who exhibited similar characteristics to the research sample. Devices for each structure can be described in the table below.

Table 1. Instrument Grid

No	Construct	Indicator	Instrument
1	Competence	1. Cognitive 2. Psychomotor 3. Affective	Test
2	Problem-solving ability	1. Understanding the Problem 2. Planning problem solving 3. Doing planning problem solving 4. Checking Troubleshooting Results Back	Test
3	Time management	1. Activities to do 2. Best activity conducted	Questionnaire

Data Analysis Techniques

Automotive electrical experts are used to assess the validity of contents using Aiken's V as an analytical technique to determine the validity of instruments (Aiken, 1980). The validity of the description using Average Variance Extracted (AVE) > 0.5 and the Loading Factor Value > 0.7 (Hair et al., 2010). Cronbach's alpha was used to analyze reliability, provided that the alpha value was >0.5(Hair et al., 2010). After the data is collected, the data is analyzed to map time management conditions, problem-solving ability, and automotive electrical competence. Analysis of Time Management and Problem Solving Skills by Automotive Electrical Skills, a double regression test was carried out. This study uses the Smart PLS 3 application. The resulting output of the Smart PLS application allows for finding the influence of free variables on independent variables.

Result

Descriptive statistics show that the study sample was 87% male and 13% female. Their age range is between 18-20 years. The instruments used in this study were tested for the validity of the contents by lecturers of electrical and mechanical subject matter. The test results were analyzed using Aiken'V (Aiken, 1980). The analysis results of each instrument are declared valid where the value of V is above 0.4.

Table 2. Instrument validation test results

Instruments	V	Information
Time Management	0,67	Valid
Problem-Solving Ability	0,726	Valid
Electrical Automotive Competence	0,778	Valid

A total of 143 students were asked to fill out instruments and take tests. The results show data like the table below.

Table 3. Average Variance Extracted Discriminant Validity Results

	Average Variance Extracted (AVE)
Electrical Automotive Competence	0,544
Problem Solving Ability	0,502
Time Management	0,653

Based on the table above, the AVE of each construct/variable has a value above >0.5. The results explained that the construct could explain more than half of the indicator variants of each construct.

Table 4. Result of Discriminant Loading Factor Validity

	Electrical Automotive Competence	Problem Solving Ability	Time Management
Affective	0,780		
Cognitive	0,711		
Psychomotor	0,720		
Problem Solving1		0,702	
Problem Solving2		0,715	
Problem Solving3		0,708	
Problem Solving4		0,708	
Time Management2			0,835
Time Management1			0,780

All indicators for each construct show loading factor values greater than 0.7. The results mean that the indicators are correlated with each component. The validity of the determinants of both AVE and stress factors allows us to conclude that the data are valid. After checking the validity, the next step is to check the data on reliability. The reliability test in this study used the reliability of Cronbach Alpha. The information is reliable if the Cronbach Alpha value is≥ 0.5.

Table 5. Cronbach Alpha Reliability Results

	Cronbach's Alpha
Electrical Automotive Competence	0,581
Problem Solving Ability	0,670
Time Management	0,570

The value of each construct on the Cronbach Alpha is above 0.5. In electrical competence, the value of 0.581 and time management of 0.570 indicates that the instrument on the construct is reliable. The ability to solve problems is 0.670, where the device is reliable.

After the data has been said to be valid and reliable, the data is analyzed to determine the effect of time management and problem-solving ability on electrical competence. The results of such analysis can be seen in the figure below.

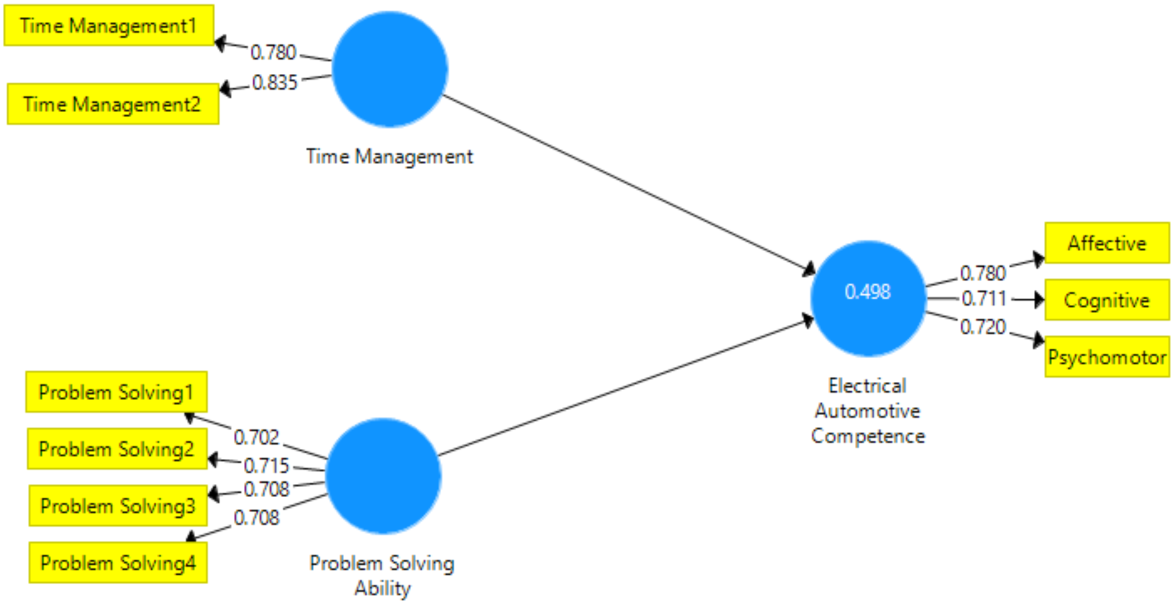

Figure 2. Data Analysis Results

1. Effect of Time Management (X1) on Electrical Competence (Y)

Based on table 6, it is found that Time Management (X1) does not affect electrical competence. The P value is 0.088, where a deal above 0.05 means time management does not impact competence.

Table 6. Values of Effect X1 on Y

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Time Management -> Electrical Automotive Competence	0.101	0.104	0.069	1.709	0.088

2. Effect of Problem-Solving Ability (X2) on Electrical Competence (Y)

Table 7 shows that Problem Solving Ability (X2) has a positive influence of 0.654 on automotive electrical competence (Y). The P value of 0.000 or less than 0.05 has the meaning of being hypothesized. From this interpretation, it can be concluded that the ability to solve problems positively and significantly influences the competence of Mechanical Engineering Education students.

Table 7. Values of Effect of X2 on Y

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Problem-Solving Ability -> Electrical Automotive Competence	0.683	0.688	0.045	15.194	0.000

Understanding problems is the highest indicator owned by Mechanical Engineering Education students. The lowest indicator is the ability to solve problems. This low ability is due to doubts about making quick and appropriate decisions.

Discussion

Knowledge, skills, and attitudes can measure competence during the student's work/assignment. Knowledge is the ability that students acquire theoretically, both formally and informally. Agility is the ability of a person to perform tasks more efficiently and accurately. At the same time, an attitude is a state of one's self that encourages one to act on specific emotions or engage in social activities when responding to objects, situations, or environmental conditions.

A student's competence can be influenced by several factors, namely internal and external factors. Internal factors are those caused by himself. At the same time, external factors arise outside the individual. This research is more focused on internal factors. Internal factors include time management and problem-solving ability.

Time management is a form of decision-making used by individuals to structure, protect, and adapt their time to changing conditions (Aeon & Aguinis, 2017). A student's success depends on his ability to manipulate time well and efficiently. Therefore, students must learn to manage their time in such a way that they can apply the same efficiency in their chosen profession after completing their education. Time management is an essential skill that mechanical engineering education students must learn during their academic life to improve their skills and quality of service.

The learning method must follow the length of learning. Learning without planning means an ineffective, organized, and balanced day; therefore, planning is essential to achieve the goal. Time management has several functions, namely 1) assisting individuals in determining priorities, 2) helping to reduce the tendency to postpone work to be completed, 3) it can prevent clashes when working on two or more jobs at the same time, 4) helping the evaluation process on individual work results.

From some of the explanations above, we can conclude that good management will help facilitate activities. Similarly, if while studying, if we manage study time with social or other interests, it will not be disturbed by the student's academic field. Some studies suggest that good student time management positively impacts learning outcomes [(Aeon et al., 2021; Nadinloyi et al., 2013).

The research resulted in time management not affecting electrical competence. These results are different from some previous studies. Most likely, students' competence is more influenced by other internal factors. Several researchers' studies include that time management does not affect learning outcomes (Saputra, 2022; Triansyah & M Fitri Ramadhana, 2018).

The ability to solve problems using their cognitive strategies is the ability to solve them (Chiou et al., 2009). There are four processes involved in problem-solving, namely understanding, formulation, and implementation, and the last one is evaluation. Before completing a given task, the student must understand the meaning of the problem. Understanding the phases of a problem is about understanding the system and the problems it solves (Mirel, 2004). The student's question comprehension process must be able to determine the keywords of the question. This keyword limits the student's answer from deviating from the question's context. Students who can understand the problem indicate that they have basic skills related to the material given in the assignment. Understanding the problem makes it easier to solve the problem.

After the student understands the problem, the next step is to formulate measures to solve the problem. The student must identify the activities and strategies necessary to solve a particular problem. Students can do this in the following ways: (1) guessing, (2) developing models, (3) sketching diagrams, (4) simple tasks, (5) recognizing patterns, (6) creating tables, (7) experimenting and simulating, (8) working in reverse, (9) testing all possibilities, (10) identifying partial goals, (11) making analogies and (12) sorting data/information. Formulate students' problem-solving skills to think critically. Critical-thinking students solve problems efficiently. The ability to think critically also positively impacts students' academic performance [(Bellaera et al., 2021; Ren et al., 2020). Students must also have sufficient understanding. Student understanding helps to find different solutions to solve problems. A quick and precise solution is chosen from several solutions.

Once you have formulated and provided the right solution to solve the problem, the next step is to have the student solve the problem. Troubleshooting actions should be consistent with the plan that has been drawn up. What is done depends on what was planned in advance and also includes the following: (1) interpreting the information provided in the form of calculations; and (2) the application of strategies during the process and calculations. Generally, the student must stick to his chosen plan at this stage. Students can choose a different method or procedure if the program cannot be implemented. Whenever a student takes a step/action, they must be careful with their actions. A misstep in the troubleshooting process results in an error at the end of the process. When solving problems in the automotive industry, students work step by step according to the usual procedure.

After the troubleshooting procedure is completed, the next step is to evaluate the work results. The following considerations should be taken into account when reviewing previous efforts to resolve the issue, namely: (1) reviewing all identified material information; (2) reviewing all included calculations; (3) considering whether the solution is logical; (4) seek other alternative solutions; and (5) re-read the question and ask yourself if it was answered.

If the student performs the troubleshooting steps well, it will help solve the problem. Our research showed that problem-solving ability has a 68.3% positive impact on competency. That is, if the problem-solving ability increases, then the know-how in the automotive industry also increases. Based on this research, it has been proven that students are often trained to develop problem-solving skills.

Conclusion

The results of the research that has been carried out to answer the hypotheses tested on each construct can be concluded as follows:

1. Time management does not affect automotive electrical competence
2. The problem solving ablility has a direct positive and significant effect on the competence of automotive electricity. The power of students to solve unwittingly will increase competence since, in the face of problems, they must apply the knowledge they have gained to determine the methods and make decisions to solve problems
3. Improve automotive electrical competence and it can be done by increasing students' ability to solve problems

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Contact email: heruarizal@unesa.ac.id

Investigating the Impact of Educational Robotics on Underserved Students' Career Interests

Jessica Drayer, Technology Teacher, United States
Lauren Harter, VEX Robotics, United States
Rachel Van Campenhout, Duquesne University, United States

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Abstract
Among its many benefits, educational robotics has been found to increase in student completion of STEM degrees and interest in science, technology, engineering, and math (STEM) careers. Given the national and international demand for a workforce trained in STEM areas, increasing student attitudes toward STEM and interest in careers in STEM areas is critical. Educational robotics provides students with an authentic, hands-on way to experience interdisciplinary STEM learning, which increases positive perceptions of these disciplines as well as interest in related careers. Yet the benefits of educational robotics are not always equally distributed for students, and therefore the impact of this curriculum is not well understood for underserved communities. In this study, an educational robotics curriculum was implemented in an urban private school that serves primarily minority students. The students at this school—ranging from third to eighth grade—had no prior experience with robotics, and little to no experience with construction-type toys or programming applications. A pre-survey was administered prior to a 12 week robotics curriculum (differentiated by age group), followed by a post-survey. The survey results on how student interest in STEM careers changed will be discussed. This research project aims to create a small window into the impact a robotics program could have on underserved students in particular to engage and prepare them for a future in STEM.

Keywords: Educational Robotics, STEM, Career Interest, Equity

Introduction

Careers in science, technology, engineering, and mathematics (STEM) are continuing to increase in number and are a valuable portion of the United States economy—23% of the total U.S. workforce in 2019 (NSF, 2021). The contributions of STEM workers should not be under-appreciated. "Individuals in the STEM workforce make important contributions to improving a nation's living standards, economic growth, and global competitiveness. They fuel a nation's innovative capacity through their work in research and development (R&D) and in other technologically advanced activities," (NSF, 2021). However, not all people are represented equally in the workforce. The National Science Foundation (2021) reported that "Hispanic or Latino and Black or African American workers are underrepresented in STEM, with the greater discrepancy being among those with a bachelor's degree or higher than those without a bachelor's degree." Women were also underrepresented. Fortunately, the U.S. STEM workforce has "gradually diversified between 2011 and 2021, with increased representation of women and underrepresented minorities" (NSF, 2023).

The shifting representation within the STEM workforce is in part due to the prior decades increased focus on STEM education. In 2015, the NSF reiterated the crucial importance of Americans acquiring the necessary STEM knowledge and skills in order to partake in an increasingly technology-intensive global economy. The education of our students can greatly impact their attitudes and interests, influencing their future career choices. In order to reduce the inequalities between gender and minority representation in STEM careers, increased focus on STEM education for these groups is necessary.

STEM education faces its own challenges: student perceptions of STEM subjects can begin to decline as early as fourth grade (Unfried et al., 2012). Better supporting students to choose STEM careers also means they need to have positive attitudes toward those subjects. Educational robotics has been increasingly used as a vehicle for STEM education, as it provides a fun, hands-on approach to these subjects in an integrated manner. In a meta-analysis, Benitti et al., (2012) found that generally educational robotics increased knowledge for specific STEM concepts. Researchers have found a spectrum of benefits for incorporating robotics into existing school curriculum, from the development and application of STEM knowledge to computational thinking and problem-solving skills, to social and teamwork skills (Altin & Pedaste, 2013; Bers et al., 2014; Kandlhofer & Steinbauer, 2015; Taylor, 2016). Notably, research across age groups has shown improvements in student interests and perceptions of STEM subjects (Nugent et al., 2010; Robinson, 2005; Rogers & Portsmore, 2004; Ching et al., 2019; deBruyn & Van Campenhout, 2022). Research has also found that when educational robotics improves perception, it also increases school achievement and more students attain science degrees (Renninger & Hidi, 2011; Wigfield & Cambria, 2010; Tai et al., 2006). For many students in high school, robotics has been used to advance college preparedness or technical career skills (Boakes, 2019; Ziaeefard et al., 2017; Vela et al., 2020), another avenue to support students considering STEM careers.

However, there needs to be more research on how to apply educational robotics to these underrepresented populations. Increasing the exposure to and interest in educational robotics for women and minorities could continue to help diversity in the STEM workforce. In a literature review by Anwar et al. (2019), only 16 of 147 studies focused on underrepresented populations and those studies generally focused on increasing availability of robotics or to evaluate overall success of the programs. The goal of this study is to contribute to this area of research by exploring how educational robotics curriculum might influence career interests for third through eighth grade African American students. This initial research can provide direction for future robotics implementation and educational interventions.

Methods

The students participating in this research are from a private Catholic school in the urban Pittsburgh area. All students in this program are African American. The school receives scholarships through the Extra Mile Foundation and all students are 100% supported by a free/reduced lunch program. An informational letter and consent form were sent home and in total there were 101 students from third to eighth grade included in the study, after parent/guardian approval.

A pre-survey was delivered to students on perceptions of STEM and career interests: the Student Attitudes toward STEM Survey - Upper Elementary School Students (Friday Institute for Educational Innovation, 2012). The survey was recreated as a Google Form and distributed to students to complete on their Chromebooks. Students who returned the consent form took the survey, while the students who did not were given another activity during that time. The instructions were read aloud to students, and some terms were defined when requested. It was reinforced that there were no correct or incorrect responses, but it was simply gathering information of their perceptions and feelings. In this study, only the career interests are investigated in detail.

The teacher (and first author) selected the VEX GO robot kits because:

- The plastic pieces are designed for younger students' motor skills
- The kits could be stored and reused for all grades and classes
- A full standards-aligned curriculum was provided at no additional cost
- Teacher training was available at no additional cost

Each grade received 13 weeks of VEX GO robotics curriculum (each class had one robotics period per week). Some classes were seen more or less often than others due to school events and schedules. Some of the STEM labs and activities were completed by all students, but there was differentiation by grade level. At the end of the school year, students completed the same survey instrument after the curriculum had been completed.

Results

Aggregated Results. After removing students who did not complete both the pre- and post-test, there were a total of 60 students included across all grades, as shown in Table 1. For each question in the career interest portion of the survey, students were given a career description and asked how interested they were in that career. An example is: 'Engineering: People use science, math and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working.' For the analysis, the answer choices needed to be recoded to integers in order to calculate means and run statistical tests. The items were recoded as: not at all interested = 1, not so interested = 2, interested = 3, very interested = 4.

	3rd	4th	5th	6th	7th	8th
Students	14	2	11	16	7	10

Table 1. Students included by grade level.

Combining all student responses, the pre- and post-survey responses are compared using independent paired sample t-tests. Variation in mean scores show that ten of the twelve careers increased on the post-survey. However, only medicine showed a significant increase ($p < 0.5$). There are some limitations for looking at the aggregated results, as it combines a wide range of ages who may respond differently to the options. Therefore, the next task is to investigate these career perspectives according to gender and grade.

	pre-survey mean	post-survey mean	*p*
Physics	2.15	2.36	.159
Environmental work	2.32	2.33	.913
Biology	2.51	2.61	.545
Veterinary Work	2.44	2.34	.522
Mathematics	2.05	2.10	.748
Medicine	2.35	2.65	.031*
Earth Science	2.39	2.47	.557
Computer science	2.36	2.36	1.000
Medical Science	2.25	2.48	.216
Chemistry	2.58	2.59	.901
Energy/electricity	2.31	2.53	.198
Engineering	2.50	2.64	.409

Table 2. Aggregated career interest results for all students.

Gender Results. The first subdivided analysis was to investigate how males and females responded to the surveys. The female group ($n = 26$) showed variation across the careers, with eight of twelve career means increasing on the post-survey (Table 3). Interestingly, the only career change to be significant was a decreased interest in veterinary work ($p < 0.1$).

	pre-survey mean	post-survey mean	*p*
Physics	2.23	2.38	.516
Environmental work	2.42	2.35	.774
Biology	2.52	2.64	.622
Veterinary Work	2.73	2.31	.086*
Mathematics	1.92	1.85	.691
Medicine	2.60	2.88	.183
Earth Science	2.52	2.60	.627
Computer science	2.24	2.32	.664
Medical Science	2.58	2.63	.866
Chemistry	2.77	2.92	.404
Energy/electricity	2.28	2.52	.341
Engineering	2.50	2.50	1.00

Table 3. Career interest results for females.

By comparison, the male group (n = 29) had eleven of twelve mean scores increase on the post-survey (Table 4). The only decrease was in chemistry at 0.04. Three careers had significant increases: physics, medicine, and medical science ($p < 0.1$).

	pre-survey mean	post-survey mean	*p*
Physics	2.11	2.48	0.86*
Environmental work	2.28	2.41	.489
Biology	2.59	2.72	.608
Veterinary Work	2.21	2.39	.433
Mathematics	2.32	2.50	.532
Medicine	2.15	2.52	.086*
Earth Science	2.34	2.55	.406
Computer science	2.43	2.46	.873
Medical Science	1.96	2.48	.074*
Chemistry	2.54	2.50	.873
Energy/electricity	2.39	2.64	.363
Engineering	2.59	2.83	.345

Table 4. Career interest results for males.

Results by Grade. There is a great deal of difference between a third grader and an eighth grader, so grade-level results were also reviewed. Given the small sample size for each grade, only mean scores are reported. For brevity, not all grade levels were reported here. There were not enough fourth graders included in the final analysis to include, so third, fifth, and eighth grade results were selected for discussion.

The third-grade students (n = 14) showed the highest initial mean scores for career interest (Table 5). This is consistent with research showing that young students have the most positive perceptions of STEM topics. There were mean score increases for eight of twelve careers. Environmental work remained the same, mathematics decreased by 0.57, computer science decreased by 0.08, and veterinary work decreased by 0.29.

	pre-survey mean	post-survey mean
Physics	2.71	2.93
Environmental work	2.79	2.79
Biology	2.79	3.14
Veterinary Work	3.00	2.71
Mathematics	3.07	2.50
Medicine	3.00	3.21
Earth Science	2.86	3.07
Computer science	3.00	2.92
Medical Science	2.64	2.77
Chemistry	2.71	2.86
Energy/electricity	2.64	3.08
Engineering	3.14	3.15

Table 5. Comparison of mean career interest scores for third graders.

The fifth-grade student results (n = 1) show slightly lower initial means scores when compared to the third graders (Table 6). They also show increased mean scores for eight of twelve careers. Engineering and biology remained the same, earth science decreased by 0.18, and veterinary work decreased by 0.10. The largest increases (more than 0.30) were in physics, mathematics, and medicine.

	pre-survey mean	post-survey mean
Physics	2.27	2.64
Environmental work	2.55	2.82
Biology	3.00	3.00
Veterinary Work	2.70	2.60
Mathematics	1.82	2.27
Medicine	2.20	2.55
Earth Science	3.00	2.82
Computer science	2.73	2.82
Medical Science	2.09	2.18
Chemistry	2.64	2.82
Energy/electricity	2.55	2.64
Engineering	3.00	3.00

Table 6. Comparison of mean career interest scores for fifth graders.

The results for the eighth graders (n = 10) show the lowest mean initial scores of all grades (Table 7). This corroborates evidence from other research that student attitudes toward STEM subjects decrease as they get older. In total, ten out of twelve careers had increases in mean score. Chemistry remained the same and computer science decreased by 0.10. The careers with increases had some of the largest increases in mean score. Environmental work, biology, mathematics, medicine, earth science, medical science, energy/electricity, and engineering all had mean increases between 0.30 and 0.76. Notably, engineering had the greatest increase.

	pre-survey mean	post-survey mean
Physics	1.40	1.50
Environmental work	1.40	1.70
Biology	1.40	2.00
Veterinary Work	1.70	1.80
Mathematics	1.30	1.70
Medicine	1.60	2.00
Earth Science	1.20	1.70
Computer science	1.50	1.40
Medical Science	1.70	2.40
Chemistry	1.90	1.90
Energy/electricity	1.60	2.20
Engineering	1.44	2.20

Table 7. Comparison of mean career interest scores for eighth graders.

Conclusion

There are limitations that are important to discuss for the interpretation of these results. Only 60% of students who participated in the robotics curriculum were included in analysis due to only completing the pre- or post-survey, which could impact results. Each grade had a small number of participants, and when aggregating all students, the differences in grade level interests make the overall results less meaningful. It is also reasonable to note that third graders may have a more abstract concept of careers compared to eighth graders who are nearing high school.

However, these results do suggest several important findings. First, across all age groups and genders, student mean scores increased the majority of the time for career interest between the pre- and post-survey. This is a generally beneficial result given the limitations discussed. Second, consistent with the literature, student interest decreased as grade level increased. The youngest students had the highest level of interest on the pre-survey while the oldest students had the lowest interest. Third, some career trends were consistent across age groups, such as veterinary work decreasing and medicine increasing.

One of the most positive findings is about the eighth graders. While they had the lowest initial mean scores, they had great improvement on most careers. Attempting to reverse negative perceptions of STEM subjects and careers is one of the primary goals of engaging students in educational robotics. To see such improvement for the oldest students in this study is a very promising result. If more students begin to think of these STEM careers as viable options for themselves, they may continue on to seek degrees and careers in those areas.

The context for this research study is also worth discussing, as it both shaped the results of this study and suggests areas for future research. The first area for future investigation is to better understand how the selection of STEM lab topics impacts student career interest. It was noticed that students had several labs with connections to science and medicine. Could this have created an extra focus on that area that influenced student interests? Similarly, the seventh and eighth graders were the only grades to have STEM labs on simple machine and other engineering-heavy builds, and the eighth graders had a large increase in interest in engineering. The STEM labs focused on during the year could have a great impact on student interests.

Next, further investigations are needed around how the integration of educational robotics impacts student career interests as well. Would having robotics every day for a quarter be more impactful than once a week for half the year? Also, including more specific examples of related careers in the STEM labs and providing specific examples of people who do those careers could help tie the robotics with real-world examples.

Supporting minority and underserved students in their STEM learning through educational robotics can give them more opportunities to learn about and grow interest in future careers in STEM. By learning from the implementation and results of this study, future research can continue to explore how educational robotics can increase student interest in STEM careers.

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Contact email: LH@vex.com

Digital Application Literacy and the Modern Classroom

LeAnne J. Schmidt, Notre Dame Marist Academy, United States
David W. Schmidt, Lawrence Technological University, United States

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Abstract

Pivoting to online learning in a pandemic posed challenges for educators, administrators, parents, and students. This exploration examined quantitative data establishing the disparities of access to computers and the internet for students, the likelihood of canceled classes, and differing experiences with virtual coursework or remote learning on paper for students based upon gender and race/ethnicity. Critical deficiencies present themselves when students lack familiarity with new learning platforms. The net result was that assessments failed to capture student learning, but instead assessed basic knowledge and facility with the application for assessment. Employing Digital Application Literacy Theory (Schmidt, 2021) indicates that learners with familiarity in the use of an application perform 10% better in the short term analysis and 25% better in the long term analysis, despite the fact that material assessed was entirely new content, not a building of incremental understanding toward a content goal. A process of Digital Application Literacy was recommended to assure that assessment results are the product of content learning and not merely savvy use of software. Schools experienced significant drawbacks when the shut-down of schools left many students without ways to participate directly in learning activities. Though many schools would pivot to online learning and Zoom classes, these suffered from a lack of preparedness among learners in the new and different styles of digital applications used in remote learning. Clear understanding and utilization of Digital Application Literacy can offer solutions to these circumstances and insight on the limited value of early assessments of learning lag.

Keywords: Digital Application Literacy, COVID, Virtual Learning, Gender, Race, Ethnicity, Learning Lag, Disparity, Pandemic, Access

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Introduction

The emergency caused by the COVID-19 pandemic has officially ended in the United States, as of April 10, 2023 (Miller, 2023). The World Health Organization met on May 4 and declared the global health emergency in response to COVID-19 at an end on May 5, 2023 (Rigby & Satija, 2023). No one would deny its impact has fundamentally changed aspects of the modern classroom. The question remains whether the pendulum will swing back to the starting point, erasing gains in educational technology integration and practice or advance the resting point along the continuum.

Effectively assessing the impact of the COVID learning dynamics on the modern classroom requires analysis of the actual demographic data. With a foundational understanding of the landscape of pandemic education, it is then possible to identify meaningful impacts in classrooms which changed during the 2020-2023 school years to accommodate new realities in teaching and learning.

The Digital Application Literacy theory expressed the necessity for explicit teaching of new applications and online protocols with students before using them in assessment practices (Schmidt, 2021). When educators use unfamiliar means of assessment with students, they risk assessing facility with the application instead of the apprehension of the content knowledge in the classroom. This risk is understandably greater in an atmosphere of virtual learning when the teacher and student connect impractically through video conferencing. Teacher monitoring of student practices is impaired. Students may be less likely to ask questions about new applications because of the vigilant notice of on-screen peers. Students engaged in remote learning bear the likelihood of being less attentive to instruction details.

This mixed methods study will begin through a literature review to address the question: "What ongoing challenges did educators, administrators, and parents express publicly about using applications in the classroom?" in order to clarify the experiences of adults during this critical period before using a quantitative analysis to describe the methods for engaging in educational activities during early 2020 through 2021.

Literature Review

A clear starting point is to understand what rates of computer access in schools and in households were prior to the pandemic. According to the Institute for Education Sciences, a division of the National Center for Education Statistics, data collected in the 2019-2020 school year, prior to the outbreak of the COVID-19 pandemic, 45% of school children in America had one-to-one access to computers for educational use (Gray & Lewis, 2021, p. 3). Further, broken down by school level, for secondary students, both middle school and high school, 63% had one-to-one access to computers for learning (Gray & Lewis, 2021, Table A-1). However, only 15% of schools permitted students to take computers home, which breaks down as 10% of elementary students, 18% for middle school students, and 26% for high school students (Gray & Lewis, 2021, Table A-3).

As a result of inadequate access to computers by students who were thrust into remote, virtual, and blended learning in the spring of 2020, many districts accelerated technology acquisition plans. Superintendent of Schools in San Antonio, Texas, Pedro Martinez advanced and secured a $90 million bond to pay for new technology to meet the needs of remote learners and stated, "There's no going back now" (Herold, 2021, para. 3). However, the possession of the devices does not ensure learning. Marlo Gaddis, the chief technology officer for Wake County, North Carolina, described the pandemic acquisitions as a “proof of concept for 1-to-1” (Bushweller, 2022, para. 3). He further admits that no school got everything right in the process of implementing new technology strategies for remote learning. District leaders surveyed indicated that 10% explored constructing an on-going model of hybrid instructional learning and 19% were seriously considering implementing remote instruction options for subsets of their students or planned to use the option in the case of a weather emergency (Herold, 2021).

The United States Census Bureau collects regular data beyond the decennial census through the American Community Survey (ACS). According to the ACS, 92.9% of households had computers and 86.4% had regular subscriptions to broadband internet in 2019 (USCB, 2019). By 2021, computer access was 95.0% and internet access was 90.1% (USCB, 2021). To clarify, the ACS surveys households with individuals of all ages, so rates of access among households with school-age children would vary.

Families

In addition to the acquisition of devices, methods for learning remotely caused new challenges for students and for the adults in the households with them. During March through June of 2020, Annette Anderson of Johns Hopkins University and deputy director of the Center for Safe & Healthy Schools, describes a “small, but significant subset of families” who became aware of discrimination and microaggressions toward their children when students were learning virtually, in the presence of alert parents (Lieberman, 2020). Still other families learned about concerning content in the curriculum choices and questioned teachers, administrators, and school boards. Anderson points out that being able to monitor the interactions between children and their teachers and peers brought a mindshift for families which they were not willing to leave behind (Lieberman, 2020). Therefore, some students and their families who experienced the online learning model elected not to return to the traditional atmosphere.

Teachers

Teachers, too, experienced changes in expectations while teaching virtually, including teaching to blank screens (students with cameras off) and an inability to manage assessment in ways analogous to the classroom. According to teachers surveyed, 41% indicated that they were not well-trained to use educational technology effectively (Bouchrika, 2022). This included frustration with hybrid learning while attempting to manage in-person students at the same time as students online in order to reduce classroom sizes in the return-to-school protocols because the needs of remote student engagement and connecting with in-person students were divergent. Teachers indicated that they were required to switch teaching methods at least once during the 2020-2021 school year, but the average teacher indicated switching twice, necessitating revision of teaching materials and a learning curve for students with each change (Zamarro et al., 2021). Another question indicated that 39% of teachers surveyed stated that their schools did not actually support the elearning tools that teachers were expected to use (Bouchrika, 2022). In a survey of 1045 teachers in various teaching conditions, 42% responded that they considered leaving the teaching profession (Zamarro et al., 2021). These frustrations would lead many educators to elect not to return to the classroom. Respondents further shared that, of those colleagues who considered leaving teaching, 40% did leave (Zamarro et al., 2021). According to the survey, in-person teachers were less likely to resign than fully remote or hybrid counterparts (Zamarro et al., 2021). Many who returned to the classroom elected to leave later in response to other challenges.

Students

In Spring 2021, Renaissance Learning, an industry technology assessment specialist, conducted a study in its' "How Are Kids Performing" series which concentrated on the year following the outbreak of the pandemic, and saw students split between in-person classrooms and virtual learning at various levels throughout the year, depending on geographic location (Renaissance Learning, 2021). Their results indicated that students of Black, Hispanic, and American Indian/Alaska Native heritage were performing at 6 to 8 points lower in Reading and 11 to 14 points below the pre-pandemic baseline in Mathematics. Students with disabilities were six points lower in Reading and nine points lower in Mathematics. English Language Learners performed five points below baseline in Reading and ten points lower in Mathematics. Locality did not demonstrate a differentiation in Reading with both rural and urban students performing at four points below the baseline, but rural students were only one point below the baseline in Mathematics, whereas urban students were nine points below the same baseline. Students at Title I eligible schools performed five points lower in Reading and seven points lower in Math. Catholic and private schools performed at the baseline, but public schools were four points below their pre-pandemic baseline. Students who completed the assessments outside of the school environment performed seven to nine points lower than students who were tested in a classroom setting. Across all subgroups except private and Catholic schools, students performed below the baseline set in the previous year prior to the pandemic outbreak. Renaissance tests three to four times per year and was able to get more detailed information on the timing effect than other annual assessments for that reason.

Digital Application Literacy theory was created in response to a one-year study of eighth grade students in a Language Arts course in which they were assessed using the NoRedInk platform at intervals throughout the school year, particularly October, December, and April (Schmidt, 2021). Between October and December, the mean score of students on grammar content material which did not reflect a progression of learning, but specific and discrete concepts, score range improved by 10% (Schmidt, 2021). Then, from December to April, scores on similarly discrete concepts improved by another 15% to reveal an overall improvement of 25% from the first assessment (Schmidt, 2021). Therefore, the improvement suggested an increased facility with the means of assessment and not with the content. The idea that facility with an application could be responsible for such a dramatic variation in assessment results calls into question the validity of online assessment unless explicit instruction and experience has been dedicated to mastering the platform before any meaningful assessment is undertaken.

Literature provided an understanding of the magnitude of the shift in education to remote, online, and blended learning to various degrees. The next step was to examine the numbers of students in these various conditions and how long the alterations continued. This yielded the following research questions: 1) What percentage of students had access to computers for learning in each period? 2) What percentage of students had access to the internet for learning in each period? and 3) How did experiences of demographic groupings based on gender and race/ethnicity vary?

Methods

This study relies on the Household Pulse Survey (USCB, 2023) which was administered to randomly-sampled American households from April 23, 2020 to the present, with the latest survey date as May 17, 2023. Participation in the survey was voluntary. The survey questions were designed for inclusion by eighteen federal agencies, including the Centers for Disease Control and Prevention, the Department of Health and Human Services, and the National Center for Education Statistics. The first weekly collection of data from April 23, 2020, to May 5, 2020, included responses from 65,371,463 households. For clarity, the United States Census Bureau states that as of 2021, there are 124,010,992 households in the United States, therefore indicating that the Household Pulse Survey was initially completed by 52.71% of the households in America.

In a report to address the methodology and nonresponse bias of the Household Pulse Report, measures detail the inclusion of housing units "where at least one email address or cell phone number was known" (2021). Further specifications included sampling across 50 states and the District of Columbia, as well as the top 15 metro areas in the United States to represent 66 reporting areas. The sample size for each of the 66 areas was equal to avoid effects based on population. A caveat was included to mention that "some small states had smaller sample sizes because the sampling frame did not contain enough addresses" (Peterson, et al., 2021, p. 2). The study recognizes limitations in that data based upon the frame condition relating to use of a cell phone and email address as a potential bias (Peterson, et al., 2021, p.10). This requirement limits survey respondents to those who were enabled to make initial contact through a connected device and would, therefore, not include those with no cell phone and no email contact, which could impact the results used pertaining to device and internet usage in the home. According to the Pew Research Center, 97% of Americans own a cell phone and 85% own smartphones (Pew, 2021). While 97% of Americans own cell phones, this does not assure that the United States Census Bureau has the contact information for all 97% of Americans or that this percentage was utilized in sampling. Ultra conservative individuals might avoid promoting government access to their devices. Elderly individuals might also be less likely to be represented in the study from a less technology-based lifestyle as a result of age and differing experiences.

In order to capture a progression of data across the developing landscape of pandemic learning, this study analyzed results for Weeks 2 (5/7/2020), 7 (6/11/2020), 12 (7/16/2020), 17 (10/14/2020), 22 (1/6/2021), and 27 (3/17/2021). Data presented focuses on the first and the last date for simplicity and contrast. For each week, Education Table 2 (COVID-19 Pandemic Impact on How Children Received Education, by Select Characteristics: United States) and Education Table 3 (Computer and Internet Availability in Households with Children in Public or Private School, by Select Characteristics: United States) were analyzed. From Table 2, data used included: Total and Impact of pandemic on children's education (five factors) across total values, sex (two factors), and Hispanic origin and Race (five factors). From Table 3, data used included: Total and Availability of computer for educational purposes (five factors) across total values, sex (two factors), Hispanic origin and Race (five factors), Computer provided by… (three factors), and Internet provided by… (three factors).

Proportions were utilized to determine the relative percentage across total households which were impacted by each condition, given that the number of students in each condition would vary.

Results

In Week 2, which was collected beginning May 7, the data provided on 67,138,021 respondents indicates 72.26% of respondents used online resources, compared to 21.27% using paper materials sent home (see Table 1, Household Pulse Report Pandemic Education Reception, Week 2). Respondents reported class cancellations in 41.29% of cases, 4.21% experienced some other type of change, and 0.26% experienced no change due to closure. Separating genders, 71.61% of boys and 72.82% of girls used online resources, compared to 20.74% and 21.72% using paper materials sent home, respectively. Additionally, 42.37% of boys and 39.50% of girls experienced class cancellations, 4.15% of boys and 4.25% of girls had classes changed in another way, 0.26% of boys and 0.21% of girls experienced no change to classes due to school closure. Separating race/ethnicity, 68.53% of Hispanic/Latino students, 74.58% of White students, 66.00% of Black students, 78.54% of Asian students, and 75.07% of students of two or more races used online resources, compared to 20.55% of Hispanic or Latino students, 22.67% of White students, 21.11% of Black students, 12.51% of Asian students, and 20.44% of students of two or more races who used paper materials sent home. Additionally, 44.08% of Hispanic or Latino students, 38.22% of White students, 49.43% of Black students, 34.27% of Asian students, and 45.07% of students of two or more races experienced class cancellations, 6.59% of Hispanic or Latino students, 2.72% of White students, 6.42% of Black students, 2.09% of Asian students, and 6.52% of students of two or more races had classes changed in some other way, and 0.23% of Hispanic/Latino students, 0.19% of White students, 0.23% of Black students, 1.13% of Asian students, and 0.18% of students of two or more races experienced no changes to classes due to school closure.

Impact of pandemic on children's education

Select characteristics	**Classes were moved to a distance learning format**					
N=67,138,021	**Using online resources**	**Using paper materials sent home**	**Where classes were cancelled**	**Where classes changed in another way**	**Where no change to classes because schools did not close**	**Did not report**
Total	72.26%	21.27%	41.29%	4.21%	0.26%	0.97%
Male	71.61%	20.74%	43.37%	4.15%	0.21%	1.07%
Female	72.82%	21.72%	39.50%	4.25%	0.31%	0.88%
Hispanic or Latino (any race)	68.53%	20.55%	44.80%	6.59%	0.23%	1.47%
White alone, not Hispanic	74.58%	22.67%	38.22%	2.72%	0.19%	0.50%
Black alone, not Hispanic	66.00%	21.11%	49.43%	6.42%	0.23%	0.83%

Asian alone, not Hispanic	78.54%	12.51%	34.27%	2.09%	1.13%	3.87%
Two or more races, not Hispanic	75.07%	20.44%	45.07%	6.52%	0.18%	0.45%

Table 1 - Household Pulse Report Pandemic Education Reception, Week 2

In Week 27, collected beginning March 17, the data provided on 48,720,070 respondents indicates 68.65% of respondents used online resources, compared to 16.19% using paper materials sent home (see Table 2, Household Pulse Report Pandemic Education Reception, Week 27). Respondents reported that in 25.40% of cases, classes experienced cancellations, 10.73% experienced some other type of change, and 10.58% experienced no change due to closure. Separating genders, 67.29% of boys and 69.78% of girls used online resources, compared to 15.27% and 16.95% using paper materials sent home, respectively. Additionally, 27.16% of boys and 23.94% of girls experienced class cancellations, 10.10% of boys and 11.25% of girls had classes changed in another way, 11.06% of boys and 10.18% of girls experienced no change to classes due to school closure. Separating race/ethnicity, 70.55% of Hispanic/Latino students, 67.57% of White students, 67.65% of Black students, 74.77% of Asian students, and 67.61% of students of two or more races used online resources, compared to 15.83% of Hispanic or Latino students, 16.38% of White students, 14.19% of Black students, 13.82% of Asian students, and 24.40% of students of two or more races used paper materials sent home. Additionally, 32.80% of Hispanic or Latino students, 22.09% of White students, 27.01% of Black students, 19.32% of Asian students, and 36.03% of students of two or more races experienced class cancellations, 5.85% of Hispanic or Latino students, 12.84% of White students, 11.99% of Black students, 7.21% of Asian students, and 9.13% of students of two or more races had classes changed in some other way, and 7.67% of Hispanic/Latino students, 12.99% of White students, 7.60% of Black students, 5.82% of Asian students, and 7.32% of students of two or more races experienced no changes to classes due to school closure.

Impact of pandemic on children's education

Select characteristics N=48,720,070	**Classes were moved to a distance learning format**					
	Using online resources	**Using paper materials sent home**	**Where classes were cancelled**	**Where classes changed in another way**	**Where no change to classes because schools did not close**	**Did not report**
Total	68.65%	16.19%	25.40%	10.73%	10.58%	2.54%
Male	67.29%	15.27%	27.16%	10.10%	11.06%	2.67%
Female	69.78%	16.95%	23.94%	11.25%	10.18%	2.43%
Hispanic or Latino (any race)	70.55%	15.83%	32.80%	5.85%	7.67%	4.21%

White alone, not Hispanic	67.57%	16.38%	22.09%	12.84%	12.99%	1.87%
Black alone, not Hispanic	67.65%	14.19%	27.01%	11.99%	7.60%	2.36%
Asian alone, not Hispanic	74.77%	13.82%	19.32%	7.21%	5.82%	3.60%
Two or more races, not Hispanic	67.61%	24.40%	36.03%	9.13%	7.32%	1.79%

Table 2 - Household Pulse Report Pandemic Education Reception, Week 27

In Week 2, the collected data from 61,361,903 In total, 58.44% of respondents reported that a device was “always” available for educational purposes, 21.72% “usually,” 11.37% “sometimes,” 4.21% “rarely,” and 2.29% “never” available. Separating genders, 62.08% of boys reported that a device was always available (see Table 3, Household Pulse Report Computer and Internet Availability, Week 2)., 21.22% “usually,” 10.29% “sometimes,” 2.84% “rarely,” and 1.51% “never” available; contrasted with girls, where 55.49% reported that a device was “always” available, 22.13% “usually,” 12.25% “sometimes,” 5.32% “rarely,” and 2.93% “never” available. Separating race/ethnicity, Hispanic/Latino students reported that 50.58% had a device “always” available, 20.96% “usually,” 15.67% “sometimes,” 5.18% “rarely,” and 3.91% “never” available. White students reported that 63.95% had a device “always” available, 20.82% “usually,” 9.72% “sometimes,” 2.76% “rarely,” and 1.55% “never” available. Black students reported that 50.05% had a device “always” available, 23.58% “usually,” 12.02% “sometimes,” 8.55% “rarely,” and 3.36% “never” available. Asian students reported that 64.70% had a device “always” available, 25.50% “usually” available, 6.42% “sometimes,” 1.84% “rarely,” and 0.32% “never” available. Students of two or more races reported that 49.31% had a device “always” available, 26.64% “usually,” 13.49% “sometimes,” 6.40% “rarely,” and 2.19% “never” available. Separating computer sources, computers provided by the school or district were always available in 61.80% of responses, 22.08% “usually,” 11.58% “sometimes,” and 4.53% “rarely” available. Computers provided by the household were “always” available in 63.19% of responses, 23.85% “usually,” 10.34% “sometimes,” and 2.62% “rarely” available. Computers provided by the other sources were “always” available in 32.34% of responses, 13.40% “usually,” 27.25% “sometimes,” and 27.00% “rarely” available. Separating internet sources, internet provided by the school was “always” available in 53.67% of responses, 19.38% “usually,” 22.09% “sometimes,” 4.38% “rarely,” and 0.39% “never” available. Internet provided by the household was “always” available in 61.20% of responses, 22.56% “usually,” 11.06% “sometimes,” 3.74% “rarely,” and 1.16% “never” available. Internet provided by other sources was “always” available in 29.91% of responses, 13.88% “usually,” 30.22% “sometimes,” 20.90% “rarely,” and 4.72% “never” available.

Select characteristics N=61,361,903	Availability of computer for educational purposes					
	Device always available for educational purposes	**Device usually available for educational purposes**	**Device sometimes available for educational purposes**	**Device rarely available for educational purposes**	**Device never available for educational purposes**	**Did not report**
Total	58.44%	21.72%	11.37%	4.21%	2.29%	1.97%
Male	62.08%	21.22%	10.29%	2.84%	1.51%	2.06%
Female	55.49%	22.13%	12.25%	5.32%	2.93%	1.89%
Hispanic or Latino (any race)	50.58%	20.96%	15.67%	5.18%	3.91%	3.71%
White alone, not Hispanic	63.95%	20.82%	9.72%	2.76%	1.55%	1.19%
Black alone, not Hispanic	50.05%	23.58%	12.02%	8.55%	3.36%	2.44%
Asian alone, not Hispanic	64.70%	25.50%	6.42%	1.84%	0.32%	1.22%
Two or more races, not Hispanic	49.31%	26.64%	13.49%	6.40%	2.19%	1.96%
Computer provided by school/district	61.80%	22.08%	11.58%	4.53%	N/A	N/A
Computer provided by household	63.19%	23.85%	10.34%	2.62%	N/A	N/A
Computer provided by other source	32.34%	13.40%	27.25%	27.00%	N/A	N/A
Internet provided by school/district	53.67%	19.38%	22.09%	4.38%	0.39%	0.10%
Internet provided by household	61.20%	22.56%	11.06%	3.74%	1.16%	0.28%
Internet provided by other source	29.91%	13.88%	30.22%	20.90%	4.72%	0.38%

Table 3 - Household Pulse Report Computer and Internet Availability, Week 2

In Week 27, 48,720,070 respondents indicated that 78.54% of households reported that a device was “always” available, 12.96% “usually,” 4.52% “sometimes,” 0.89% “rarely,” and 0.82% “never” available (see Table 4, Household Pulse Report Computer and Internet Availability, Week 27). Separating genders, 78.54% of boys reported that a device was “always” available, 13.64% “usually,” 3.90% “sometimes,” 0.68% “rarely,” and 0.85% “never” available; contrasted with girls, for whom 78.54% reported that a device was “always,” 12.39% “usually,” 5.04% “sometimes,” 1.06% “rarely,” and 0.79% “never” available. Separating race/ethnicity, Hispanic/Latino students reported that 69.23% “always” available, 19.52% “usually,” 5.33% “sometimes,” 0.63% “rarely,” and 0.71% “never” available. White students reported that 82.09% had a device “always” available, 10.66% “usually,” available, 3.85% “sometimes,” 1.08% “rarely,” and 0.88% “never” available. Black students reported that 78.76% had a device “always” available, 12.06% “usually,” 5.48% “sometimes,” 1.00% “rarely,” and 0.53% “never” available. Asian students reported that 80.90% had a device “always” available, 12.66% “usually,” 3.32% “sometimes,” 0.01% “rarely,” and 0.61% “never” available. Students of two or more races reported that 75.14% had a device “always” available, 12.32% “usually,” 8.69% “sometimes,” 0.54% “rarely,” and 1.62% “never” available. Separating computer sources, computers provided by the school/district were “always” available in 82.41% of responses, 13.18% “usually,” 3.85% “sometimes,” and 0.56% “rarely” available. Computers provided by the student household were “always” available in 83.19% of responses, 12.37% “usually,” 3.77% “sometimes,” and 0.68% “rarely” available. Computers provided by the other sources were “always” available in 49.56% of responses, 10.22% “usually,” 28.23% “sometimes,” and 12.00% “rarely” available. Separating internet sources, internet provided by the school or district was “always” available in 70.04% of responses, 14.41% “usually,” 11.76% “sometimes,” and 3.27% “rarely” available. Internet provided by the student household was “always” available in 81.33% of responses, 13.26% “usually,” 4.01% “sometimes,” 0.71% “rarely,” and 0.34% “never” available. Internet provided by other sources was “always” available in 41.93% of responses, 15.41% “usually,” 25.68% “sometimes,” 9.52% “rarely,” and 3.07% “never” available.

Select characteristics N=48,720,070	Availability of computer for educational purposes					
	Device always available for educational purposes	**Device usually available for educational purposes**	**Device sometimes available for educational purposes**	**Device rarely available for educational purposes**	**Device never available for educational purposes**	**Did not report**
Total	78.54%	12.96%	4.52%	0.89%	0.82%	2.28%
Male	78.54%	13.64%	3.90%	0.68%	0.85%	2.39%
Female	78.54%	12.39%	5.04%	1.06%	0.79%	2.18%
Hispanic or Latino (any race)	69.23%	19.52%	5.33%	0.63%	0.71%	4.57%
White alone, not Hispanic	82.09%	10.66%	3.85%	1.08%	0.88%	1.43%

Black alone, not Hispanic	78.76%	12.06%	5.48%	1.00%	0.53%	2.17%
Asian alone, not Hispanic	80.90%	12.66%	3.32%	0.01%	0.61%	2.50%
Two or more races, not Hispanic	75.14%	12.32%	8.69%	0.54%	1.62%	1.67%
Computer provided by school/district	82.41%	13.18%	3.85%	0.56%	N/A	N/A
Computer provided by household	83.19%	12.37%	3.77%	0.68%	N/A	N/A
Computer provided by other source	49.56%	10.22%	28.23%	12.00%	N/A	N/A
Internet provided by school/district	70.04%	14.41%	11.76%	3.27%	N/A	0.51%
Internet provided by household	81.33%	13.26%	4.01%	0.71%	0.34%	0.34%
Internet provided by other source	41.93%	15.41%	25.68%	9.52%	3.07%	4.39%

Table 4 - Household Pulse Report Computer and Internet Availability, Week 27

Discussion

In data collected less than two months after the national outbreak, children in 41% of households had classes canceled, providing no educational services (USCB Week 2, Table 2, 2020). Of other students, 93% were learning remotely and 4% had other learning opportunities (USCB Week 2, Table 2, 2020). Of students learning remotely, 72% engaged through online resources and 21% used paper materials from home without virtual contact (USCB Week 2, Table 2, 2020). White and Asian students and students of two or more races (not Hispanic) were more likely to be using virtual resources than Hispanic/Latino or Black students, by 6-13% (USCB Week 2, Table 2, 2020). Among students with computers for educational purposes, only 58% always had access to the device (USCB Week 2, Table 3, 2020). Among boys, 62% had access to the device all the time, whereas only 55% of girls could say the same (USCB Week 2, Table 3, 2020). Among Hispanic/Latino students, 51% had devices available all of the time, similar to Black students at 50% and students of two or more races at 49%, whereas White (64%) and Asian (65%) student enjoyed significantly more access (USCB Week 2, Table 3, 2020).

Just under one year later, statistics among 48.7 million households were quite different and some disparities were less pronounced. While 25% of households reported school closures during the year, 11% of households indicated that schools were not closed (USCB Week 27, Table 2, 2020). Of those in districts conducting school remotely, 69% were using online resources, 16% used paper materials at home, 11% indicated other variations, and 3% did not report on that item (USCB Week 27, Table 2, 2020). Hispanic/Latino students were 11% more likely than White students, 6% more likely than Black students, 14% more likely than Asian students, and 3% less likely than students of two or more races to be in districts which canceled classes (USCB Week 27, Table 2, 2020). Boys and girls were equally likely to have access to a device "always" (79%) and "rarely" (1%) or "never" (1%) (USCB Week 27, Table 3, 2020). However, White students were 13% more likely than Hispanic/Latino students to "always" have a device available for educational purposes, 3% more likely than Black students, 1% more likely than Asian students, and 7% more likely than students of two or more races (USCB Week 27, Table 3, 2020).

Regarding Research Question 1 (What percentage of students had access to computers for learning in each period?), 80.16% of households reported computer access for educational purposes at "always" or "usually" in Week 2, whereas 91.62% had access in Week 27, which effected an 11.46% increased access in less than one year.

Regarding Research Question 2 (What percentage of students had access to internet for learning in each period?), 2.21% of households enjoyed district-provided internet which was always or usually available in Week 2 compared to 4.20% in Week 27, which increased the coverage 90.04% in less than one year. Most households (90.88%) provided their own internet in Week 2 and continued to do so with a slight increase (91.58%) of less than 1%.

Research Question 3 (How did experiences of demographic groupings based on gender and race/ethnicity vary?) demonstrated disparities in experience between boys and girls, which equalized within one year. Further, White and Asian students were more likely to engage classes virtually and were less likely to have classes canceled than Hispanic/Latino, Black, or mixed-race students in Week 2, but Hispanic/Latino and Asian students were more likely to be learning online than White, Black, and mixed-race students in Week 27. Hispanic/Latino (48.48%) and mixed-race students (63%) were more likely to experience canceled classes in Week 27 than White counterparts. Black students were 18.77% more likely to have returned to classrooms than Hispanic/Latino learners and 32.95% more likely than mixed-race children. Therefore, gender effects disappeared over time, but conditions for student groups based on race/ethnicity became more pronounced with time for Hispanic/Latino students and less true of Black students.

Conclusion

Pandemic learning in the United States was an extreme experience without planning or precedence. School closures rolled through the country in a matter of a few weeks and persisted in many cases for more than a year. Parents gained a front row seat for curriculum delivery and began to question decisions (Lieberman, 2020). Administrators were pressed to leverage district resources and even debt to acquire computers and related hardware to enable virtual and remote learning for a duration which had no end in sight (Herold, 2021). Teachers were frustrated by minimal training in new technology resources, lack of support for online applications, and the challenges of meeting the needs of virtual and in-person students with differing needs (Bouchrika, 2022). Further, 42% of teachers indicated consideration of leaving the profession because of situations surrounding COVID-19 (Zamarro, et al., 2021). Virtual teachers in particular were most likely to consider abandoning teaching because of necessary changes in teaching modes which increased workload, although in-person teachers were more likely to leave for other reasons, like a lack of substitute teacher coverage, daily stress, and additional tasks without adequate compensation (Zamarro, et al., 2021). Across all stakeholders, adult participants in education during the pandemic encountered significant challenges which threatened their opportunity for success. Like a pendulum, they were pushed to the extreme during 2020 and 2021. However, it is the statistics of impacts on students which tell a more important story.

Students

While the survey comments and interview quotes share the perspective of adults, the Household Pulse Report provides quantitative details about student experiences. Initially, reports of canceled classes demonstrated a dramatic disparity across conditions of race/ethnicity with Asian students least likely to have classes canceled (34%) and Black students most likely to be in that condition (49%). White students were most likely to be using paper materials from home (23%) with Asian students to be least likely to experience the same condition (13%). Girls were 7% less likely to have a device always available for educational purposes than boys. Asian (65%) and White (64%) students were more likely to have a device always available to them than Hispanic/Latino (51%), Black (50%), or mixed race (49%) students.

Less than one year later, class cancellations were reported in 19% of Asian students (lowest) and 36% of students of two or more races (highest). Students using online resources ranged from 75% (Asian) to 68% (White, Black, and mixed race). Black and Asian students had the lowest rate of using paper materials (14%) with Hispanic/Latino and White students slightly higher at 16% and mixed race students significantly higher at 24%. By Week 27, rates of girls and boys with device availability at “always” were the same at 79%. Hispanic/Latino students, however, were more than 12% less likely than to identify device availability as “always” than White or Asian students.

Based on the Household Pulse Report, class cancellations were reduced by half and, at first, disenfranchising Black students the most, but mixed race students by the end of the 2020-2021 school year. At the same time, mixed race students were twice as likely to experience remote (not virtual) learning than other students. While girls were at a disadvantage about computer availability initially, that statistic equalized by the end of the school year. Hispanic/Latino students encountered limited device availability along with Black and mixed-race students early, but did not rise at the same rate as other groups, lagging 13% one year later. These results indicate an initial gender bias in device availability, which was mediated. Also, Black, Hispanic/Latino, and mixed-race students were disadvantaged at the beginning of the pandemic, but the matter was partially resolved over time, except for Hispanic/Latino students. Fortunately, the availability of devices provided by the district increased from 62% to 82% throughout the year, though the availability of school-provided Internet only increased from 54% to 70%.

In total, by the end of the 2020-2021 school year, 92% of students were reported as having a device “always” or “usually”available to them for educational purposes, up from 80% at the beginning of the pandemic. At the same time, 69% of households (over 33 million) engaged in virtual learning. Among the untold stories of the crisis is the level of unpreparedness to move to the virtual learning platforms. While the vast majority of students engaged in online learning, many were widely reported as failing to engage in school work or connecting with the teacher regularly or at all. One culprit in the matter is the inability of teachers to fully prepare students to use the digital applications that would be necessary for effective online engagement. Among these applications were online versions of assessments, including standardized state tests and the College Board Advanced Placement exams. Without proper preparedness, Digital Application Literacy theory would indicate that students are not actually being assessed on their knowledge of the content, but their facility with the application for the assessment (Schmidt, 2021). These alternate versions of classroom assessments were used to widely report the inadequacies of pandemic learning and the learning lag recorded by them. While other assessments like the STAR by Renaissance learning also reported learning lags, such assessments had previously been given in the same digital format (Renaissance, 2021). Even this report indicated a variation between students testing at home and those testing at school (Renaissance, 2021).

In the wake of the most recent shockwave in education – ChatGPT – access to online resources has become even more limited on student devices for fear of breaches of digital citizenship and use of the artificial intelligence tools to assist with or to complete classroom prompts. The same connectivity which permitted a successful pivot to remote learning for tens of millions of students is under scrutiny and is quickly being curtailed. As Digital Application Literacy theory would indicate, the steps of preparing students to properly utilize such online resources are essential for success in this arena. When unprepared and under-equipped, students are far more likely to make mistakes in the ethics and appropriate usage of applications like ChatGPT. Without effective protocols like the Digital Application Literacy model, classroom experiences can devolve like a pendulum swinging from one extreme to the opposite. The only hope is that it will eventually return. However, physics would indicate that the next swing will never be quite as expansive as the prior one without additional energy being expended. Is there enough motivation left to push the boundaries of online educational opportunities?

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Contact email: schmi6l@cmich.edu

Lecturers' Experiences in Teaching STEM Courses Online During COVID-19: Case of a Zimbabwean University

Sibusisiwe Dube, National University of Science and Technology, Zimbabwe
Belinda Mutunhu, University of South Africa, South Africa
Sinokubekezela P. Dube, National University of Science and Technology, Zimbabwe

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Abstract
This paper explains the university lecturers' experiences of teaching Science, Technology, Engineering, and Mathematics (STEM) courses during the coronavirus (COVID-19) pandemic. The 210 research participants were drawn from a single university in Zimbabwe, a developing country in southern Africa. While there exists literature on the online teaching approaches during COVID-19, this paper argues that there is limited literature on lecturers' experiences in teaching STEM courses online because focuses literature discusses the experiences of lecturers in developing countries with different contextual conditions. Other existing literature focuses on learners, whose online learning experiences may be different from those of the lecturers. Furthermore, much existing literature focuses on a similar subject uses data collected using qualitative methods. Lastly, focuses literature did not apply any theory for guidance. It was therefore, imperative to fill this gap in the literature by conducting this quantitative research. That was guided by Giddens' Structuration theory, which focussed on the lecturers of a university in a developing country context. The findings of this research support Structuration theory's observation that human activities are bound by space and time. Poor economic conditions and the restrictive period of COVID-19 constrained online teaching activities. Furthermore, the traditional teaching methods, misallocation of online teaching resources, and reliance on the prevailing teaching culture corresponding to structures of signification, domination, and legitimation respectively, also constrained teaching of STEM courses online. The paper concludes with a causal loop diagram of factors influencing the lecturers' teaching of STEM courses online.

Keywords: STEM, Teaching, Online, Lecturers, COVID-19

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1. Introduction

This study explains the experiences of the lecturers in teaching STEM courses during the Corona Virus (COVID-19) pandemic. The outbreak of COVID-19 pandemic, which was first experienced at the end of the year 2019, and stretched for at least three years, disrupted much of human social and business activities including the physical teaching and learning process. Physical contact was restricted, which meant that neither lecturers nor students could attend physical classes or participate in in-person interactions as per the norm of traditional teaching and learning (Orlov et al. 2021; Lapitan et al. 2021). For the education process to continue undisrupted, new ways of teaching and learning had to be devised, which included the introduction of virtual classes conducted through online tools and technologies (Bruggeman et al. 2022). Lecturers from different university institutions must have had different experiences while teaching STEM courses online. For a better understanding of these experiences, it was imperative to conduct this study.

2. Purpose of the study

Several studies have been conducted regarding the benefits and problems of teaching and learning online during COVID-19 pandemic. For example, Özüdoğru (2021) investigated the problems faced by the Turkish state university teachers who migrated to online distance education during COVID-19. Using a different approach, Orlov et al. (2021) examined the effects of introducing online learning approaches on students during COVID-19 pandemic. While there are studies that were conducted on the teaching of STEM courses online (Lapitan et al. 2021), there are limited similar studies conducted in the context of developing countries, Zimbabwe in particular. Much of these studies either focussed on developed countries, learners or teachers of other courses than STEM courses. Questions on the experiences of lecturers in the developing countries' online teaching of STEM courses remain unanswered. This research was therefore aimed at providing answers to the following research questions, which sought to explain the experiences of university lecturers in their endeavor to apply online teaching approaches to teach STEM courses.

1. What benefits were enjoyed by lecturers while teaching STEM courses online during COVID-19 pandemic?
2. What were the challenges faced by lecturers while teaching STEM courses online during COVID-19 pandemic?
3. What factors influenced the smooth transition from physical to online classes during constraining situations like COVID-19 pandemic?

3. Related Work

Literature exists that discusses the transition from face-to-face to online teaching and learning during COVID-19 pandemic. There are many publications on the topic of online teaching and learning during COVID-19. Some of the publications are listed in Table 1.

Publication	Purpose	Collected Data	Findings
Orlov et al. (2021)	Examined the effects of COVID-19 pandemic on student learning of economic courses	Quantitative	Students' performance in the pandemic semester was very poor
Lapitan et al. (2021)	Surveyed the impact of online instruction on undergraduate students' Chemistry lecture courses	Quantitative	The authors identified challenges like stability of internet connection and instructor's familiarity with readily available internet-based teaching tools, such as video conferencing software
Bruggeman et al. (2022)	Investigated the online education experiences of Belgium university teachers during COVID-19 pandemic	Qualitative	The study shows that teachers were stressed due no-connection with students and colleagues, lack of control of students' learning processes, poor online interaction, changing teacher roles, (5) tension due to time pressure and support issues.

Table 1: List of a sample of reviewed literature

Table 1 has a sample of reviewed literature relating to online teaching during COVID-19. Adding to the literature is Lukas and Yunus (2021) who examined the limitations of eLearning in teaching English language at a Malaysian primary schools. The findings revealed that limited readiness, access to mobile phones and poor connectivity, classroom management, and assessment hindered use of eLearning in those Malaysian schools. The findings from a study by Aladsani (2022) indicated that local culture prevented the success of online learning at six Saudi Arabian universities that were examined.

An investigation on the impact of online teaching at South Korean universities revealed that the adoption of online methods was influenced by the shortage of resources and other academic dilemmas (Lee et al., 2022). Kim et al. (2021) examined physical education teachers'perceptions about teaching online during COVID 19. Their findings show that all the participants agreed that online classes deprived them of in-person relationships and interactions with their students. A similar study was conducted by Cruickshank, Pill, and Mainsbridge (2021), who also investigated the Australian teachers'experiences of teaching physical education online and they concluded that the move to online provision resulted in diminished educational purpose. ÖZÜDOĞRU (2021) investigated the problems faced by pre-service teachers of a state university in Turkey during COVID-19. They found that lack of time for course implementation; failure to communicate with friends, internet connectivity, lack of technical support, etc., were the major problems of ICT-supported distance education.

Almahasees, Mohsen, and Amin (2021) examined lecturers and students'perceptions about online learning and they found that deaf and hard of hearing students had challenges relating to a lack of interaction and motivation, technical, and Internet issues, data privacy, and security issues. Mutunhu et al. (2022) explains Zimbabwean university students' experiences of learning online during COVID-19 pandemic. Their findings revealed that students were stressed by high costs of mobile data, boredom, lack of resources, and limited training. In an earlier study, Dube (2020) identies the structural mechanisms for adopting the ICT-supported education in Zimbabwe's higher education institutions. The findings from this study demonstrate that there were domination, signification, and legitimation structures influenced the success of ICT-supported education. in an earlier study, Dube and Scott (2018) reported limited resources, lack of management and technical support, electricity power outages, and resistance to change as the organisational constraints of online education.

Much of the reviewed literature was based on qualitative data collected through interviews and focus group discussions. None of the reviewed literature was guided by a theoretical framework except one study by Lee et al (2022), whose study was informed by the lens of an activity theory. In addition, most of the reviewed articles were based on qualitative data, which lacks the insight and richness provided by the qualitative data.

4. Structuration theory

Giddens (1984) proposed Structuration theory, which is a social theory that depicts the duality or interplay of structure and agency. While structure refers to rules and resources, agency refers to human actions. Both structure and agency interact such that structure can either enable or constrain human activities. The duality, is in the interplay between structure or structural properties and human action as bound by space and time (Giddens 1984). According to Structuration theory, structural properties are a result of social practices, which in-turn are either enabled or sanctioned by the same social practices that formed them. In other words, structure is both the medium and the outcome of the reproduction of practices. As such, structure is created by agency, and simultaneously, agency is facilitated or sanctioned by the same structures it creates. Structure is divided into; signification, domination, and legitimation structures that influence the human activities of communication, power and sanction through the modalities of interpretive scheme, facility and norm, as shown in a model in Figure 1.

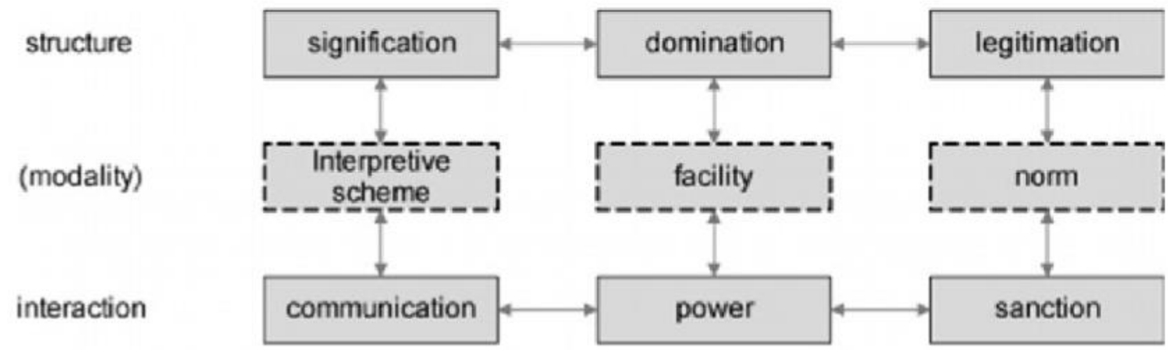

Figure 1: Structuration Theory M*odel (adopted from Giddens [1984, p. 29]*)

Figure 1 shows the three structures of signification, domination, and legitimation as well as the three human activities (interaction) that include communication, power, and sanction, which all interact with the corresponding structures through the modalities of interpretive scheme, facility, and norm, respectively. According to Structuration theory social practices (human activities) are bound by both space and time (Giddens 1984). This implies that both the conditions of the university case in a developing country context, (**space)** and the particular point in (**time)** of the prevalence of COVID-19 pandemic had an important role to play in the advancement or sanctioning of the adoption and usage of online methods in the teaching of STEM courses.

Accordingly, according to **structures of signification**, lecturers of STEM courses can determine the significance of teaching STEM courses online by verbally or non-verbally communicating knowledge drawn from the interpretive scheme (stored in memory or observed from the environment) about available teaching methods, which could be of significance. This means that if online methods of teaching STEM courses are considered significant if they add value, such methods tend to be adopted, otherwise, if they are not of any significance, they will be rejected. Similarly**, domination structures** enable or hinder the adoption of online methods of teaching STEM courses if the management is considered to appropriately use their power to allocate resources that can facilitate the teaching of STEM courses online. Consequently, the **structures of legitimation** mean that the lectures in STEM courses tend to legitimize only those teaching methods that are not sanctioned by the prevailing cultural norms. In this regard, this study collected data to explain the lecturers' experiences of teaching STEM courses online during COVID-19 era.

5. Methods of data collection

Quantitative data were collected from a survey of professors, lecturers, and teaching assistants, which was conducted through a Google Form sent to the research participants via email. This was a purposive sample of research participants involved in the teaching of STEM courses at a single university in Zimbabwe, a developing country in Southern Africa. In a population of four hundred lecturers, 210 responded and completed the emailed Google Form. This was a favourable response rate since it exceeded the threshold sample size of 196 in accordance with Yamane's formula: $n = N/(1+N(e)^2$ where the confidence level is 95% and the margin of error is 5%. The questionnaire was divided into 5 sections, which included demographic data, teaching devices, tools, techniques, benefits of online teaching, challenges of online teaching, and recommendations for future improvements. An analysis of the collected data revealed results discussed in the section on findings and discussion.

6. Findings and Discussions

The data analysis revealed that there was an unequal distribution of participants by gender. Figure 2 shows that there was 50% male representation, 47.1% female representation, and 0.9% non-disclosed gender representation. The results confirm the status quo of the institution, which is male dominated, a situation that could be attributed to the idea that females usually shy away from STEM subjects.

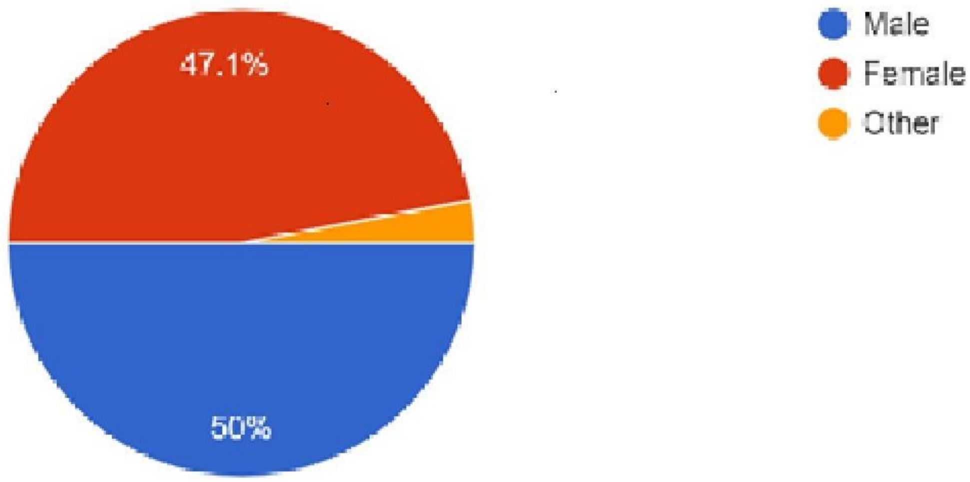

Figure 2: Research participants' distribution by gender

The research participants were also required to choose from the provided set of devices that they used in the teaching of the STEM courses during COVID-19 pandemic. The responses are depicted in Figure 3.

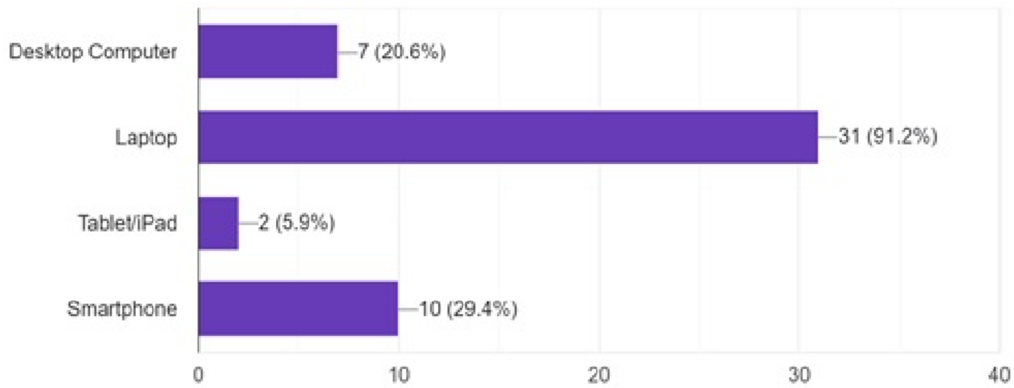

Figure 3: ICT devices used for teaching during COVID-19 pandemic

Depicted in Figure 3 are the devices used by lecturers in teaching during COVID-19 pandemic. It is evident that most lecturers used their personal laptops to both prepare and deliver the lectures. Smart phones had a minimum usage rate, which makes sense since such mobile devices are usually used for communication and gaming rather than as tools for teaching. Surprisingly, desktop computers and tablet PCs / iPads were not popular among lecturers. Figure 4 shows the distribution of online teaching platforms that were accessible to the lecturers during COVID-19.

The platforms included both proprietary and purchased platforms and free online platforms. Google Classroom had the highest ranking, followed by Google Meet and WhatsApp. The popularity of these platforms could be attributed to both their ease of access and their useful features, such as document sharing, video conferencing, real-time participation, meeting, recording etc. Furthermore, unlike ZOOM, which requires installation, Google Meet and Google Classroom can be used online without installing them on the user's device, which is an advantage as it saves the device storage space. Learning management systems (LMS) and Facebook were rarely used, probably due to the fact that while LMS are rigid, Facebook was not designed for teaching and learning. Telegram and Skype were not used by the research participants for teaching purposes, which could be an issue of a lack of familiarity with those platforms as tools for teaching.

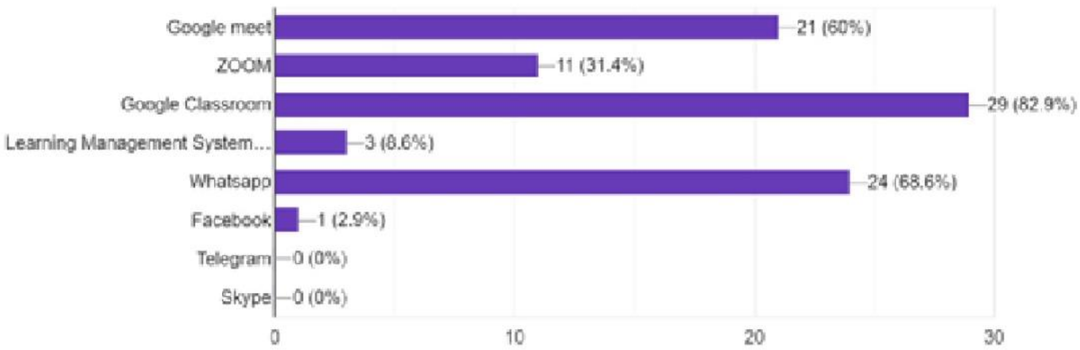

Figure 4: Common online teaching platforms used during COVID-19 pandemic

This study sought to answer three research questions relating to the benefits of teaching STEM courses online, challenges faced while teaching STEM courses online, and the strategies for improving the transformation from physical to virtual classes during life-threatening pandemics similar to COVID-19. The results of this study revealed that the research participants enjoyed many benefits from teaching STEM courses online. Some of the identified benefits are shown in Figure 5.

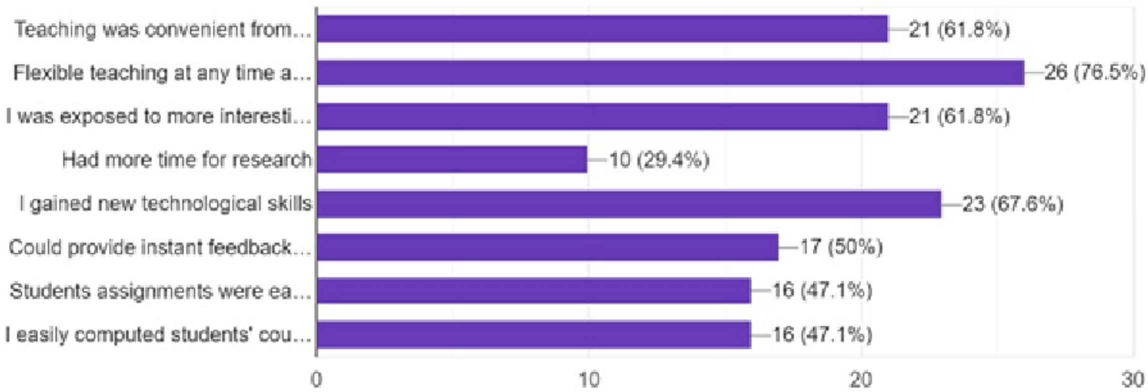

Figure 5: Sample benefits for teaching STEM courses online during COVID-19

The identified benefits of teaching STEM courses online included the following:

- Easy access to course content
- Increased collaboration
- Enhanced knowledge and skills on the use of electronic devices and online tools
- Reduced transport costs to and from campus
- Teaching flexibility
- In the difficult era students were taught
- Instant feedback
- Course content sharing

The findings of this research also revealed that there were challenges associated with teaching STEM courses online. A sample of these challenges is depicted on Figure 6. And they include：

- Lack of access to electronic devices
- Lack of management support
- Limited funding for data
- Low student turn-out for virtual classes
- Lack of personal touch (students and lecturer)
- Lack of access to paid tools or apps 2)
- Timeous and tedious preparation of course content
- Lack of training on how to teach with online tools and devices
- Lack of online plagiarism checking tools: insufficient data bundles
- Internet connectivity challenges
- Difficulty of assessing and monitoring students' participation during the lecture

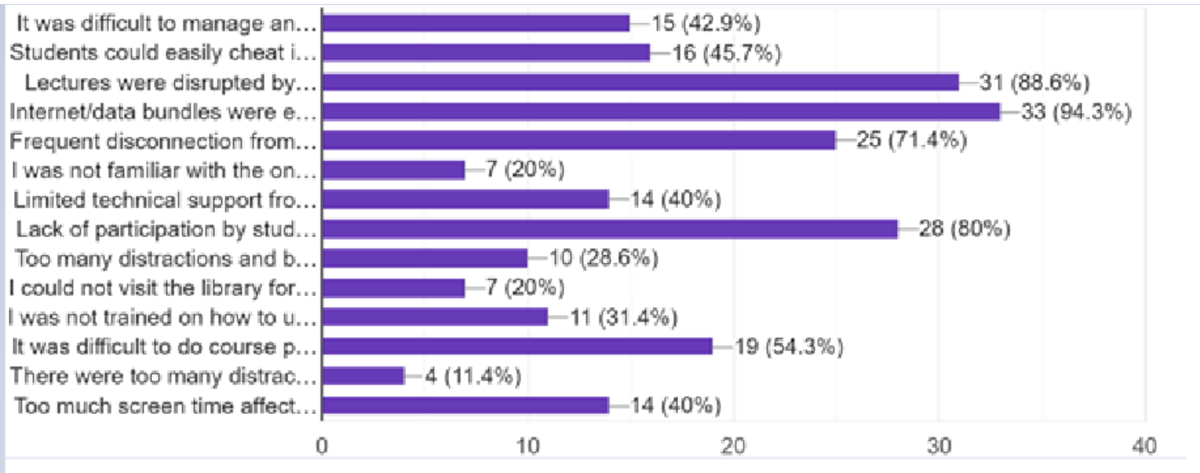

Figure 6: Challenges of teaching STEM courses online during COVID-19

The research participants concluded by recommending some practical strategies for improving the teaching of STEM courses online, particularly during restraining spaces and times as it was experienced by lecturers during the life-threatening COVID-19 pandemic. A summary of the challenges of teaching STEM courses online is depicted in Figure7.

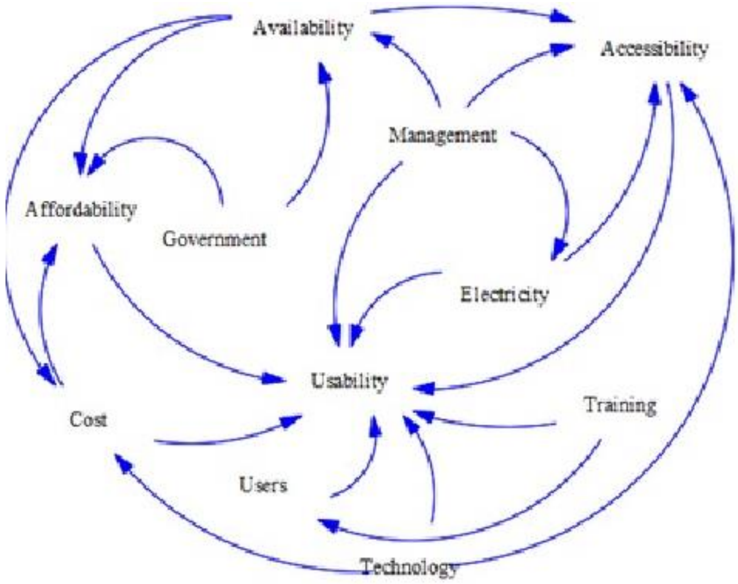

Figure 7: Causal Loop Diagram of factors influencing teaching of STEM courses online

Figure 7 presents the factors that influence the adoption of ICT technologies in teaching STEM courses online. These factors include the availability, accessibility, affordability and the usability of resources for teaching STEM courses online. For instance, if the resources are neither available, accessible, affordable nor usable, they cannot be adopted in the teaching of STEM courses. Both the government of a country in question and the management of the specific universities have a major role in availing the tools and technologies for teaching STEM courses online. Both parties could ensure that the concerned tools and technologies are affordable by either subsidising the costs or relaxing importation duty fees for such resources. If the relevant ICT resources are affordable, they will automatically become easily accessible to both the lecturers and students. If the lecturers and students are both equipped with the necessary knowledge for using the accessible ICT resources, they will enjoy maximum utilisation of the accessible ICT resources, and actively participate in the online teaching and learning of STEM courses. The lecturers proceeded to recommend strategies for improving the teaching of STEM courses online, which are shown in Figure 8.

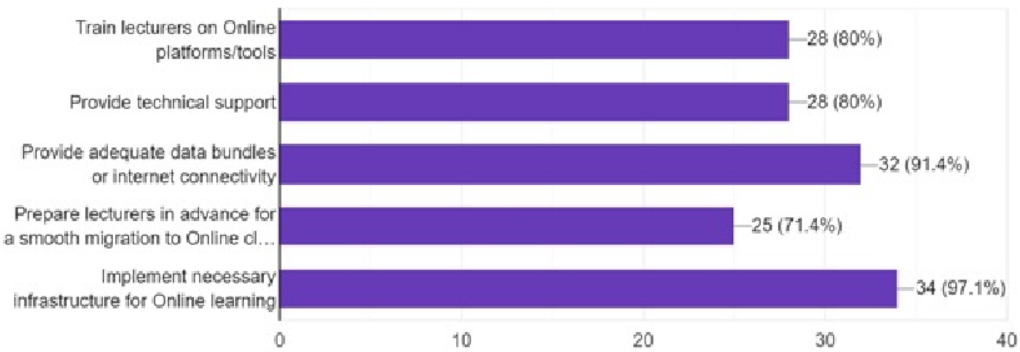

Figure 8: A list of recommendations for improving teaching STEM courses online

The strategies recommended by the research participants can be summed up as:

- Increase student support online facility
- More training would be beneficial especially on better security measures when doing online tests etc.

- Hands on training preferable to a pdf
- Ensure that students have access to ICT
- Familiarization with online tools is important

7. Discussion

This study acknowledges that much of these findings exist in literature, it is worthwhile to note that much of such existing studies were conducted qualitatively with a small sample size as it was shown in Table 1 and much of such studies were not focussed on STEM courses, were not informed by concepts and relationships of any theory. It was therefore imperative to understand the lecturers' experiences from a quantitative data's view point for generalisability, and using the lens of Giddens' Structuration theory to gain an insight into the structures that either enable or prevent the successful teaching of the STEM courses online. According to Giddens (1984), space and time can bind any human activity.

The findings of this research confirm the truthfulness of this claim because it was shown that during the time of COVID-19 pandemic, in the context of a university in a developing country, there existed structures of signification, domination, and legitimation, which either enabled or sanctioned the teaching of STEM courses online. For example, the poor economic conditions in Zimbabwe made it very difficult for lecturers to teach online since both the lecturers and students lacked the important resources such as the internet, computing devices, electricity power etc. for online teaching and learning. This shows that there were domination structures that prevented the relevant authorities from exercising their power to allocate tools and technologies that promote the teaching of STEM courses online. Furthermore, the prevailing teaching culture has continued to promote traditional physical classes while sanctioning the use of emerging educational technologies such as Google Meet, Zoom, Telegram, Skype, etc. More-so, the findings of this research revealed that the transition to some online classes was instantaneous and not prepared for. However, Bruggeman et al (2022) emphasize the importance of preparation prior to engaging in online teaching and learning.

The findings of the study have shown the need for affordable and usable resources that must be readily available to the intended users, who in this case are lecturers and students. For example, resources, such as computing devices must be available on the market for them to be adopted for online teaching. Furthermore, the resources, such as computing devices and internet or mobile data, must be affordable for them to be accessed for online teaching. Lastly, online tools and technologies like zoom, Google Meet, Skype, LMS, and others must be user-friendly for them to be utilized as the medium for online teaching and learning. The feasibility of teaching STEM courses online depends on the collaboration and cooperation of such major stakeholders as the government, university management, parents, and users (lecturers/students).

8. Conclusion

This study sought to investigate the lecturers' experiences of teaching STEM courses online. The research participants revealed that they had both positive and negative experiences with teaching STEM courses online. The findings also acknowledge Structuration theory's realization that space and time influence the success of an activity such as teaching STEM courses online. For example, the research cohort was drawn from a poor, developing country that lacks basic resources such as electricity and computing devices for teaching STEM courses online. The process was further influenced by the timing because, during the COVID pandemic era, it was impossible to import computing devices, and physically accessing resources from education institutions or libraries was also restricted. The study findings also confirmed Structuration theory’s claim that human agency/action, in this case teaching STEM courses online, is both enabled and constrained by structures of signification, domination, and legitimation.

The results of the study further showed that according to structuration theory, these structures are both a means and an end of human agency/action. For instance, the research cohort revealed that the success of their teaching STEM courses online was defined by the existing structures of signification (what is important), domination, (power to allocate resources), and legitimation (sanctioning/enabling norms) all of which were created by the actions of major stakeholders involved in the teaching practice, such as the government, university management, parents, students, and the lecturers themselves. It was then concluded that the collaboration and cooperation of these stakeholders can either promote or sanction the smooth transition from physical to virtual STEM classes. The causal loop diagram depicted in Figure 7 provides an insight that the collaborative efforts of the major stakeholders could result in the development of a framework that could guide the transition from physical to virtual classes including the STEM courses.

9. Limitations and recommendations for future work

The study was limited to a single university case, for improved generalisability of the findings, we recommend that a multiple case study be conducted that may involve several universities sampled from several countries. Furthermore, since the study was limited to lecturers only, it would be interesting to perform a comparative study involving both lecturers and students to result in more informed decisions regarding the teaching and learning of STEM courses via online tools and technologies. The study was also limited to quantitative methods, a mixed approach, which includes the collection of qualitative data, could result in better insight based on the lived-experiences and narrative stories of the lecturers. Finally, the study was conducted on a cross-sectional time frame, the collection of data over an elongated period of time would cater for the changes that might happen over time and ensure that the decisions made incorporate the dynamicity of the contextual conditions of the research case, space, and time.

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Contact emails: sibusisiwenkonkoni@gmail.com
belindamutunhu@gmail.com
dsinokubekezelap@gmail.com

Critical Thinking (Ct) Skills Gap in Data-Driven Decision (Ddd) Making: An Exploration in the Banking, Financial Services, and Insurance (Bfsi) Industry

Anu Jossan, Al Rayyan International University College - University of Derby, Qatar

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Abstract

In the era of AI-supported business operations, the underutilisation of critical thinking by employees poses a significant challenge. By relying on AI systems for decision-making, organisations risk overlooking the invaluable insights and creative problem-solving abilities that critical thinking brings. Harnessing the power of critical thinking in conjunction with AI technologies holds the key to unlocking untapped potential and achieving optimal outcomes in today's complex business landscape. Banking, financial services and insurance companies are leading employers for business graduates. With heavy usage of data in the BFSI companies' departments, graduate employees make data-driven decisions that impact businesses. Hence, decision quality is crucial for graduate employability and business success. Critical thinking for decision-making is proven to be an effective way for quality decisions. Nevertheless, critical thinking usage in data-driven decision-making in banking, financial services and insurance companies remains unexplored. A skill gap analysis shall throw light on the employer expectation vs satisfaction on graduate data-driven decision quality using critical thinking. This research explores the perception/expectation and satisfaction of the Banking, financial services and insurance employers on graduate employees' data-driven decision outcomes, and the critical thinking skill usage by data-driven decision makers is analysed to find out if there is an evident gap in the same. This article highlights the significance of critical thinking and data-driven decision-making in AI-driven businesses. The research indicates that while critical thinking is crucial, it is currently lacking among employees. The findings emphasise the importance of incorporating critical thinking in business studies.

Keywords: Critical Thinking (CT), Decision-Making (DM), Data-Driven Decision (DDD), Data-Driven Decision-Making (DDDM), Banking, Financial Services, and Insurance (BFSI) Industries, Graduate Employees, Business Studies, Skill Gap

INTRODUCTION

Higher education institutions play a crucial role in understanding industry expectations and equipping graduates with the necessary skills for improved performance and employability (Gibbs, Steel, & Kuiper, 2017; Thi Quynh Lan, 2018). Skill gaps, which impede industry growth due to inadequate human skills, are a concern for organizations (Peter Cappelli, 2012; Beach, 2013). Reports suggest that universities are not adequately preparing graduates with the skills demanded by employers (Laud & Johnson, 2013; Chenoy, 2017; Gowsalya & Kumar, 2017; Thi Quynh Lan, 2018). To address this, it is essential to assess skill gaps based on industry expectations, employee performance, and workforce employability (Nair, Patil, & Mertova, 2009; Ibrahim Gamer Eldeen et al., 2018; Manevska et al., 2019; Sharvari, 2019). Graduate employability is now heavily reliant on skills rather than certifications or qualifications (Mcgunagle & Zizka, 2020). Critical thinking (CT) is a widely applicable transferable skill that plays a significant role in decision-making across disciplines and industries (Jackson, 2012; Kerle, 2020). CT involves objectively analyzing and assessing opportunities or issues to make informed judgments (Ennis, 1985; Facione, 2011). Many universities teach CT as a transferrable skill due to its importance in the business industry (Brahler, Quitadamo, & Johnson, 2002; Kahlke & White, 2013; Helyer, 2015; Howlett, Ferreira, & Blomfield, 2016). CT helps business professionals enhance decision quality, avoid assumptions and fallacies, and differentiate human decision-making from machine automation (Kahlke & White, 2013; Whittington, Scholes, & Angwin, 2017). Despite the increasing demand for CT skills, studies indicate that graduates still lack the ability to think critically and make decisions effectively (Tymon & Batistic, 2016; Bahmani, 2016). Data-driven decision-making (DDDM), driven by the growth of data analytics and big data, is becoming essential in the business industry (Bohler, Krishnamoorthy, & Larson, 2017). CT skills are crucial for ensuring decision quality in DDDM (Nielsen & Nielsen, 2020). Given the significance of the banking, insurance, and financial services industry (BFSI), which heavily relies on data-driven decisions, it is crucial to address the skill gap in CT skills for decision-making within this industry (Jackson & Chapman, 2012; Awang & Makhbu, 2015; Cassidy, 2017; Abbasi, Ali, & Bibi, 2018). To bridge this gap and improve graduate employability, it is necessary to understand the expectations of BFSI employers regarding CT skills, the current state of CT skills in data-driven decisions, and potential improvements to the business studies curriculum (Powell, 2018). Conducting skill gap research can help identify weaknesses in the curriculum and enable the development of these essential skills for business graduates (Chenoy, 2017; Gowsalya & Kumar, 2017; Unni, 2017). This research aims to provide a descriptive analysis, mapping the expected CT skill level against its fulfillment in employee data-driven decision-making, to identify gaps and propose measures for improvement (Mbambo, 2009). The research reasons out to be offered as descriptive research(Mbambo, 2009), where objective measurement is more relevant for this research as the CT skill expectation (required/ perceived) mapped against its fulfilment in employee data-driven decision-making.

The research explores the skill gap through a thorough analysis of the following.

- The expectations of the BFSI industry about its graduate employee data-driven decision-making in terms of CT skills usage and decision outcomes
- The usage of CT skills is evident in data-driven decisions and outcomes made by the graduate employees in the BFSI industry
- The evidence of practice-theory CT skill gap in graduate employees' data-driven decision-making alongside the expectations of the BFSI industry

THEORETICAL BACKGROUND

The demand for transferrable soft skills in the business industry is increasing, with at least 57% of senior professionals valuing soft skills more than hard skills (Petrone, 2019). Universities need to focus on providing practical education that emphasizes these skills to prepare graduates for employability and success in the workplace. The deficiency of employability skills among graduates has raised concerns in the business industry (Birrell & Edwards, 2009; Clarke, 2018; Cotronei-Baird, 2013; Eldeen et al., 2018). Problem-solving, logical analysis, teamwork skills, CT skills, and communication are among the crucial employability skills sought by employers (Pazim et al., 2018). Decision-making, which is influenced by education and training, is an outcome of these skills (Tyler and Brunner, 2014). Direct and indirect instructions from managers, policies, procedures, and personal judgment play a role in employee decision-making at the workplace (Böttcher and Meisert, 2013; Zhang et al., 2016). The World Economic Forum ranks CT skills as the second most important skill required by human resources (2017), and employers increasingly seek graduates with CT skills for data-driven decision-making (Graduate Management Admission Council, 2018).

CT skills are crucial in the business industry and have been identified as a skill gap in various fields such as nursing and clinical studies (Kahlke and White, 2013; Monaghan, 2015). However, their application in the Banking, Financial Services, and Insurance (BFSI) industry, which has a high demand for business studies graduates, has not been extensively studied. CT skills are essential for data-driven decision-making in the BFSI industry, which heavily relies on structured thinking (Provost and Fawcett, 2013). Higher education has long aimed to develop CT skills (Ennis, 1985; Facione, 2011; Bryan, 2014; Shakouri, 2016), and their integration into the university curriculum is necessary for workplace efficiency (Keengwe & Byamukama, 2019). Employability skills initiatives that involve employer involvement in course design and delivery have shown positive impacts on graduates' labor market performance (Mason, Williams, and Crammer, 2009). However, there is a gap between the understanding of employability skills by academics and the industry, resulting in limited emphasis on CT skill development in curriculum design (Tymon & Batistic, 2016; Shewakena Tessema, 2017).

To address this problem, this research incorporates concepts from Human Capital Theory (Schultz, 1963; Becker, 1975) to explore the practice of CT skills in the workplace and the knowledge gained from a graduate degree. The Theory of Practice Gap is used to measure the gap between the skills needed at work and those possessed by employees, specifically in the context of CT skills in the BFSI industry (Metilda & PC, 2016; Gowsalya & Kumar, 2017; Abbasi, Ali, and Bibi, 2018b). By analyzing employer expectations and satisfaction with CT skills used for data-driven decision-making, this research aims to identify areas for improvement in the graduate business studies curriculum.

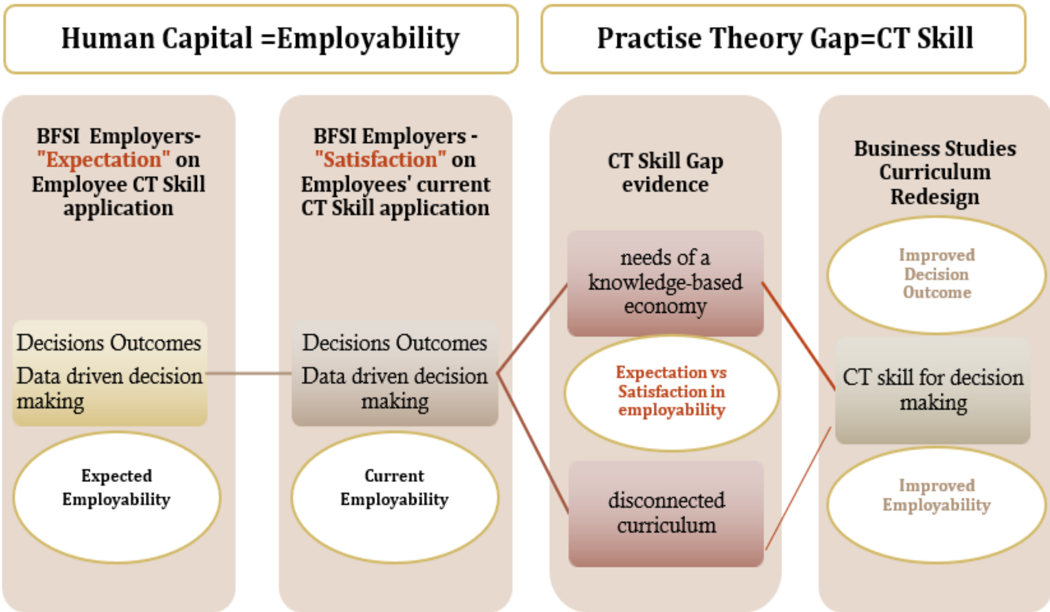

Figure 1: Conceptual framework

As in the conceptual model, the CT skill expectation on the BFSI industry's data-driven decision-making is analysed and mapped against the CT skill delivery by the graduate employees. In terms of **Human Capital Theory**(Schultz, 1963), the worker's employability in his workplace depends on the current skills and knowledge-based economy. Research question 1 measures the expected employability aspect of general decision-making and DDDM (Parvaiz, 2014) to understand the **expected employability** of BFSI graduates. By exploring this research question, the human capital requirement for decision-making in the BFSI industry shall be evolved, and the depth shall be understood by measuring the extent of the skill requirement. Through research question 2, employer satisfaction on CT skills' current usage, to measure employability of the existing graduate employees or **current employability** is done. The Theory Practise Gap measures the CT skill gap in expectation versus current satisfaction. Research question 3, throws light on the gaps in the available knowledge base and evidence of disconnected curriculum based on industry employability expectations. The gap between the knowledge acquired and real-world application can influence professional competency, leading to complexities in advancing from a graduate to a novice professional. Hence, the entire research process's outcome sheds light on redesigning the graduate business studies curriculum for **improved decision outcomes and graduate employability.**

RESEARCH DESIGN

The study focuses on exploring the skill gap, with a realist ontology research philosophy. The researcher maintained an outsider perspective to ensure objectivity, following an etic epistemology. The research adopted a deductive approach using a survey with Likert scale questions supported by open-ended data. The research method was feasible within the time constraints and employed LinkedIn for data collection. Two surveys were used for quantitative and qualitative data collection. The quantitative survey consisted of 33 Likert scale questions exploring employer expectations and satisfaction regarding graduate decision-making and critical thinking (CT) skills in data-driven decision-making (DDDM). The reliability of the instrument was tested using Cronbach Alpha. An open-ended survey was used to collect qualitative data on satisfaction, dissatisfaction, evidence of skill gaps, and recommendations. Data collection was conducted through an anonymous Qualtrics link sent via LinkedIn, with a response rate of 62%. The sample participants were managers from the banking, finance, and insurance industry, with 106 quantitative survey respondents. The data analysis involved descriptive statistics, nonparametric tests (Friedman test, Kruskal Wallis test, Wilcoxon signed rank test), and thematic analysis for qualitative data. The analysis was conducted using the SPSSTM software package. The statistical procedures aimed to explore expectations, satisfaction, and gaps in decision-making and CT skills. The results were interpreted based on significance levels and effect sizes. The qualitative analysis involved organizing themes, codes, and concepts derived from the open-ended survey responses. The analysis aimed to support and triangulate the quantitative findings. The overall Cronbach alpha stood at 0.928, excluding Qs2 and 0.924 including it. The composite reliability of different variable sections stood between 0.777 to 0.899, and individual factors reliability was between 0.667 and 0.887. The individual items greater than 0.7 are counted to be sufficient, and the Cronbach alpha of all items in this research are above 0.7, which demonstrates that there is a high level of internal reliability/consistency and the questions targeted to capture each variable are at an acceptable level for any analysis.

DATA ANALYSIS

Data analysis has been staged in three parts. The first part explored the BFSI industry **employers' expectations** of their graduate employees' decision-making and data-driven decision-making skills and outcome. The second part explores exploring the **current satisfaction** of the BFSI industry employers with their graduate employees' usage of critical thinking skills in data-driven decision-making. The third part explores the **evidence of the skill gap**.

Part A- Expectations of the BFSI industry employers on its graduate employees' DM and DDDM skills and outcome

The sections below show various aspects of general decision-making, decision outcome, CT skills usage in decision-making and DDDM. This part sets the expectation context based on which later gap analysis in part 3 follows.

The extent of DM and DDDM at the departments in BFSI companies

The extent of decision-making happening at the departments in the BFSI companies is analysed in this section using frequency analysis. The employer's general decision-making and data-driven decision-making, in specific, are analysed in the two sections of the table below. From the employers ' perspective, it outlines the extent and importance of DM and DDDM in the banking, financial and insurance industry.

Position	General DM department frequency						
	Rarely	Some times	NOT FREQUENT	Most of the time	ALWAYS	FREQUENT	Total
Junior Managers	2	0	22.22%	0	7	77.78%	9
Middle Managers	0	6	15.79%	16	16	84.21%	38
Senior Managers	0	2	4.17%	25	21	95.83%	48
Executive managers	0	1	9.09%	3	7	90.91%	11
TOTAL	2	9	10.38%	44	51	89.62%	106
Average			12.33%			87.67%	
Position	DDDM department frequency						
	Rarely	Some times	NOT FREQUENT	Most of the time	ALWAYS	FREQUENT	Total
Junior Managers	0	2	22.22%	2	5	77.78%	9
Middle Managers	0	10	26.32%	16	12	73.68%	38
Senior Manager	0	11	22.92%	20	17	77.08%	48
Executive managers	0	2	18.18%	2	7	81.82%	11
TOTAL	0	25	23.58%	40	41	76.42%	106
Average			22.64%			77.36%	

Table 1: Cross-tabulation (Respondents' managerial positions vs frequency of decision in the department- a. General decision-making (DM) and b. data-driven decision-making (DDDM)

The cross-tabulation analysis reveals that the majority of employers in the BFSI industry frequently engage in decision-making (87.67%) and data-driven decision-making (77.36%). Nearly 9 out of 10 employers make decisions at their workplace, with a high frequency of data-driven decision-making. Only a small percentage of junior managers (less than 2%) reported rarely making decisions. The descriptive analysis indicates that decision-making and data-driven decision-making occur most of the time, with average scores above the midpoint. According to the qualitative survey, employers highlight the significant impact of these decisions on income, cost, and overall business performance in the BFSI industry.

The extent of DM and DDDM by graduate employees at the departments in BFSI companies

The extent of decisions made by the graduate employees in the BFSI companies is analysed using frequency analysis. With the analysis, understanding the extent and importance of graduate DM and DDDM in the banking, financial, and insurance industry are aimed. The analysis of graduate employees' decision-making frequency shall illuminate the research topic's extent and give insights to analyse the upcoming sections.

Position	General DM graduate employee frequency						
	Rarely	NOT FREQUENT	Some times	Most of the time	Always	FREQUENT	Total
Junior Managers	2	22.22%	3	0	4	77.78%	9
Middle Managers	10	26.32%	19	7	2	73.68%	38
Senior Managers	8	16.67%	24	9	7	83.33%	48
Executive managers	1	9.09%	8	1	1	90.91%	11
TOTAL	21	19.81%	54	17	14	80.19%	106
Average			18.82%			81.18%	
Position	DDDM graduate employee frequency						
	Rarely	NOT FREQUENT	Some times	Most of the time	Always	FREQUENT	Total
Junior Managers	1	11.11%	4	0	4	88.89%	9
Middle Managers	9	23.68%	18	8	3	76.32%	38
Senior Manager	7	14.58%	23	10	8	85.42%	48
Executive managers	0	0.00%	9	1	1	100.00%	11
TOTAL	17	16.04%	54	19	16	83.96%	106
Average			13.08%			86.92%	

Table 2: Cross-tabulation(Respondents' managerial positions vs employee frequency of decision in the department- a. General decision-making (DM) and b. data-driven decision-making (DDDM)

The Friedman test showed a significant difference in the extent of graduate decision-making among managers ($\chi2$ (df:3, n=106) = 171.606, $p < 0.001$). On average, 81.18% of graduate employees frequently make decisions, and 8.7 out of 10 graduates engage in data-driven decision-making. Employers confirmed that graduate employees make impactful decisions related to planning and business outcomes.

Basis of employee decision-making at the workplace

The basis of employee decisions is analysed in this section to give an overview of the support factors that help graduate employees make decisions. By doing this analysis, the value of the skills attained at the university can be understood in terms of their impact on decision-making.

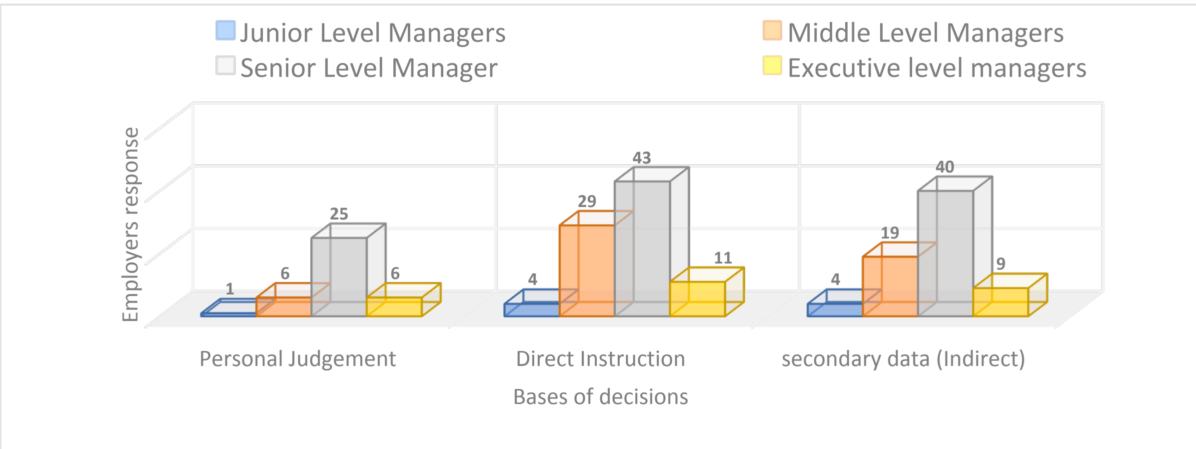

Figure 2: Basis of employee decision-making

The analysis of employee decision-making factors revealed that direct instruction is the primary basis for graduate employees' decisions, with 78.48% of employers agreeing. Additionally, employers identified secondary data (65.50%) and personal judgement (33.88%) as other influential factors. Employers emphasized the importance of direct procedural-level instructions and regular manager guidance in the decision-making process, indicating a level of dependency on managers rather than personal efficiency.

The employer's expectation of graduate employees' CT skill usage on general decision-making at the workplace

The employers' expectation of graduate employees' CT skill usage on decision-making skills is studied under the six CT elements mentioned in the literature review.

Employer Expectations	Mean (M)	Mean Rank (MR)	Std. Deviation (SD)	Range (R)
a. Understanding Purpose	3.54^{H}	3.93	0.588	1-4
b. Setting clear goals	3.34	3.38	0.584	1-4
c. Planning	3.22^{L}	2.99	0.552	2-4
d. Collection of all info	3.52	3.90	0.589	1-4
e. Weighing up alternatives	3.27	3.17	0.578	2-4
f. Identify Risks and Consequences	3.43	3.65	0.586	2-4
Average	3.50	0.58	0.580	

Table 3: Employer expectation of CT steps in employee decision-making(DM)

The Friedman test conducted on the expectations of different critical thinking (CT) skills in decision-making showed a significant difference between the mean ranks of the skills ($\chi2$ (df:5, n=106) = 54.812, p = 0.001). Understanding the purpose of the decision and collecting all information before decision-making had the highest average means, while planning effort for decision-making had the lowest. Qualitative analysis supported these findings, as participants highlighted the importance of skills such as identifying, reasoning, evaluating options, and evaluating impacts for informed decisions.

The Kruskal Wallis test, comparing the expectations on employee decision-making skills across different managerial levels, showed no significant differences except for weighing up alternatives. Junior managers had different expectations compared to more experienced managers in this particular skill (p = 0.033 for senior managers vs. junior managers, p = 0.011 for middle managers vs. junior managers). It suggests that more experienced managers consider weighing up alternatives before decision-making to be a crucial step in critical thinking, unlike junior managers.

The employer's expectation of graduate employees' CT skills usage on DDDM at the workplace

The employers' expectation of graduate employees' CT skills in data-driven decision-making is studied under various parameters. a.) understanding the purpose of decision-making and setting clear goals, b.) collecting all information available beforehand, c.) usage of adequate tools for data collection, d.) usage of adequate tools for data analysis, e.) weigh up all alternatives before decision-making.

Employer Expectations	Mean (M)	Mean Rank (MR)	Std. Deviation (SD)	Range (R)
a. Understanding the purpose of decision-making and setting a clear goal	3.46^{H}	3.25	0.538	2-4
b. Collection of all information	3.44	3.25	0.618	1-4
c. Usage of tools for data collection	3.28^{L}	2.80	0.530	2-4
d. Usage of tools for data analysis	3.28^{L}	2.81	0.530	2-4
e. Weighing up alternatives	3.31	2.90	0.575	2-4
Average	3.39	3.50	0.580	

Table 4: The Employer expectation on CT steps in DDDM

The Friedman test revealed a significant difference in the expectations of critical thinking (CT) skills for data-driven decision-making (DDDM) ($\chi2$ (df:4, n=106) = 22.208, $p < 0.001$). Understanding the purpose of decision-making and setting clear goals, as well as collecting all necessary information, were considered highly important, while the use of tools for data collection and analysis was rated lower. The Kruskal Wallis test showed significant differences in employer expectations based on experience levels, except for understanding the purpose and setting clear goals. More experienced managers had higher expectations compared to junior managers in all other skill areas. Qualitative analysis supported these findings, emphasizing the importance of comprehensive decision-making backed by data and the expectation of CT in day-to-day business decisions.

The employer's expectation of graduate data-driven decision-made (DDDM) outcomes

The expectation of the employers on graduate employees' data-driven decision- outcomes were studied in the below table as a.) probable/predictable outcome, b.) comprehensive decision, c.) unbiased/non-personal judgement, d.) follows structured process e.) timely decisions.

Employer Expectations	Mean (M)	Mean Rank (MR)	Std. Deviation (SD)	Range (R)
a. Probable/Predictable	3.19	3.09	0.664	2-4
b. Comprehensive	3.04^{L}	2.75	0.716	1-4
c. Unbiased/Non-personal	3.11	2.87	0.734	2-4
d. Follow structured process	3.18	3.01	0.644	2-4
e. Timely decision	3.26^{H}	3.28	0.637	2-4
Average	3.16	3.00	0.679	

Table 5: Employer expectation on data-driven decision outcomes

The Friedman test revealed a significant difference in the expectations of data-driven decision-making (DDDM) outcomes ($\chi2$ (df:4, n=106) = 19.816, $p = 0.001$). Timely decisions and following a structured process were considered highly important, while comprehensive decision outcomes were rated lower. The Kruskal Wallis test showed no significant differences in expectations based on experience levels, except for probable and predictable decision outcomes. Junior managers had lower expectations in this area compared to middle and senior managers. Qualitative analysis supported the importance of comprehensive decision-making backed by data, with an emphasis on reducing errors and delays through systematic and structured approaches. Employers acknowledged the impact of graduate employees' decisions on business operations and performance and provided examples of both successful and unsuccessful decision-making instances.

Part B: BFSI employers' satisfaction with the graduate employee usage of ct skills in data-driven decision-making

After the detailed analysis of employer expectations on graduate employees' general decision-making and data-driven decision-making skills and outcome, the following sections analyse the employer satisfaction with the current CT skills usage amongst their graduate employees.

Employer Satisfaction on graduate employees' current usage of CT skills for DDDM

Employer satisfaction with graduate employees' data-driven decision-making was studied under various CT parameters, as in the below table. a.) understanding the purpose of decision-making, b.) setting clear goals, c.) collecting all information available beforehand, d.) weighing up all alternatives before decision-making, e.) Use adequate software tools for data collection and analysis f.) Identifying risk and consequences.

Employer Satisfaction	Mean (M)	Mean Rank (MR)	Std. Deviation (SD)	Range (R)
a. Understanding Purpose	2.98^{H}	3.85	0.457	2-4
b. Setting clear goals	2.85	3.46	0.531	2-4
c. Collection of all info	2.82	3.43	0.582	1-4
d. Weighing up all alternatives	2.75	3.22	0.618	1-4
e. Usage of software tools	2.94	3.76	0.549	1-4
f. Identifying Risk and Consequences	2.74^{L}	3.27	0.694	1-4
g. Overall Usage of CT	2.79	3.64	0.643	1-4
Average	2.84	3.52	0.580	

Table 6: Employer satisfaction on graduate employees' current CT skills usage for DDDM

The Friedman test revealed a significant difference in employer satisfaction levels regarding the usage of critical thinking (CT) skills in data-driven decision-making (DDDM) ($\chi 2$ (df:5, n=106) = 36.088, $p < 0.001$). Employers were relatively satisfied with CT skills related to understanding purposes and the usage of tools for data collection and analysis, but less satisfied with weighing alternatives and identifying risks and consequences. Overall, employers rated their satisfaction with CT skills in DDDM below the agreed level. The Kruskal Wallis test showed no significant difference in satisfaction levels among managers, indicating a general dissatisfaction with the current usage of CT skills in employee decision-making. Qualitative analysis revealed that employers perceived the usage of CT skills in DDDM as highly dissatisfactory, attributing decision-making errors to a lack of comprehensiveness and consideration of alternatives.

Employer Satisfaction on current DDDM outcome

The employer satisfaction with graduate employees' CT skill usage on data-driven decision-making is studied under the parameters of a.) Probable/Predictable outcome, b.) comprehensive decision, c.) unbiased/non-personal judgement, d.) follows structured process, e.) timely decisions.

Employer Satisfaction	Mean (M)	Mean Rank (MR)	Std. Deviation (SD)	Range (R)
a. Probable/Predictable	2.85[H]	3.71	0.548	1-4
b. Comprehensive Outcome	2.67	3.30	0.700	1-4
c. Unbiased/Non-personal decisions	2.61[L]	3.16	0.725	1-4
d. Structured outcome	2.76	3.51	0.610	1-4
e. Timely decisions	2.83	3.68	0.560	1-4
Average	2.74	3.47	0.629	

Table 7: Employer Satisfaction on graduate employees current DDDM outcomes

The Friedman test revealed a significant difference in employer satisfaction levels regarding the outcomes of data-driven decision-making (DDDM) made by graduates ($\chi2$ (df:5, n=106) = 26.118, $p < 0.001$). Employers expressed comparative satisfaction with probable and predictable outcomes, as well as timely decisions, but were dissatisfied with comprehensive outcomes and unbiased/non-personal decisions, which scored below 3 on average. The high standard deviations (±0.700 and ±0.725) suggest that data for comprehensive outcomes and unbiased decisions may fall as low as M=1.97 and M=1.885, respectively, indicating high employer dissatisfaction. Overall, employer satisfaction with the current DDDM outcomes of graduate employees was relatively low, with an average rating of M=2.74 on a scale of 1-4. The Kruskal Wallis test indicated no significant difference in satisfaction levels among managers, suggesting a general lack of satisfaction with the current outcomes of employee decision-making.

Part C: Evidence of graduate employees' CT skill gap

Based on the analysis of expectations **(Part A)** and satisfaction **(Part B)** on employee CT skills on decision-making and decision outcome in the above sections, this section analyses the skill gap in terms of outcome and skill using Zscore and effect size r.

Employer expectation vs Satisfaction gap on employee DDDM outcome

Based on the previous analysis of expectation and satisfaction on DDDM outcome, this section analyses the extent of the decision outcome gap using correlation.

Expectation vs Satisfaction	DDDM Outcome Expectation Means (Mexp)	DDDM Outcome Satisfaction Means (MStf)	Z score	Effect size r
a. Probable/Predictable	3.19	2.85	-4.727	-0.459[L]
b. Comprehensive	3.04	2.67	-4.738	-0.460
c. Unbiased / Non-personal	3.11	2.61	-5.772	-0.561[H]
d. Follow a structured process	3.18	2.76	-5.311	-0.516
e. Timely decision	3.26	2.83	-5.413	-0.526
Average	3.16	2.74	-5.192	-0.504

Table 8: Decision outcome gap of graduate employees based on employer expectation and satisfaction.

The table provided indicates that the average expectations for data-driven decision-making (DDDM) outcomes were above 3 (M=3.16), while the average satisfaction with these outcomes was below 3 (M=2.74). The Wilcoxon test revealed a significant effect in all five pairs of DDDM outcomes (expectation and satisfaction), with a p-value of 0.000. The effect size analysis (r) showed that the widest outcome gap was observed for fair DDM outcomes, while three desired outcomes (unbiased, structured, and timely decisions) exhibited a large effect size (>0.5). Qualitative data supported these findings, with employers citing instances where decisions went wrong and had negative impacts, indicating a noticeable gap in DDDM outcomes.

CT Skill Gap analysis on the employee DDDM at the workplace

Based on the analysis of expectations and satisfaction on DDDM outcome in the above section, the below sections analyse the CT skill gap on DDDM at the workplace.

Expectation vs Satisfaction	Skill Expectation Means (Mexp)	Skill Satisfaction Means (MStf)	Z score	Effect size r
A. Understanding the purpose	3.46	2.98	-6.527	-0.634
B. Setting a clear goal	3.46	2.85	-7.087	-0.688[H]
C. Collection of all information	3.44	2.82	-6.753	-0.656
D. Usage of tools for data collection	3.28	2.94	-4.612	-0.448[L]
E. Usage of tools for data analysis	3.28	2.94	-4.710	-0.457
E. Weighing up alternatives	3.31	2.75	-6.133	-0.596
F.Identifying Risks and Consequences	3.31	2.74	-5.982	-0.581
Average	3.36	2.86	-5.972	-0.580

Table 9: DDD skill gaps analysis

The above table shows that the average expectations on the CT skill usage on DDDM stood above 3(M=3.36) and satisfaction on the same below 3(M=2.86). The Wilcoxon test performed on all the seven pairs of CT skills on DDDM (expectation and satisfaction) from a-f showed a significant effect of the group with p=0.000 less than alpha 0.001, z and r value given as in the table. Based on effect size r, the skill gap is the widest for b. setting clear goals and collecting all information compared to the least, using data collection and analysis tools. Out of the seven desired CT skills on DDDM, except 1(usage of tools for data collection) falls under the large effect skill gap with >0.5 effect size r. The CT skill gap on DDDM is evident in the quantitative analysis and is supported by the qualitative data wherein the employers agree that an evident skill gap must be fixed. Employers confirm that lack of employee CT skills imposes pressure on managers to function well as a unit and brings reputation compromises, wastage of time and incompetence for further analysis.

Inputs from the BFSI industry to improve the business studies curriculum to incorporate CT skills to enable better data-driven decision-making.

Based on the qualitative data collected through the open-ended survey, the employers agree that CT should be added as part of the graduate curriculum to improve employability. Both the respondents have given varied but limited suggestions on improving the curriculum. The main argumentation for incorporating CT in decision-making is the recurrence of DDDM in the industry. The employers agree that data-driven decision being the core function, expects employees to know the course of action to avoid delays, wastage of time and inefficiencies. Machine elements of decision-making, which can be software that helps in data collection and analysis to support decision-making, are emphasised along with the transferrable human skills of setting goals, understanding purpose etc. In this regard, one of the respondents suggested that the best practises of business operations like six sigma can help in quality decision-making. The employers also emphasise CT's application to business problems as an area of study in the business studies curriculum.

DISCUSSIONS

Expectations of the BFSI industry on its graduate employee's general decision-making and DDDM skills

A substantial amount of decision-making takes place in the banking and financial domain-based companies, with employers of varying experience levels being involved in decision-making. The decisions made by employees in these industries have an impact not only at the department level but also at the organizational level, aligning with previous research (Hensman and Sadler-Smith, 2011). The analysis indicates that graduate employees in the BFSI industry are expected to participate in decision-making to various extents, with a higher frequency of data-driven decisions being observed due to the industry's reliance on data (Brynjolfsson, Hitt and Kim, 2011). The analysis also reveals that decisions made by employees are primarily based on workplace instructions, highlighting the importance of comprehension and personal judgment in decision-making. Employers emphasize the need for employees to be independent but structured, with better decision outcomes. The analysis demonstrates that employers value cognitive ability and comprehensive decision-making, with the understanding that critical thinking skills contribute to improved decision outcomes. Employers place higher importance on employees' inherent and personal skills rather than relying solely on machine support. Overall, employers expect employees to make accurate and timely decisions following a structured process, with comprehensive outcomes desired.

BFSI employers' satisfaction with the graduate employee usage of CT skills in DDDM

CT skills play a crucial role in enabling employees to make successful decisions that impact business operations and performance. However, the analysis reveals that employers are dissatisfied with the current usage of CT skills for data-driven decision-making in the workplace. There is a notable absence of several CT features, particularly in weighing alternatives and identifying risks and consequences. The dissatisfaction extends to the overall decision-making outcomes, with employers expressing dissatisfaction with non-comprehensive outcomes and biased/personal judgment-based decisions. This dissatisfaction is consistent across managers with different levels of industry experience, indicating a widespread issue in the industry.

Evidence of graduate employees' CT skill gap and employer recommendations to higher education

The analysis reveals a significant gap between employer expectations and satisfaction regarding the usage of CT skills by graduate employees in data-driven decision-making (DDDM) at the workplace. This gap is associated with delays, inefficiencies, and gaps in decision quality. The study highlights the wider gap in CT skill usage compared to the gaps in decision outcomes. Employers expect graduates to possess CT skills such as understanding purpose, setting clear goals, collecting information, utilizing IT tools, weighing alternatives, and identifying risks. It is crucial to address this CT skill gap in graduate studies to enhance decision-making and improve business performance in the banking, financial, and insurance industries.

CONCLUSIONS

The exponential advancement of technology, particularly AI, in business operations will significantly increase the demand for data-driven decisions. This necessitates employees to make high-quality decisions at the workplace, as employers recognize the importance of data-driven decision-making. In the context of the BFSI industry, decision-making abilities enhance the employability of graduate employees and have a significant impact on business performance. Through a detailed analysis, this research reveals a clear gap in CT skills based on practice theory and a gap in DDDM outcomes among current graduate employees in the BFSI sector. Addressing the evident skill gap in critical thinking is crucial to empower employees with CT skills for effective data-driven decision-making in BFSI companies. Refining the graduate business studies curriculum at the higher education level is recommended, with a focus on decision-making skills to improve graduate employability, considering human capital theory. The integration of decision-making as a transferrable skill within various disciplines in the era of AI is suggested to enable students to make better decisions in their employment and enhance their employability. Comprehension, which involves understanding the requirements and scope of decisions, is highlighted as the initial step in decision-making. It is essential for graduate employees to comprehend direct and indirect instruction-based decision-making to avoid delays, errors, and wastage during the decision process. Students should be equipped with techniques, tools, and processes to effectively comprehend information. The findings of this research indicate that CT skills play a vital role in supporting efficient comprehension, understanding, and unbiased judgment in decision-making, complementing technology-based systems such as AI. Promoting CT skills for structured decision-making in the workplace can improve graduate employability and meet employers' expectations. Integrating CT into the business studies curriculum with a comprehensive understanding of its concepts and practical application is strongly recommended. The training of data-driven decision-making skills should encompass both human and machine elements, including software support. Case and scenario-based applications integrated into various business subjects are suggested as effective learning approaches, encouraging students to make decisions utilizing CT elements. According to Chang, Kao, and Hwang (2020), an RSI (Recognise, Summarise, Inquire) modelled flipped classroom can enhance CT-based problem-solving and decision-making skills, surpassing traditional case-based learning methods. Employers' emphasis on CT's cognitive elements over machine support, such as software tools for data collection and analysis, highlights the importance of cognitive CT elements in enhancing thinking abilities and utilizing machines to improve productivity and efficiency. These cognitive elements, including interpretation, analysis, evaluation, inference, explanation, and self-regulation, can be taught at different levels throughout graduate study years, allowing students to progressively enhance their thinking skills for better decision-making. The development of human capital involves enhancing employees' skills, bridging the practice theory gap, and improving graduate employability (Chang, Kao, & Hwang, 2020). One limitation of the current study is that it solely considered managerial positions and their experience as factors influencing employers' expectations and satisfaction. However, it is important to acknowledge that expectations of employee decision-making skills may differ across departments within the BFSI companies, depending on their specific operational requirements. For instance, call centre or back-office employees may not engage in data-driven decision-making using critical thinking as frequently as employees in other departments. This study did not capture the diversity of departmental needs and operations, which was a constraint. Additionally, within the BFSI industry, the nature of data-driven decision-making varies between financial service companies and insurance companies. This study did not account for this distinction, which is another limitation. Future research can address these limitations by incorporating departmental variations and exploring how the profile and activities of different BFSI companies impact the expectations of critical thinking skills at various levels.

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Implementing Flipped Classroom for Chinese Intellectual Property Lawyers

Dan Liu, University of the Cordilleras, Philippines
Marcelino M. Agnawa Jr., University of the Cordilleras, Philippines

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Abstract

Flipped classroom is one of the alternative learning modalities beyond simply delivering lectures in the classroom and assigning homework for students at home. During the COVID-19 pandemic, Wusong Law School, a commercial educational institution for Chinese lawyers, initiates the flipped classroom where both distance e-learning prior to the class and online collaborative activities are integrated in the Intellectual Property Law Department. This paper assesses the best practices and challenges to Wusong Law School in the implementation of flipped classroom for Chinese intellectual property lawyers, which have been determined with the thematic approach. This research suggests that flipped classroom could promote student engagement, improve learning independence and self-control, and enhance student-teacher relationship. It also reveals that the students and teachers undertake the challenges of technical problems, time intensive preparation and procrastination. Law schools need to establish a sustainable flipped classroom model in consideration of the potential best practices and the worldwide spread of COVID-19, by reshaping the classroom in a collaborative, independent and customized way, proving technical supports, well-planned preparation and time management guidance for lawyers. This paper shall be significant and beneficial to law schools and law firms to assess current practices and gain insights into how to improve their education strategy to meet the needs of law students during the pandemic of COVID-19. For future researchers, it can be referred to as a foundation and basis for further studies about alternative learning modalities implemented by educational institutions of law.

Keywords: Flipped Classroom, Law School, Intellectual Property Lawyer

1. INTRODUCTION

As a typical alternative learning modality, flipped classroom was brought into law schools in the context of the lockdown and quarantine caused by the COVID-19 pandemic. Flipped classroom, as defined by Tucker (2012), is a teaching method that learning materials and instructions which used to occur in class are accessed at home in advance of class, while class sessions are used for working through problems, advancing concepts and engaging in collaborative learning. Halili and Zainuddin (2015) defined flipped classroom as an element of blended learning that integrates face-to-face learning through group discussion and distance learning by watching asynchronous lectures and online collaboration. It is clear that with this type of education strategy, students need to learn fundamental knowledge at home and then participate in active learning activities in the classroom with teachers.

Tucker (2012) indicated that flipped classroom helped educators maximize the scarcest learning resource, i.e., time. According to Fulton (2012), flipped classroom allowed the students to study at their own pace and it also allowed the teachers to customize their curriculum to meet individual needs of their students, which could strengthen the relationship between teachers and students. Moran and Young (2015) discovered that flipped classroom shaped education in ways that fit contemporary time. As a popular education strategy, it was able to increase student participation and engagement, and enhance the student-teacher bond. Clark (2015) illustrated that flipped classroom educational model directly increased student engagement, communication and collaboration. Kirvan et al. (2015), Kostaris et al. (2017), Smallhorn (2017) and Bond (2020) also noted student engagement as promoted by the flipped classroom model. Another study found that students taught with the strategy of flipped classroom improved their learning autonomy and paced as independent learners (Abeysekera & Dawson, 2015; Hermanns et al., 2015).

In the study by Hermanns et al. (2015), some educators were apprehensive about the flipped classroom because they were unfamiliar with the new technology used for video instructions. Chen (2016) conducted a qualitative investigation of the flipped classroom instructional pedagogy in a ninth-grade health education class and reported that the video lessons prepared by teachers might not be uploaded properly. According to Van Sickle (2015), Chen (2016), Johnson and Misterek (2017), some students did not watch the videos in advance of class for various reason. Recent studies also found it challenging for some teachers to deal with students who did not watch the video as their assignment prior to class or did not have internet access (Schmidt & Ralph, 2016; Van Sickle, 2015). Teachers also faced challenges in the flipped classroom, such as increased workload, lack of network connectivity and planning time constraints (Chen, 2016; D'addato & Miller, 2016; Unal & Unal, 2017). Johnson & Misterek (2017) indicated that the major challenge of flipped classroom was the time intensive preparation.

This paper shall be significant and beneficial to law schools and law firms to assess current practices and gain insights into how to improve their education strategy to meet the needs of law students during the pandemic of COVID-19. For future researchers, it can be referred to as a foundation and basis for further studies about alternative learning modalities implemented by educational institutions of law. This qualitative study explores the bests practices and challenges in implementing flipped classroom and provides evidence-based conclusions and recommendations for the sustainable development of flipped classroom in law school.

2. METHODOLOGY

In this study, one-on-one interview was used to collect qualitative data because it is a technique to improve understanding, help explain and explore the experiences, behaviors, and opinions of the research subjects. The researcher interviewed five key informants on which purposive sampling was applied for participant selection. Participants were selected on the basis that they met the study criteria, with the potential to impart pertinent and comprehensive data (Showkat & Parveen, 2017). Thematic analysis approach was applied to examine and identify the common themes of the research participants, involving the topics, ideas, patterns of meaning that appeared repeatedly (Caulfield, 2022).

3. FINDINGS & DISCUSSION

The following themes of participants' sentiments related to the best practices and challenges in implementing flipped classroom are summarized by way of coding and categorizing the data collected from the key informants.

3.1 Best Practices in the Implementation of Flipped Classroom for Chinese IP Lawyers

3.1.1 Promote Student Engagement

As students participate in classroom activities to address legal issues through group discussion in a collaborative way, flipped classroom is a place for law students to develop problem-solving, communication, and collaboration abilities. As KI3 and KI5 mentioned:

> *"My students are active in group discussion, and they have improved their risk awareness of intellectual property. They have better performance and make significant progress in problem-solving and communication." (KI3)*

> *"Through participating in the flipped classroom, our lawyers who studied at Wusong (Law School) have improved their abilities of communication and collaboration, which are transferable at work." (KI5)*

Comparably, Clark (2015) indicated that flipped classroom directly increased student engagement, communication and collaboration. In order to implement flipped classroom more effectively, teachers should choose appropriate classroom activities in line with the video lectures and make proper use of class time with good planning (Lo et al., 2018).

3.1.2 Improve Learning Independence and Self-control

It allows students to study at their own pace and take control of their own academics. Students could improve their learning attitude and become independent learners. As demonstrated in the following statements by KI1 and KI4:

> *"I can study at my own pace at home... I can pause and rewind the videos until I have fully understood. I also have enough time to revise my learning materials over and over again. So it makes my study of IP law more focused." (KI1)*

> *"This alternative learning modality also improves student learning autonomy of the law students. They manage to get rid of the reliance on teachers and become independent learners." (KI4)*

As explained by Smale-Jacobse et al. (2019), students can quickly get access to their learning resources at their own time and replay the videos until they have fully understood the concept studied. Therefore, it is essential for teachers to develop the flipped classroom with a view to enhancing the motivation of self-study and the independence of students.

3.1.3 Enhance Student-Teacher Relationship

Compared with traditional classroom, flipped classroom enables teachers to teach more actively and individually. The curriculum is also customized for each group of the students. Having participated in group discussion and presentation with professional guidance, students develop closer relationships with their teachers. KI3 and KI5 best stated this practice:

> *"... I join the student groups to listen to their arguments and encourage my students to share their viewpoints. I also wok with students individually and even customized curriculum for certain students. By giving one-to-one instructions for all, I've been able to call the name of each student. We also have good relationship after class." (KI3)*

> *"... the young lawyers (students) also have good relationship with their teachers. They go out for dinner once a month and discuss the new IP cases." (KI5)*

Fulton (2012) found it helpful to strengthen the student-teacher bond when teachers work with students more individually and provide with personalized learning activities. Many research studies on flipped classroom also emphasized the value of student-teacher relationship (Moran & Young, 2015; Hall & DuFrene, 2016; Gough et al., 2017). For fostering a strong relationship with students, teachers should play a role in facilitating the student-teacher interaction while meeting their academic needs.

3.2 Challenges in the Implementation of Flipped Classroom for Chinese IP Lawyers

3.2.1 Technical Problems

Both students and teachers ever experienced problems with the technical difficulties. In this study, the most common technical problems are related to the lack of network connectivity, website instability and unfamiliarity with ICT skills. As stated by KI1 and KI3:

> *"... network is essential for each teacher and student. If the teacher doesn't have network connection, the whole teaching and learning process might come to an end. Sometimes we have the problem of poor communication with teachers and classmates due to the unstable network. Another challenge is the using of e-learning devices. I still remember I failed to download an e-learning mobile application because this APP is only compatible with Android system, but my iPhone is running in the IOS system." (KI1)*

> *"... the biggest challenge is the technical difficulty. For example, no internet connection, poor communication due to unstable network, unable to upload videos properly, etc. These negatively influenced the quality of our classes." (KI3)*

Previous studies mentioned the same challenges in flipped classroom, such as lack of technical skills to manage recording, editing and uploading videos (Chen, 2016), and lack of internet (Chen, 2016; D'addato & Miller, 2016; Unal & Unal, 2017). For teachers, the lockdown caused by the pandemic of COVID-19 otherwise brought opportunities to improve their ICT and other professional skills, which would reshape education in ways that fit the 21^{st} century.

3.2.2 Time Intensive Preparation

Compared with traditional classroom, extra time is needed by teachers in flipped classroom because it requires massive preparation, such as recording, editing, uploading video lessons and devising proper in-class activities in line with the pre-session materials within a short period. This sentiment was evident in the following responses:

> *"... the flipped classroom increases our workload. We need extra time to prepare the online videos and proper guidance for our students." (KI3)*

> *"... some teachers complain about the increased workload and ask for a raise." (KI4)*

Previous studies reported this disadvantage of flipped classroom that teacher's planning and preparation time increased (Petrovici & Nemesu, 2015; Guy & Marquis, 2016; Hajhashemi et al., 2017). It was emphasized by Simonson (2017) that flipped classroom should be approached with careful planning to frontload preparation for students by the teachers.

3.2.3 Procrastination

For a student in flipped classroom, the pre-session preparation is required as the foundation of the in-class activities, driven by the motivation and self-control. In this study, some participants raised concerns about productivity and time management. This problem was evident in KI2's response:

> *"During the deadline's eve, I watch online lectures and read physical materials in a rush and stay up late until one or two... I have a little bit panic disorder and depression prior to the class... I also suffered from palpitation and insomnia before deadline."*

KI3 echoed the same issue:

> *"... there are several students not having enough time or interest to get well-prepared. They did their self-study in a rush at home and tend to 'ride on their teammates' coattails' in the oral presentation or group discussion."*

Schmidt and Ralph (2016) noted the challenge in implementation of flipped classroom that some students did not watch the video as their homework for various reasons, which caused trouble to both teachers and students. In order to overcome the problem of procrastination, teachers should also guide students to manage their daily workload and become productive in their learning process.

4. CONCLUSIONON

This paper has evaluated the best practices and challenges to Wusong Law School in the implementation of flipped classroom. The best practices to implement flipped classroom are categorized as promoting student engagement, improving learning independence and enhancing student-teacher relationship, which directly associate with the teaching and learning approach in a collaborative, independent and customized way. The challenges to Wusong Law School in implementing flipped classroom can be concluded as technical problems, time intensive preparation and procrastination.

To address the challenges in the implementation of flipped classroom for Chinese IP lawyers, it is recommended to provide technical supports for the lawyers and teachers. In addition, teachers should frontload well-preparation for lawyers with careful planning and provide time management guidance to enhance their productivity.

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APPENDIX A: KEY INFORMANTS' PROFILE

Key Informant 1
Position: Student
Designation: Top Student (Intellectual Property Lawyer in Yingke Law Firm)

Key Informant 2
Position: Student
Designation: Poor Student (Intellectual Property Lawyer in Yingke Law Firm)

Key Informant 3
Position: Teacher
Designation: Intellectual Property Law Teacher in Wusong Law School

Key Informant 4
Position: Department Head
Designation: Intellectual Property Law Department of Wusong Law School

Key Informant 5
Position: Employer of KI1 and KI2
Designation: Partner in Yingke Law Firm

APPENDIX B: GENERATED THEMES

1. What best practices are being implemented in the flipped classroom at Wusong Law School for intellectual property lawyers?

Code	Theme
Communication and collaboration	Promote student engagement
Active in group discussion	
Fierce debate	
Meaningful participation	
Reshape the classes and become active	
Make full use of the class time	
Develop a positive attitude on case study	
Better performance and progress	
Deeper understanding	
Interesting learning process	
Flexible	Improve learning independence and self-control
Study at students' own pace	
Improve student autonomy of law students	
Availability of online classes at home	
Revise learning materials over and over again	
Become independent learners	
Pause and rewind the videos until fully understand	
More focused	
Provide various learning tools for students	
Online lectures, MOOC, websites, journals	
Transferable at work	
Get rid of the reliance on teachers	
Conduct legal research at higher level	
Improve the ability to raise questions	
Need strong willpower	
Work with student individually	Enhance student-teacher relationship
Customize curriculum for certain students	
Provide personalized learning	
Proper guidance for students	
Deal with common and specific questions	
Meet students' learning needs	
Give one-to-one instructions	
Get closer emotionally	
Join the student groups to listen and share opinions	
Able to call the name of each student	
Strong relationship after graduation	

2. What are the challenges encountered in implementing flipped classroom at Wusong Law School for intellectual property lawyers?

Code	Theme
Unfamiliar with the e-learning devices	Technical problems
Unable to upload videos properly	
Lack of network connections	
Poor communication due to unstable network	
Learning software incompatible with the devices	
Need technical supports	
Unable to use proper online teaching tools	
Increase workload for teachers	Time Intensive preparation
Lack of student preparation	
Do not have enough time to get well-prepared	
Extra time is needed	
In a rush	
Stay up late	
Learning material unfit for the in-class activities	
Become exhausted	
Students do not study at home before classes	Procrastination
Poor time management	
Lack of interest and motivation	
Riding on teamate's coattails	
Distracted by social medias	
Unable to meet the deadline	
Panic disorder and depression prior to classes	
Palpitation and insomnia before deadline	
Absence	

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Contact emails: liudan_llm2015@163.com
mmagnawa@uc-bcf.edu.ph

Virtual Reality (VR) Simulation of Chemistry Lab Using Blender and Unity

Belinda Mutunhu Ndlovu, National University of Science and Technology, Zimbabwe
Ngonidzashe Maphosa, National University of Science and Technology, Zimbabwe
Sibusisiwe Dube, National University of Science and Technology, Zimbabwe

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Abstract
The new age of coping with change has driven us to employ all the technology to make everything in our day-to-day work and study life available remotely. In the time of virtual education and virtual meetings, this project intends to add to virtual education. Modern times have made us realize that lessons may be held online and do not require a physical presence in the institution of education, but the same cannot be said for laboratory-integrated disciplines. Our answer to having access to laboratories that would necessitate physical participation is to recreate the laboratory and its exercises to deliver an analogous interactive experience through a Virtual Reality (VR)-rendered 3D simulation. In this project, we are replicating a chemical laboratory with 3D animation. This allows the user to do experiments in the same manner as they would in a chemistry laboratory. The simulation is rendered in VR so that the user can interact with the objects in the 3D world. The elements are generated with Blender and the interactions are managed with Unity. Thus, universities and institutions that have chemistry laboratory integration into their curricula can benefit tremendously from this project.

Keywords: Virtual Reality, Blender, Unity, 3D Simulation

1. Introduction

The Covid-19 pandemic forced everyone to isolation from the public. However, the processes of society could not stay idle for long. A solution had to be discovered to make everything function again. Mutunhu-Ndlovu et.al (2022) notes that educational institutions had to switch blindly from physical classes to online classes whilst having inadequate resources to do so. Thus during this era classes and meetings moved to virtual meeting platforms. All conceivable systems that could run virtually did so and are still doing so as a contingency plan, especially for low to middle-income countries (Zheng,2021; Vincent-Lancrin,2022). For the education sector with laboratory experiments, Virtual Reality seemed to be the inevitable next step for the advancement of education (Lampropoulos ,2022).

Virtual Reality (VR) is a computer-generated simulated experience where the user may interact with an artificial world or an environment that mimics an actual one with the use of electronic equipment such as a VR headset or a keyboard and a mouse Ip (2022). With the use of VR, we build or develop an artificial, interactive, computer-made environment or simply a "world" (which might look fairly real to an existent area) inside which the user can immerse themselves (Lege,2020). Interactions in the virtual world might range from gazing left, right, or any other direction, as if they were genuinely there in that reality It can also entail interactions of the elements existing in the world to create a more real-time experience of a particular job. With education at the cornerstone of a successful community and the transfer of information being humanity's number one priority since the dawn of civilization, humans have been exploring ways to communicate information more readily, promptly, and efficiently (Akuma and Callaghan,2018; Keiner and Graulich,2021). In the digital era, we now can employ technology to improve the technique of learning.

Not only are there very few systems that exist for VR laboratories but there are hardly any institutions implementing them. This project aims to be friendly for the institution and the courses it will supplement using Virtual Reality. A virtual environment in which any chemical interaction is possible, can lead to unaccounted possibilities and affect the accurate learning process. Hence limiting the experiments to a set of allowed possibilities allows for precise learning. Rarely can a university support a fleet of pricy and cutting-edge research instruments exclusively for pedagogical purposes. As a result, rather than keeping up with the newest discoveries, the design of the analytical chemistry curriculum is bound by the access and availability of scientific instruments. How can we get past the dilemma of restricted access to scientific knowledge and the desire for sophisticated content that demands the usage of scientific equipment? In this paper, we address this issue by inventing a virtual reality (VR) chemistry education platform that leverages VR connectivity to connect scientific equipment to a huge classroom.

This project will enable one more system to the virtual world, the laboratories. Creating the laboratory setting, where a given set of experiments have to be done could comprise the set of experiments needed completion by a course. The laboratory is displayed in VR output so that the user may interact with the elements as he would in a real-world chemical laboratory. The created environment, if offered to every person who is required to complete the experiments, can permit remote access and completion of the course without needing to be present physically in the laboratory. We propose a small-scale 3D environment where the experiments are performed as per the course that an institution requires. The deviation from the experiments will be very less as, in a simulated environment, if it’s not coded it’s not possible. This controls the degree of freedom that a student or a user has in the environment.

2. Objectives

1. To develop a web application that simulates a chemistry laboratory
2. To simulate a chemistry practical experiment
3. To set up chemistry apparatus in a virtual environment

3. Existing Systems

Agbonifo et al. (2020) developed a Virtual Chemistry lab for acid–base titration experiments. Their virtual lab is an alternative to physical laboratories with inadequate reagents. Their lab provides students with real-life experiences of practical labs thus enabling adaptive learning.

Bortnik (2017) developed a chemistry laboratory platform enhanced with virtual reality. The experiments carried out in their Virtual lab is a titration. This enables students to do pre-lab experiments virtually before accessing the chemistry wet lab. This enables autonomous learning. Georgiou (2007) developed an integrated web-based learning environment for the simulation of chemical experiments. Their application presents institutions with low resources and inadequate infrastructure with an opportunity to familiarize themselves with a real chemical laboratory using cost-effective measures. Hu-Au and Okita (2020) did a comparison study between Virtual Reality and Real Life chemistry laboratories. Their study shows that there are differences in learning experiences in terms of laboratory skills, safety standards, and knowledge content.

In all these systems noted, several programming engines were used in the study of virtual environments which included Unreal Engine, Panda 3D, and libGDX.

Despite the recognition of these existing systems we identified limitations faced by these systems which include the following:

1. Simulation as it is not tailored to a course.
2. The endless possibilities under a sequence of actions are not accounted for and are inaccurate.
3. Expensive simulation as the mixing up of solutions and salts is not limited.
4. Redundant complex interactions in the perspective of a course.

To overcome the above limitations we propose a new system to counter some of these limitations. This system we propose, has tailored experiments to a particular course. The aim is to allow four experiments from the twelfth-grade state syllabus of the Karnataka government.

4. Research Methodology

For the research, a Build methodology is being used. A build methodology is used considering this as a new piece of technology and the research aims to test whether the approach of building this software will influence one's understanding. The hardware requirements for this project are a VR headset and controllers for an immersive experience. This application also runs on the student's personal computer where the application is interactive with an available mouse. The chemistry laboratory should have experiments that can be performed.

In this project, we have simulated four experiments:

1. $CuCO_3$ heat $CuO + CO_2$
2. $CuSO_4.5H_2O$ heat $CuSO_4 + 5H_2O$
3. $2Pb_3O_4$ heat $6PbO + O_2$
4. $2HgO$ heat $2Hg + O_2$

In the figures below we can see the color change as part of experiment number three where the orange Pb_3O_4 changes its color to reddish brown when heated and yellow when it is cooled.

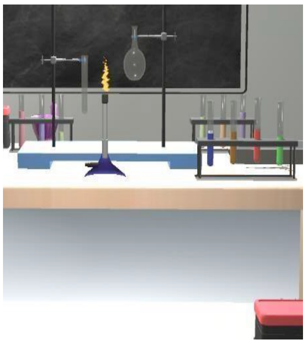

Fig 1: Orange solution of lead oxide in the second test tube from left

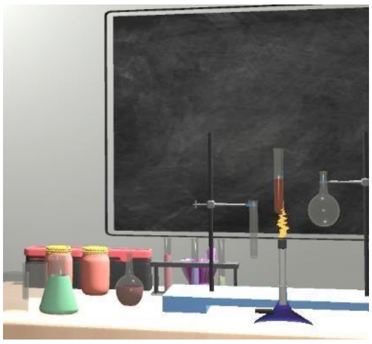

Fig 2: Solution changes color to reddish brown on heating

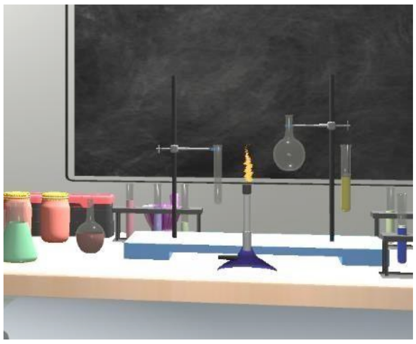

Fig 3: Solution turns color again to yellow on cooling

i. Light green copper carbonate turns black on heating along with carbon dioxide gas
ii. Blue copper sulphate solution turns white on heating
iii. Orange lead oxide solution turns reddish brown on heating and yellow on cooling releasing oxygen gas
iv. Red solid mercuric oxide turns to silver droplets near the mouth of the test tube on heating along with oxygen

The experiments have been selected due to visible inference. The experiments show a change in the color of compounds when heated. The color changes for the experiments are as such.

4.1 Different Modules of the Project

1. Camera Control

The VR simulation can be experienced only through a VR headset and hence for that experience, there must be a camera system that translates the users viewing position from which they see into the simulation. The camera control module takes care of the camera movement.

2. Collision

In a 3D world, the interaction of elements can also be called collisions. For an environment that is built in the 3D workspace, the interactions make the environment an active one.

The collision module states the rules of the interactions like when one particular element will change interaction depending on how far away it is from the element that it interacts with.

3. Materials

Just like everything in the real world has its appearance. The virtual world elements must also have their appearance and attributes like gloss, grading, and transparency. The materials are fine-tuned to mimic the real-life inspired elements.

4. Particle Color

The flame element is a type of element that uses a particle flow system since it is not a rigid entity. The particles of the flame simulation allow for an unpredictable movement of the flame that mimics the uncertainty of a real-world flame.

4.2 Code Snippet of Particle Colors

Particle Colors

```
using System.Collections; using System.Collections.Generic; using UnityEngine;
public class ParticleColor: MonoBehaviour
{ public GameObject particle;
// The new material you want to apply to the particle system
public Material new material;
private void Start() {
// Access the 'ParticleSystemRenderer' component,
and change the material to 'new material'.
Particle.GetComponent<ParticleSystemRenderer>().material = newMaterial; } }
```

The application when launched finds the 3D elements within its camera frame. These 3D elements have properties that allow them to be dragged and dropped along the axes. The active elements in the environment when interacting with each other, like the test tubes and the flame, a change in the color of the content of the test-tube occurs. Until this change is noticed the elements have to be brought near each other. The change in the color of the elements is not spontaneous and is only triggered when it comes in contact with the flame.

5. Experimental results

3D environment:

Fig 4: Frontside

Fig 5: Backside

Fig 6: Camera View

From this angle, the simulation can be viewed. This is a fixed camera position. The experiments can be performed and viewed from this angle.

The following is a demonstration of one of the experiments conducted.

5.1 Experiment on CuSO4.H2O

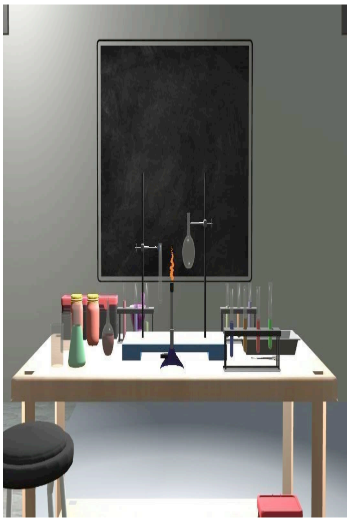

Fig 7: Initial position Test tube containing CuSO4.H2O is in the test-tube tray.

Fig 8: When brought near flame element

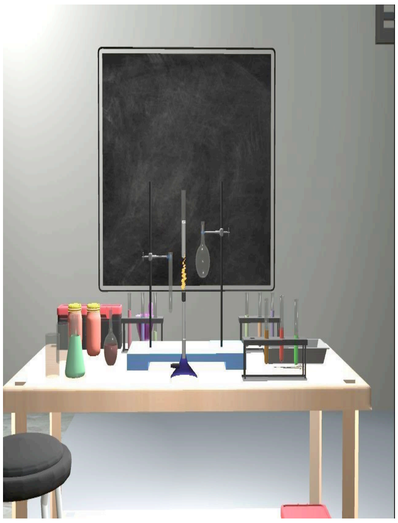

Fig 9: Near the flame for some time

The color change of the solution is visible as it changes from blue to white.

6. Conclusion and Future Enhancement

We believe that this project will be instrumental in a time when access to laboratories is limited. In 2019 when the pandemic got the whole world, the quick response and solutions to shifting education and work to virtual platforms was one way to have everything moving. In such a time, laboratories were the hardest to implement, in terms of education. This project is also for those who would like to access the laboratories but are not able to because of distance and inaccessibility physically or various other reasons. The project was created with animation in 3D not only to provide for learning but also to provide a safe space where the deviations from the experiment and its consequences are minimum. The 3D immersive experience can be out of the ordinary, capturing the attention of its users more than regular labs attended physically. The project allows for a reality where the resources are never exhausted. The chemicals that are used in the real-world laboratory can be expensive and hard to maintain. A virtual reality where you can do something, restart and everything is back to the same as it was, in the beginning, offers the best cost-cutting solution to this problem. The virtual platform has a fixed number of possible actions. In a real-world laboratory, however, the resources could be misused. This project offers a solution to all misuse of resources in a chemistry laboratory. The project can work as a hybrid learning platform. This flexibility can inspire the education field to make use of such platforms. This project could also be seen as a game, providing an immersive experience to its users and keeping them interested.

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The Use of Mathematics Modules in Supporting Self-Regulation Among Junior High School Students in a Flexible Online Learning Environment

Rio Jane Diaz, University of Santo Tomas, Philippines
Evelyn Songco, University of Santo Tomas, Philippines

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Abstract
Examining how students manage their learning through the mathematics modules in a flexible online learning setup can help educators plan and implement a curriculum in this environment. Hence, this study aims to assess the use of mathematics modules in supporting students' self-regulation in a flexible online learning environment. This study utilized an explanatory sequential mixed methods design. The Online Self-Regulated Learning Questionnaire (OSLQ) evaluated the students' self-regulation. After analyzing the results from the OSLQ, focus group discussions, and individual interviews were conducted. The results showed a significant difference between students in grades 7 and 10 in terms of self-regulation. The study discovered that JHS students "often" use environment structuring, goal setting, time management, and self-evaluation strategies. However, they rated themselves "sometimes" in using help-seeking and task strategies. Findings from the focus group discussion and interviews revealed that different features of the math modules, such as the module planner, pre-test, list of most essential competencies, module activities, answer key, and self-check activities, allowed the JHS students to engage in forethought, performance, and self-reflection phases of self-regulation. However, challenges in using the modules emerged, such as heavy workload, the irrelevance of activities, student attitudes, and teacher factors. Overall, the students and teachers have positive experiences using mathematics modules. The research findings could be used to improve schools' existing programs and establish best practices for using modules in a flexible online learning environment.

Keywords: Flexible Online Learning, Modular Learning, Self-Regulated Learning

Introduction

The emergence of the COVID-19 pandemic has brought both a challenge and an opportunity for the Philippine educational system to innovate. Different educational institutions were forced to close physically to protect the teachers, the students, and the other stakeholders from the virus. This situation has caused the Philippine educational system to adapt suddenly and meet the demands of the new normal. Of these demands, the foremost is the abrupt shift from traditional face-to-face learning to distance learning.

Before the pandemic even began, distance learning, now commonly called online learning, became the preferred instruction in the higher education sector (You, 2016). It provides flexible learning opportunities to learners, who learn synchronously, asynchronously, or both. However, this modality is still novel in Philippine Basic Education. Therefore, the Department of Education (DepEd) released the Basic Education Learning Continuity Plan (BE-LCP) under DepEd Order No. 012 s. 2020. To address the lack of gadgets and poor signal connections, self-learning modules or packets, which were made available online or offline, were also offered along with the different modalities mentioned.

While the current learning approach provides flexibility and freedom among the students, it also requires them to independently acquire the necessary knowledge, skills, and attitude. Students must have commitment and discipline in this learning modality (You, 2016; Kulusakli, 2021); since external regulation from the teacher might be limited in online learning, students need to become more self-regulated learners (Hutt et al., 2021).

The purpose of this study is to examine how Junior High School (JHS) students manage their learning in a flexible online learning environment and evaluate the use of mathematics modules in supporting their self-regulation based on teachers' and students' experiences and recommendations so that appropriate measures can be taken for future improvement of schools' existing programs and to establish best practices for the use of modules in a flexible online learning environment.

This study also aims to answer the following research questions:

1. What is the self-regulation profile of the JHS students who are using the mathematics modules in a flexible online learning environment?
2. What are the students' experiences in using mathematics modules in supporting their self-regulation in a flexible online learning environment?
3. What are the teachers' experiences in using mathematics modules to support students' self-regulation in a flexible online learning environment?

Research Methods

This study implemented the explanatory sequential design. Here, the quantitative data are collected and analyzed first. Afterward, the qualitative data are collected and analyzed to support the quantitative results (Creswell, 2009).

The study's participants consisted of 932 enrolled regular JHS students, aged 12-17 years old, and 5 JHS Mathematics teachers, aged 23-35 years old. The researcher used stratified random sampling in determining the student participants for the survey questionnaire (OSLQ). The target number of participants was 273 JHS students using Slovin's formula with a margin of error of 5%.

Meanwhile, convenience sampling was utilized in formulating the focus group. After the data in the quantitative phase were analyzed, the sample for focus group discussion was chosen from those students who agreed to be interviewed. The students were divided based on the result of the OSLQ. The two groups consisted of students whose OSLQ scores were above the mean, while the other two consisted of students whose scores were below the mean. Each group had representatives per grade level. Since many students consented to be interviewed, four groups were formed. This was also done to ensure that the possibility of neglected themes was lessened (Saunders et al., 2019).

On the other hand, all JHS math teachers were recruited to lessen the possibility of neglected themes (Saunders et al., 2019). The researcher, one of the JHS math teachers, was excluded to avoid bias. All JHS math teachers agreed to participate in the interview.

Results and Analysis

RQ1: What is the self-regulation profile of the JHS students who are using the mathematics modules in a flexible online learning environment?

The questionnaire used here is adapted from the Online Self-Regulation Questionnaire (OSLQ) of Barnard et al. (2009). The questionnaire was revised to simplify the language and to incorporate mathematics modules in the questionnaire. Education experts validated it. It was revised, and then students who were not included in the study answered the OSLQ for pilot testing. The Cronbach Alpha coefficient is 0.903, which suggests high internal consistency. The revised questionnaire is a 5-point Likert scale format (never-often) consisting of 23 items assessing students' SRL in flexible online learning using the math modules.

The JHS students' self-regulation was identified using their responses to the Online Self-Regulated Learning Questionnaire (OSLQ). The mean and standard deviation were computed for every item.

Grade 7			
	Mean	S. D	Verbal Interpretation
1. I set learning objectives or learning targets for my activities in Math class.	3.49	1.05	Often
2. I set short-term (daily or weekly) goals and long-term goals (monthly or for the semester) to accomplish my math modules.	3.71	1.25	Often
3. I keep a high standard for my learning in math class.	4.06	0.90	Often
4. I do not compromise the quality of my work just because it is an online setup.	3.59	1.34	Often
5. I set goals to help me manage study time for my math modules.	3.65	1.15	Often
6. I work on my math modules at a time when there are no distractions at home.	3.51	1.41	Often
7. I know the venue where I can study most efficiently for math modules.	3.82	1.34	Often
8. I try to take more thorough notes in my math class because I use those notes to answer my math modules.	3.59	1.33	Often
9. I read aloud math modules posted online or offline as a way to fight against distractions.	2.63	1.40	Sometimes
10. I prepare my questions about the math modules before joining the synchronous class.	2.27	1.15	Rarely
11. I work on extra problems in my math modules in addition to the assigned ones to master the topic.	2.90	1.22	Sometimes
12. I allocate extra study time for my online class because I know that it is time demanding.	3.55	1.12	Often
13. I try to schedule a time to study the modules for my online class and regularly observe this schedule.	3.45	1.17	Often
14. Although we do not have to attend daily classes, I still try to distribute my study time evenly across days.	3.65	1.13	Often
15. I find someone knowledgeable in Math so that I can consult with him/her when I need help.	3.55	1.35	Often
16. I am persistent in getting help with the math module lesson from the instructor through e-mail (or chat).	2.88	1.38	Sometimes
17. I share my problems regarding Math modules with my classmates online, so we know what we are struggling with and how to solve our problems.	2.63	1.33	Sometimes
18. If needed, I try to connect with my classmates through video calls to ask and seek help regarding the math modules.	2.27	1.39	Rarely
19. I communicate with my classmates to find out how I am doing in my math module activities.	2.37	1.41	Rarely
20. I communicate with my classmates to find out if what I am learning is different from what they are learning from the module.	2.29	1.29	Rarely
21. I summarize my learning about the math modules to examine my understanding of what I have learned.	3.75	1.21	Often
22. I ask myself a lot of questions about the content of the math modules.	3.27	1.13	Sometimes
23. The Math modules helped me to control my learning in the online class.	3.94	0.95	Often
TOTAL	3.25	1.36	Sometimes

Table 1: Grade 7 (n=51) Students' OSLQ Result per Item

***Legend used in subsequent tables:**

4.21-5.00	Always
3.41-4.20	Often
2.61-3.40	Sometimes
1.81-2.60	Rarely
1.00-1.80	Never

The overall result of Grade 7 students' use of self-regulation strategies under the flexible online learning mode has an average of 3.25, which is verbally interpreted as "sometimes." This suggests that Grade 7 students do not often use SRL strategies in their flexible online classes using math modules.

Grade 8			
	Mean	**S.D**	**Verbal Interpretation**
1. I set learning objectives or learning targets for my activities in Math class.	3.71	0.72	Often
2. I set short-term (daily or weekly) goals and long-term goals (monthly or for the semester) to accomplish my math modules.	3.63	0.99	Often
3. I keep a high standard for my learning in math class.	3.76	0.86	Often
4. I do not compromise the quality of my work just because it is an online setup.	3.41	1.18	Often
5. I set goals to help me manage study time for my math modules.	3.90	1.02	Often
6. I work on my math modules at a time when there are no distractions at home.	4.39	0.86	Always
7. I know the venue where I can study most efficiently for math modules.	4.02	1.15	Often
8. I try to take more thorough notes in my math class because I use those notes to answer my math modules.	3.71	1.19	Often
9. I read aloud math modules posted online or offline as a way to fight against distractions.	3.17	1.22	Sometimes
10. I prepare my questions about the math modules before joining the synchronous class.	2.29	0.87	Rarely
11. I work on extra problems in my math modules in addition to the assigned ones to master the topic.	3.00	1.02	Sometimes
12. I allocate extra study time for my online class because I know that it is time demanding.	3.71	0.93	Often
13. I try to schedule a time to study the modules for my online class and regularly observe this schedule.	3.46	0.92	Often
14. Although we do not have to attend daily classes, I still try to distribute my study time evenly across days.	3.39	1.00	Sometimes
15. I find someone knowledgeable in Math so that I can consult with him/her when I need help.	3.71	1.45	Often
16. I am persistent in getting help with the math module lesson from the instructor through e-mail (or chat).	2.90	1.02	Sometimes
17. I share my problems regarding Math modules with my classmates online, so we know what we are struggling with and how to solve our problems.	3.05	1.41	Sometimes
18. If needed, I try to connect with my classmates through video calls to ask and seek help regarding the math modules.	2.76	1.50	Sometimes
19. I communicate with my classmates to find out how I am doing in my math module activities.	2.85	1.33	Sometimes
20. I communicate with my classmates to find out if what I am learning is different from what they are learning from the module.	2.76	1.39	Sometimes
21. I summarize my learning about the math modules to examine my understanding of what I have learned.	3.78	0.91	Often
22. I ask myself a lot of questions about the content of the math modules.	3.68	1.04	Often
23. The Math modules helped me to control my learning in the online class.	3.90	1.00	Often
TOTAL	3.43	1.20	Often

Table 2: Grade 8 (n=41) Students' OSLQ Result per Item

The overall result of Grade 8 students' use of self-regulation strategies under the flexible online learning mode has an average of 3.43, which is verbally interpreted as "often." This suggests that Grade 8 students frequently use SRL strategies in their flexible online classes using math modules.

Grade 9			
	Mean	S.D	Verbal Interpretation
1. I set learning objectives or learning targets for my activities in Math class.	3.48	1.07	Often
2. I set short-term (daily or weekly) goals and long-term goals (monthly or for the semester) to accomplish my math modules.	3.70	1.05	Often
3. I keep a high standard for my learning in math class.	3.84	1.02	Often
4. I do not compromise the quality of my work just because it is an online setup.	3.50	1.05	Often
5. I set goals to help me manage study time for my math modules.	3.80	1.18	Often
6. I work on my math modules at a time when there are no distractions at home.	3.98	1.10	Often
7. I know the venue where I can study most efficiently for math modules.	4.12	1.10	Often
8. I try to take more thorough notes in my math class because I use those notes to answer my math modules.	3.68	1.25	Often
9. I read aloud math modules posted online or offline as a way to fight against distractions.	2.54	1.15	Rarely
10. I prepare my questions about the math modules before joining the synchronous class.	2.06	1.04	Rarely
11. I work on extra problems in my math modules in addition to the assigned ones to master the topic.	2.68	1.08	Sometimes
12. I allocate extra study time for my online class because I know that it is time demanding.	3.56	1.03	Often
13. I try to schedule a time to study the modules for my online class and regularly observe this schedule.	3.42	1.14	Often
14. Although we do not have to attend daily classes, I still try to distribute my study time evenly across days.	3.66	1.06	Often
15. I find someone knowledgeable in Math so that I can consult with him/her when I need help.	3.90	1.20	Often
16. I am persistent in getting help with the math module lesson from the instructor through e-mail (or chat).	2.78	1.30	Sometimes
17. I share my problems regarding Math modules with my classmates online, so we know what we are struggling with and how to solve our problems.	3.52	1.49	Often
18. If needed, I try to connect with my classmates through video calls to ask and seek help regarding the math modules.	2.94	1.42	Sometimes
19. I communicate with my classmates to find out how I am doing in my math module activities.	2.90	1.46	Sometimes
20. I communicate with my classmates to find out if what I am learning is different from what they are learning from the module.	2.92	1.41	Sometimes
21. I summarize my learning about the math modules to examine my understanding of what I have learned.	3.40	1.12	Often
22. I ask myself a lot of questions about the content of the math modules.	3.54	1.11	Often
23. The Math modules helped me to control my learning in the online class.	3.66	0.89	Often
TOTAL	3.37	0.89	Sometimes

Table 3: Grade 9 (n=50) Students' OSLQ Result per Item

The overall result of Grade 9 students' use of self-regulation strategies under the flexible online learning mode has an average of 3.37, which is verbally interpreted as "sometimes." This suggests that Grade 9 students occasionally use SRL strategies in their flexible online classes using math modules.

Grade 10			
	Mean	**S.D**	**Verbal Interpretation**
1. I set learning objectives or learning targets for my activities in Math class.	3.61	1.03	Often
2. I set short-term (daily or weekly) goals and long-term goals (monthly or for the semester) to accomplish my math modules.	3.81	0.99	Often
3. I keep a high standard for my learning in math class.	3.92	0.90	Often
4. I do not compromise the quality of my work just because it is an online setup.	3.61	1.26	Often
5. I set goals to help me manage study time for my math modules.	3.88	1.06	Often
6. I work on my math modules at a time when there are no distractions at home.	4.00	1.11	Often
7. I know the venue where I can study most efficiently for math modules.	4.24	1.04	Always
8. I try to take more thorough notes in my math class because I use those notes to answer my math modules.	3.97	1.19	Often
9. I read aloud math modules posted online or offline as a way to fight against distractions.	2.73	1.46	Sometimes
10. I prepare my questions about the math modules before joining the synchronous class.	2.34	1.32	Rarely
11. I work on extra problems in my math modules in addition to the assigned ones to master the topic.	2.86	1.30	Sometimes
12. I allocate extra study time for my online class because I know that it is time demanding.	3.47	1.09	Often
13. I try to schedule a time to study the modules for my online class and regularly observe this schedule.	3.46	1.18	Often
14. Although we do not have to attend daily classes, I still try to distribute my study time evenly across days.	3.70	1.16	Often
15. I find someone knowledgeable in Math so that I can consult with him/her when I need help.	4.00	1.12	Often
16. I am persistent in getting help with the math module lesson from the instructor through e-mail (or chat).	2.81	1.32	Sometimes
17. I share my problems regarding Math modules with my classmates online, so we know what we are struggling with and how to solve our problems.	4.20	0.95	Always
18. If needed, I try to connect with my classmates through video calls to ask and seek help regarding the math modules.	3.66	1.38	Often
19. I communicate with my classmates to find out how I am doing in my math module activities.	3.82	1.26	Often
20. I communicate with my classmates to find out if what I am learning is different from what they are learning from the module.	3.99	1.15	Often
21. I summarize my learning about the math modules to examine my understanding of what I have learned.	3.73	0.98	Often
22. I ask myself a lot of questions about the content of the math modules.	3.59	1.06	Often
23. The Math modules helped me to control my learning in the online class.	3.73	1.10	Often
TOTAL	3.62	1.25	Often

Table 4: Grade 10 (n=74) Students' OSLQ Result per Item

The overall result of Grade 10 students' use of self-regulation strategies in flexible online learning has an average of 3.62, which is verbally interpreted as often. This suggests that grade 10 students frequently use SRL strategies in the flexible online learning environment using math modules.

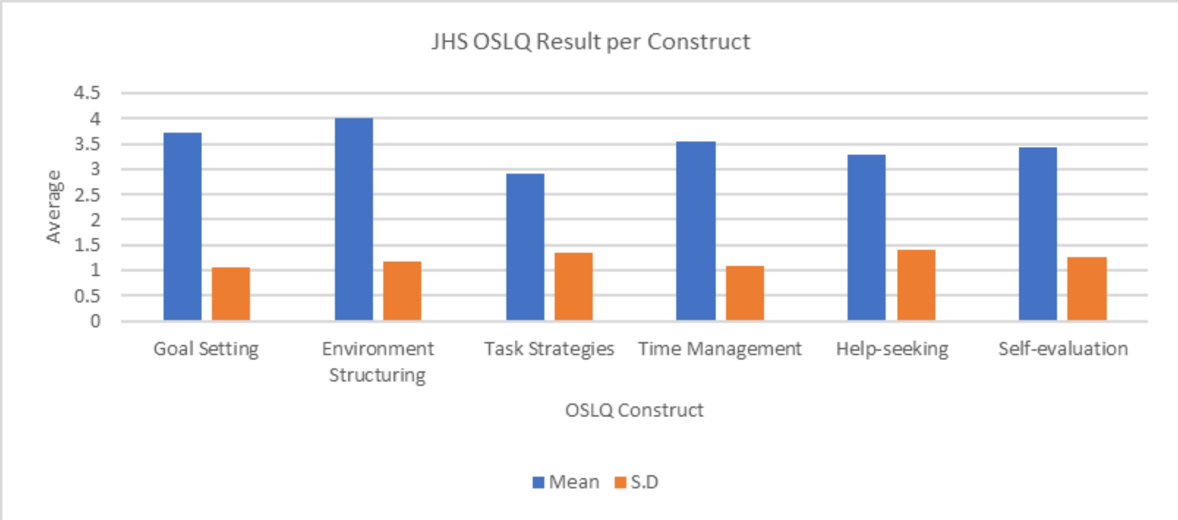

Figure 1: JHS Students' OSLQ Result

Figure 1 shows the OSLQ results of students per construct. Based on the results, one may say that the JHS students attained the highest score in environment structuring *(M=4.01, S.D.=1.16)*. This implies that students are good at finding a venue with no distractions and that they can study their math modules most efficiently. Second in rank is goal setting *(M=3.71 S.D.=1.07)*. This suggests that students perceived themselves to often set objectives to accomplish their math modules and kept a high standard for their learning in math class. Third in rank is time management *(M=3.54, S.D.=1.09)*. This indicates that students often scheduled a time to study the modules for their math online class. Next is self-evaluation *(M=3.43, S.D.=1.26)*. This shows that students often assess their understanding of the math modules.

On the other hand, the JHS students obtained the lowest mean score for help-seeking *(M=3.28, S.D =1.42)* and task strategies *(M=2.90, S. D= 1.34)*. This indicates that students were not frequently persistent in getting help in answering the math module from their math teacher, and they did not usually connect with their classmates through video calls to ask and seek help regarding their math modules. Furthermore, for task strategies, students seldom prepared questions about the math modules before joining their SLA class. Also, they did not usually work on extra problems in the math modules, and they did not usually read aloud math to fight distractions.

To determine whether there is a significant difference between the self-regulation of Grades 7, 8, 9, and 10, students' scores in the OSLQ were totaled first. After this, descriptive statistics of each grade level were obtained.

Grade Level	N	Mean	Standard Deviation	Coefficient of Variation	Minimum	Maximum
Grade 7	51	74.82	17.364	23.20%	43	106
Grade 8	41	78.95	15.377	19.48%	31	100
Grade 9	50	77.58	14.723	18.98%	42	115
Grade 10	74	83.15	13.462	16.19%	52	115
Total	216	79.10	15.348	19.40%	31	115

Table 5: Descriptive Statistics of JHS Students' OSLQ Scores

Table 5 shows the descriptive statistics of the OSLQ scores of the JHS students. Grade 10 students have the highest mean, followed by grade 8, grade 9, and grade 7 students, respectively. All coefficients of variation are less than 100% which means that the standard deviations are low in relation to the means.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2262.099	3	754.033	3.304	.021
Within Groups	48384.859	212	228.230		
Total	50646.958	215			

Table 6: Analysis of Variance

A one-way ANOVA was performed to compare students' self-regulation total scores per grade level. Before conducting the one-way ANOVA, the researcher checked if the assumptions of normality, equal variances, and independence were met. Using Shapiro-Wilk and Kolmogorov-Smirnov, Levene's test, and since participants are from different grade levels, then all the assumptions were met. The one-way ANOVA revealed a statistically significant difference in grade level between at least two groups (F (3, 212) = 3.304, p = 0.021).

GRADE		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
7	8	-4.128	3.169	.562	-12.33	4.08
	9	-2.756	3.007	.796	-10.54	5.03
	10	-8.325*	2.749	.015	-15.44	-1.21
8	7	4.128	3.169	.562	-4.08	12.33
	9	1.371	3.183	.973	-6.87	9.61
	10	-4.197	2.941	.484	-11.81	3.42
9	7	2.756	3.007	.796	-5.03	10.54
	8	-1.371	3.183	.973	-9.61	6.87
	10	-5.569	2.766	.186	-12.73	1.59
10	7	8.325*	2.749	.015	1.21	15.44
	8	4.197	2.941	.484	-3.42	11.81
	9	5.569	2.766	.186	-1.59	12.73

Table 7: Paired Comparisons using Tukey HSD

To determine the levels that have a significant difference, Tukey's HSD Test for Multiple Comparisons was used. It was found that the mean value of grade level was significantly different between Grade 7 and Grade 10 (p = .015, 95% C.I. = [-15.44, -1.21]). On the contrary, there was no statistically significant difference between Grade 7 and Grade 8 (*p*=.562), Grade 7 and Grade 9 (*p*=.796), Grade 8 and Grade 9 (*p*=.973), Grade 8 and Grade 10 (*p*=.484), and Grade 9 and Grade 10 (*p*=.186).

	Grade 7			Grade 8			Grade 9			Grade 10		
	M	S.D	V.I	M	S.D	V.I	M	S.D	V.I	M	S. D	V.I
Goal Setting	3.70	1.16	Often	**3.68**	**0.97**	Often	3.66	1.08	Often	3.76	1.06	Often
Environment Structuring	3.67	1.37	Often	**4.21**	**1.07**	Always	4.05	1.10	Often	4.12	1.08	Often
Task Strategies	2.85	1.34	Sometimes	**3.04**	**1.19**	Sometimes	2.74	1.27	Sometimes	2.98	1.44	Sometimes
Time Management	3.55	1.14	Often	**3.52**	**0.95**	Often	3.55	1.08	Often	3.55	1.14	Often
Help-seeking	2.83	1.43	Sometimes	**3.10**	**1.40**	Sometimes	3.29	1.42	Sometimes	3.67	1.31	Often
Self-evaluation	3.13	1.38	Sometimes	**3.40**	**1.21**	Sometimes	3.28	1.25	Sometimes	3.77	1.11	Often

Table 8: OSLQ Result per Construct per Grade Level

Table 8 shows that all grade levels often used strategies for goal setting, environment structuring, and time management. On the other hand, task strategies were infrequently used. Furthermore, grade 10 students often used help-seeking and self-evaluation strategies, unlike in Grades 7, 8, and 9, who only used them sometimes. This suggests that grade 10 students seek help more and evaluate themselves better than grades 7 to 9. Overall, JHS students often use goal setting, environment structuring, time management, and self-evaluation strategies.

RQ2. What are the students' experiences in using mathematics modules to support their self-regulation in a flexible online learning environment?

The researcher followed Braun and Clarke's six phases of analysis (2006) as a guide in doing the thematic analysis for focus group discussion. The findings underwent member checking, also known as respondent or participant validation, to check their accuracy. This process increased the reliability of the findings (Birt et al., 2016). The emerging themes did not vary between groups. The four themes produced were shown in Figure 2.

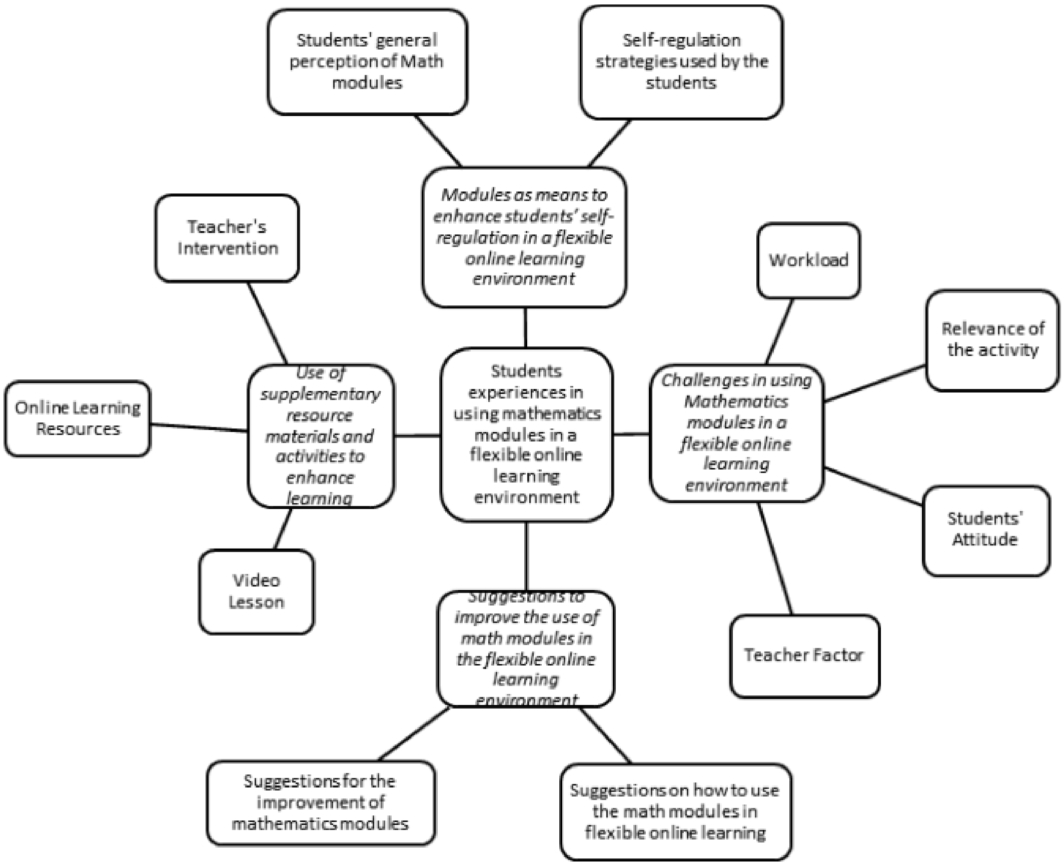

Figure 2: Thematic Map for Focus Group Discussion

Theme 1: *Mathematics modules as a means to support students' self-regulation in a flexible online learning environment.*

Most of the participants across groups gave a positive assessment of the use of mathematics modules. They stated that modules served as their guide and helped them learn in a flexible online learning setup. Students shared how the modules helped them in their online mathematics classes. They emphasized that they used mathematics modules in studying their math lessons. Participants said that mathematics modules assisted in studying in advance for their lessons and in deepening their understanding of the topic, especially whenever they missed a lesson.

> ***G8-34:***
> *Yes, because it also helps me beforehand, before SLA class starts, it helps me advance study in [a] certain lesson.*
>
> ***G9-40:***
> *But whenever I look across those, I think they are important, especially since they are not exactly required. They are, I believe, to help encourage the students in learning and to understand the topic better. Whenever you missed a lesson, they give you an opportunity to enhance or deepen your understanding of a topic or a lesson.*

Furthermore, mathematics modules helped students perform well in math as these complemented the SLA discussions.

G7-14:

For me po, it helps me perform well in my Math online class because the information in the module makes me generate more questions in my mind. Which I then put into a list form to ask during SLA sessions.

Also, the students shared their experiences in using different features of the modules. The students expressed how they used these features in their planning, goal setting, environment structuring, task strategies, time management, help-seeking, and self-evaluation, as shown in the following quotes.

Planning	*G9-33:* *Dun po sa first part ng module, meron pong module planner and naka-help po dun yung pagpa-plan kasi meron po yung target date and such. And dun ko po madalas binibase yung pagsasagot ko ng Math modules. Maybe around 1-2 module activities po per day.* English Translation: In the first part of the module, there is a module planner, and it helps me with planning my schedule because there is a target date and such. And that's where I often base when to answer my math modules. Maybe around 1-2 module activities per day.
Goal setting	***G9-19:*** *And yung list of most essential competencies po is going to give you ng parang goal or objectives po that you need to attain when accomplishing the module.* English Translation: And the list of most essential competencies is going to give you a goal or objectives that you need to attain when accomplishing the module.
Environment Structuring	***G10-29:*** *In accomplishing the module activities, I do it with my friends. We started doing it from the first quarter until the fourth quarter po. I think it's really fun to accomplish it with friends since hindi lang ikaw yung nahihirapan pati sila nahihirapan din.* English Translation: In accomplishing the module activities, I do it with my friends. We started doing it from the first quarter until the fourth quarter. I think it's really fun to accomplish it with friends since it's not just you struggling. They are also struggling.
Task-strategies	*G7-51:* *The strategy that I used is just to go lesson by lesson and do the activities right after the teacher discussed the lessons during the SLA lessons.*
Time-management	*G9-40:* *As for the module planner itself, is quite essential because it helps you organize what you are going to do and what can you do. It shows you what you have and haven't accomplished, and personally, for me, who is someone who quite struggles to make a reliable schedule with the task I do, it is quite a lot of help.*
Help-seeking	*G7-5:* *Yes po. Sometimes po when I get confused, I either asked help from people or look on the internet.*
Self-evaluation	*G9-21:* *For the list of most essential competencies and module planner, it helped me assess myself po in answering the following module activities.*

Table 9: Excerpt from FGD (Verbatim)

These responses illustrate that the features of the math modules, such as the pre-test, list of most essential competencies, module planner, and self-check activity encouraged them to use self-regulation strategies. On the other hand, module activities and answer keys allowed the students to perform well in their classes as they helped them gain the necessary math skills.

> ***G7-39:***
> *They help me to perform well po because the math modules po are the only things I used upon reviewing po for something po or for refreshing before answering an activity po.*
>
> ***G10-32:***
> *The answer key, it will help you enhance your skill po. Kasi sometimes, yun nga, may mistake yung answer key. So, with that, you have to take to your teacher and ipaglalaban mo na mali yung nasa answer key at tama yung sagot mo. You have to persuade him or her (teacher) na tama yung process mo.*
>
> English Translation:
> The answer key will help you enhance your skill. Sometimes, answer keys contain mistakes. From there, you can discuss with your teacher that the answer key is wrong, and your answer is correct. You must persuade your teacher that your solution is correct.

Students also talked about some of the task strategies they used for their mathematics class. For example, one student shared that she took notes during SLA and compared it to the math module for better understanding.

> ***G10-24:***
> *For me po, nagnonotes lang din po ako from the SLA session tapos chinicheck ko lang po uli sa module kung ano yung pinakameaning ng lesson na iyon or formulas.*
>
> English Translation:
> For me, I just took notes from the SLA discussion, and then I studied the modules to understand better the lesson or the given formulas during SLA.

Theme 2: *Use of supplementary resource materials and activities to enhance learning.*

It is also revealed that students used help-seeking strategies not mentioned in the OSLQ. They shared that whenever they find the topic in the math module hard to understand, aside from asking for help from other people, they use supplementary materials. The links to some of these materials can be found in the mathematics modules. Here are some quotes about students' use of video lessons.

> ***G8-30:***
> *Here is my response to the YouTube links embedded in the modules. Some students find it necessary because the videos contain step-by-step instructions for those who haven't fully grasped the lessons.*
>
> ***G7-14:***
> *I think these links are very important po because they further explain the topic to the students aside from the given examples of the teacher in the SLA and in the module, nagbibigay din po ng examples yung mga YouTube links and Khan Academy.*
>
> English Translation:
> I think these links are very important because they further explain the topic to the students aside from the given examples of the teacher in the SLA and in the module. YouTube [videos] and Khan Academy also give examples.

While these are some of the statements about their use of online learning resources.

G8-29:
Pero yung ibang website links po tulad ng desmos and other stuff, I think medyo importante po iyun kasi kapag mahirap po talaga yung topics and need na po ng help, I think dun na po papasok yung help ng mga websites na iyun.

English Translation:
But the other website links like Desmos [calculator] and other stuff, I think that's quite important because when the topics are difficult, and you need help, I think that's where the help from those websites comes in.

G10-24:
Tapos I seek help, minsan lang po. And usually po, I tried to do it myself po. I try to search in google po.

English Translation:
I seek help sometimes. Usually, I try to do it myself. I try to search on Google.

Moreover, students preferred to listen to their teachers during SLA discussions before working on their modules. One student expressed that SLA discussions are better than modules alone since their learning styles are addressed.

G9-40:
I have to agree that when it comes to comparing these two ways of taking information [module and synchronous meeting], I believe that when it comes to – let's say – the teacher is presenting the module and discussing the topic with the teacher, it is more effective because, like the other participant has said, each and every student is different from the other students. Each one has [their] own way of learning, either auditory, visual, tactile, etc. And also, I would like to bring up that you can ask the teacher and have discussions, which are more interactive [than answering modules]. You can discuss this in real-time. Connection is being made. And when you compare it with just reading the module by yourself, there isn't much variety to it. It is just you reading whatever is on the module, and there is not much auditory or much discussion between you and the module itself.

Theme 3: *Challenges in using mathematics modules in a flexible online learning environment.*

It is revealed that students also experienced challenges in using the mathematics modules in flexible online learning. Due to the number of activities, not only in the math modules but also in other subjects, students expressed that they felt overwhelmed.

Workload

G10-70:
But to be honest, sometimes, it is quite tedious working on these activities because there are other activities that we need to do in other subjects. And sometimes it is hard to do these extra activities.

G9-38:
It's overwhelming po because of the number of activities in it.

Some students also find it unnecessary to answer some module activities because they need to see the relevance of these to real-life scenarios. One student explained that the activity was unnecessary if it was not in line with the topic, and he could not see how it relates to real-life situations.

Relevance of the Activity

G9-31:
And also, yung essential questions and Bedan talk po, I just answer it when it's required po but actually it is unnecessary na po for me. And this year po, parang wala naman na akong masyadong naencounter na essential questions and just the Bedan talk. But for me po, I don't think na it is not in line with the topic po talaga. So parang naging reckless lang po yung naging sagot ko because I really don't know how it is related to real-life situations and the Benedictine Hallmarks.

English Translation:
And, regarding the essential questions and Bedan talk, I just [answered] them when required but actually, it is unnecessary for me. And this year, it seems that there [were] fewer essential questions and Bedan talks. But for me, I [didn't] think that they [were] in line with the topic. So, it is like, I [answered] them carelessly because I [didn't] know how they [were] related to real-life situations.

Furthermore, the participants also clarified that the reasons for not frequently asking for help from their teachers were that they were shy, and they felt intimidated by their teachers since they seem not approachable.

Student Attitude toward Learning and Teacher Factor

G9-21:
And in seeking help po, I usually don't seek help because I have fewer friends po in the class. And somehow, I find the teacher intimidating. I am afraid to get asked po if I am really listening to the discussion.

G10-29:
I try not to [ask for help] so that I can be more independent. And my math teacher is not really approachable po.

Theme 4: *Suggestions to improve the use of mathematics modules in the online learning environment.*

Through these challenges, they gave the following suggestions. For the content of the module, they suggested lessening module activities, providing detailed examples of the different math problems, considering the learning styles of the students, and providing vocabulary or review activities and more difficult word problem samples. Moreover, they suggested that students may allot time to accomplish the module activities, and teachers may offer options on how to accomplish the module activities. Here are some of their statements:

G8-26:
But I think it is important to be given a chance to think freely outside of the given formulas and given answers. Otherwise, I find it a bit hard since it helps me change my trend of thought after I was just thinking about formulas.

G9-21:
I think the modules are quite wordy po that somehow confuses the other students. Instead of creating a whole paragraph po, I think it would be better we have a page po for the different terminologies.

G9-40:
Each one has [their] own way of learning, either auditory, visual, tactile, etc. And also, I would like to bring up that you can ask the teacher and have discussions, which are more interactive. You can discuss this in real-time. Connection is being made. And when you compare it with just reading the module by yourself, there isn't much variety to it. It is just you reading whatever is on the module, and there is not much auditory [stimulation] or much discussion between you and the module itself.

RQ3. What are the teachers' experiences in using mathematics modules to support students' self-regulation in a flexible online learning environment?

The researcher interviewed individually the math teachers from different grade levels to gather their observations regarding students' SRL in the classroom. The researcher also followed the six phases of analysis of Braun and Clarke (2006) as a guide in doing the thematic analysis. The findings also underwent member checking, also known as respondent or participant validation, to check their accuracy and to increase the reliability of the findings (Birt et al., 2016). The four themes produced were shown in Figure 3.

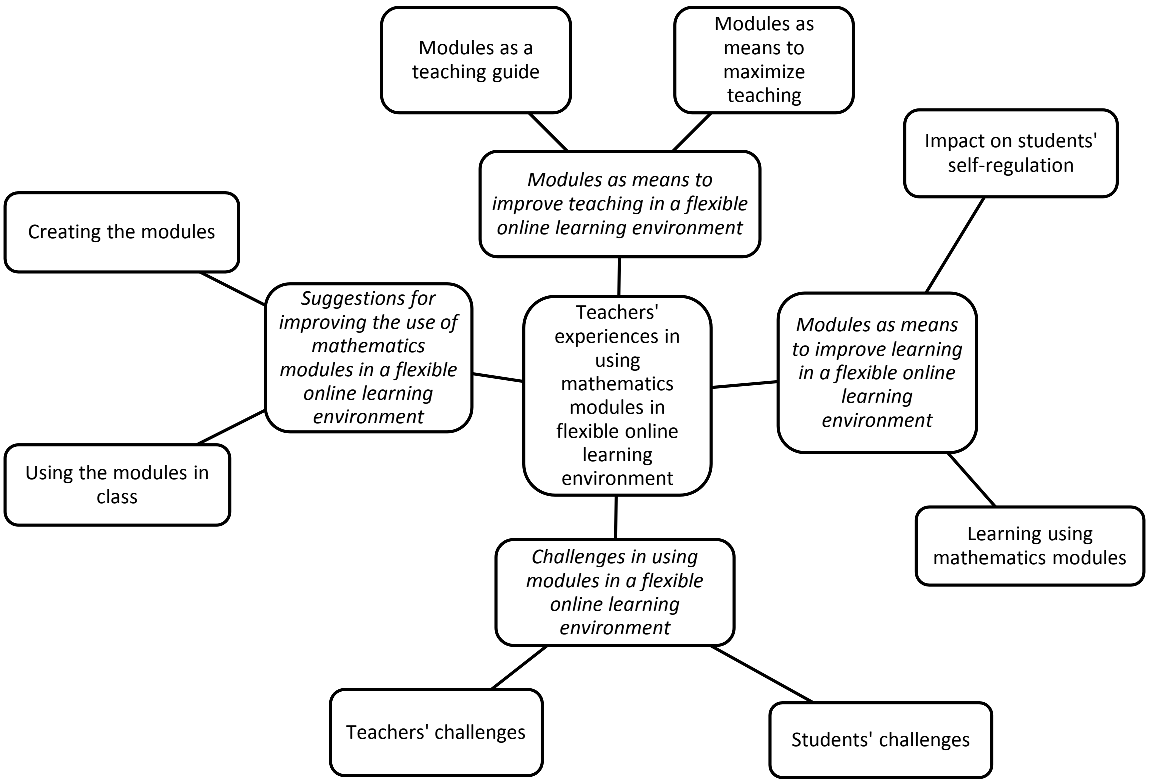

Figure 3: Thematic Map for Individual Interviews

Theme 1: *Mathematics modules as means to improve teaching in a flexible online learning environment.*

The teachers emphasized that the modules served as their guide during discussion. Also, modules helped teachers maximize their time in the flexible online learning setup. Teacher A shared that in the current setup, many learning activities can be given to the students using modules, unlike in the face-to-face setup where modules were not utilized.

> ***Teacher E****:*
> *In my class po kasi, I used the modules as my guide during the discussion. For example, I want my students to try the content or topic that we discuss during SLA, I'm going to ask my students to answer specific activity in the module po. So that's one, that's one way I used the module.*
>
> ***Teacher A:***
> *Actually, ito yung napansin ko. Compare dun sa face-to-face na set-up natin, yung module natin, marami siyang activities. Mas marami yung activities na naibibigay natin sa students because of the module compare nung andoon tayo sa face-to-face set-up.*
>
> English Translation:
> Actually, this is what I noticed. Compared to our face-to-face setup, our module has many activities. There are more activities that we can give to students because of the module compared to when we were in the face-to-face set-up.

Teachers also viewed the answer key as an immediate way of giving feedback to students that allowed them to monitor their own performance in answering the mathematics module activities.

> ***Teacher A:***
> *Beneficial, first, yung answer key. Kasi parang feedbacking na rin iyon eh. Makikita nila agad kapag nagsolve sila, kung tama yung sagot nila o hindi.*
>
> English Translation:
> The answer key is, first, beneficial. Because that's like giving feedback too; they will see immediately when they solve if their answer is correct or not.

One teacher also shared that, through the modules, he can encourage his students to study in advance about the lessons to be discussed during SLA.

> ***Teacher E:***
> *The other one is if I want them to do the advanced reading. So, before the SLA session, I'll ask my students to do the advanced readings, which is the module nga po. So those are the two things na ginagamit ko yung module in my class.*

Math modules also helped math teachers teach under the flexible online learning mode. One teacher shared that the math module served as his guide in class as it helped him with the activities to be assigned in class. He also emphasized that the answer keys made it easier for him to check students' outputs.

Teacher E:
Para sa akin naman, as a teacher, mas madali magturo since meron ng prepared activities included sa modules. So I don't have to think of another activities na kailangan nilang gawin during ALA. That's one. Second is yung sa answer key nga, mas madali na para sa akin magcheck since nacheckan na nila and I just have to double check their work. Ayun so, I think that's it.

English Translation:
Teacher E: For me, as a teacher, it is easier to teach since there are prepared activities included in the modules. So, I don't have to think of another [set of] activities they have to do during ALA. That's one. Second is the answer key; it's easier for me to check since they have already checked their work, and I just have to double-check their work. So, I think that's it.

Theme 2: *Mathematics modules as means to improve learning in a flexible online learning environment.*

It was revealed that different features of the mathematics modules allowed the students to engage in different self-regulation strategies were also supported by the analysis of teachers' individual interviews.

Goal Setting	***Teacher A**:* *Maganda 'yung module planner actually. Kasi, una pa lang, pwede 'yung, let's say ALA, pwede nilang i-list 'yung [activities] and then ma-answer nila. Guide kasi nila 'yun para ma-accomplish 'yung module.* English Translation: The module planner is good. Because it's possible that, let's say, it's their ALA. They can list the activities, and then they can answer them. Because that is their guide to accomplishing the module.
Task Strategies	***Teacher B:*** *Magtatanong ako bago mag-start kasi instruction ko rin 'yun sa kanila na read ahead of time; parang [babasahin nila] or study na the module para during SLA meetings, example na lang [kami]. May mga nakakasagot na agad. Talagang alam na nila yung lesson namin.* English Translation: I will ask questions at the start of the discussion because I also instructed them to read ahead of time, like they should read or study the module. So that, during SLA meetings, we will focus on examples. There are students who can answer immediately. They know our lesson.
Time management	***Teacher A:*** *'Yung parang – I don't know. Siguro kasi gano'n yung thinking nila. Siguro kung ako din yung student, gano'n din yung iisipin ko – na instead [of] wasting the time of the class for my question, I'll just listen first and then, kung meron akong tanong, during ALA na lang. Kaming dalawa na lang ni teacher. Parang gano'n.* English Translation: It's like – I don't know. Maybe because that's how they think. Maybe if I were the student, I would think the same thing; instead of wasting time in class on my question, I'll just listen first, and then, if I have a question, I will ask it during ALA. So it's just the two of us: the teacher and me. Something like that.
Help-seeking	***Teacher B:*** *Nakatulong din yung SLA recordings kaya nabawasan yung mga nagtatanong na bata. Kasi nare-replay nila. At sabi ko naman sa kanila na they may rewatch the SLA recordings kung may mga concern [sila], bago [nila] itanong talaga sa akin ['yung mga tanong nila]. Sinusunod naman nila yun.* English Translation: The SLA recordings also helped in minimizing the number of students who asked me questions. [It's] because students can replay them. I also told them that they could rewatch the SLA recordings if they had any concerns before they ask me questions. They do just that.
Self-evaluation	***Teacher A:*** *So, I think, it's a good point of the module na meron siyang answer key kasi nave-verify nila agad kung yung answer nila ay tama.* English Translation: So, I think, it's a good point of the module that it has an answer key because they can immediately verify if their answer is correct.

Table 10: Excerpt from Interviews (Verbatim)

Teachers also observed that students learn through the mathematics modules. Teachers explained the different learning processes that students went through using the modules. Also, one teacher noticed that students could answer during the discussion since they have read the module.

Teacher B:
Sa modules, since may book rin naman sila, siyempre, kumukuha ako ng resources na iba. I mean parallel with the book pero may ibang approach. May discussion and after that may activity agad. Discussion-activity, discussion-activity. May mga Explore [activity] na pwede nilang ma-watch, tapos a-answeran nila 'yung mga guide [question]. O [kung] may mga problem, doon sa Explore [activity] pa lang may problem na agad para malaman natin kung paano iso-solve [mga] 'yun nang hindi pa naituturo sa kanila 'yung problems. Or baka alam na nila i-solve. And then sa module natin may apat na part e: Explore, Firm-Up, Deepen, and Transfer. So, sa Deepen [part], more on problem-solving. Sa Transfer [part], mga PT, mini-tasks. Gano'n, miss.

English Translation:
In the modules, since they also have a book, of course, I use different resources, I mean those that are parallel with the book but with a different approach. After the discussion, there is always an activity. So, it's like discussion-activity, discussion-activity. There are also Explore activities that they can watch, then they will be able to answer the guide questions. Or there are problems in the Explore activity so that we can know how they will solve them even though I have not taught to them. And then, in our module, there are four parts: Explore, Firm-Up, Deepen, and Transfer. So, in the Deepen part, that section is more on problem-solving. In the Transfer part, it's more on PTs [performance tasks], and mini tasks,

Teacher C:
Also, sometimes, ayun nga 'yung answers nila doon na nanggagaling. So kapag ako naman ang nag-ask ng questions, 'yung answer nila ay based on what they have read [on the module].

English Translation:
Also, sometimes, that's where their answers come from. So, when I ask questions, their answer is based on what they have read [on the module].

Furthermore, teachers clarified that students do not often ask for help because they were oriented on what to do if they find the lesson in the mathematics module difficult to understand.

Teacher C:
Kasi, it has been discussed na rin with the students na before the consultation would be done, they have to look at the procedures muna, which is 'yun nga, reviewing muna of the recordings, then the modules; pero, kung hindi talaga na maintindihan, that's the time that we will schedule for a consultation.

English Translation:
It has been discussed with the students that, before a consultation period is done, they must look at the procedures first, which is, as I said, reviewing the recordings first and then the modules. If they cannot understand them, that's the time to schedule a consultation period.

Teachers also noticed that most students preferred to listen first in the SLA discussion before they answered the module activities or instead of asking questions about the module activities. One teacher explained that the possible reason for this is for them to maximize their time in accomplishing their tasks.

> ***Teacher A:***
> *'Yung parang, I don't know, siguro kasi gano'n yung thinking nila. Siguro kung ako din yung student, gano'n din yung iisipin ko na "Instead [of] wasting the time of the class for my question, I'll just listen first and then, kung meron akong tanong, during ALA na lang – kaming dalawa na lang ni teacher." Parang gano'n.*
>
> English Translation:
> Teacher A: It's like, I don't know, maybe because that's how they think. Maybe if I were the student, I would think the same thing: "Instead of wasting time in class for my question, I'll just listen first, and then, if I have a question, I'll ask it during ALA. It's just me and the teacher." Something like that.

Furthermore, one teacher observed that students had developed the initiative to accomplish their tasks during ALA without teachers' instruction.

> ***Teacher C:***
> *In accomplishing their tasks, I noticed na yung students na mismo yung naghahanap [ng activities]…sometimes, there are times kasi in a quarter, especially kapag alam natin na sabay-sabay na talaga 'yung activities nila, na binabawasan na natin yung pinapagawa natin sa kanila. So, there was a time na hindi ko na binigay yung certain activity for ALA; meron na akong hindi inassign, or meron na akong binawas; but then, the students themselves are asking me na "Miss, should we answer this po?" Kasi it has become a routine for them already. So ayun yung napansin ko – na they were able to build up a routine na alam nila na, kapag ALA time, "Itong part ng module 'yung kailangan kong i-answer." Then, [merong] proficiency task after.*
>
> English Translation:
> In accomplishing their tasks, I noticed that the students themselves were searching [for the activities]. There are times in a quarter, especially when we know that there are activities in different subjects that are given at the same time, we reduce the activities that we ask them to do. So, there was a time when I didn't give a certain activity for ALA, I didn't assign something, or I deducted something; but then, the students themselves asked me, "Miss, should we answer this?" [It's] because it has become a routine for them already. So that's what I noticed that they were able to build up a routine that they know that when it's ALA time, "This part of the module is what I must answer." Then, [there is a] proficiency task after.

Theme 3: *Challenges in using mathematics modules in a flexible online learning environment.*

The findings from the interview revealed that teachers also experienced challenges in using the math modules in flexible online learning. These challenges include training, limited resources, and time, minimizing the activities, student's motivation, and learning styles.

Due to the sudden shift from face-to-face to online learning, there was not enough training for the teachers on how to write the mathematics modules, as mentioned by the teachers.

Training

Teacher A:
Trainings? Parang wala yata. For webinars? Webinars in creating a module? I can't remember e. Siguro, di siya workshop e, so baka webinar nga lang siya.

English Translation:
Training? I think there were none. For webinars? Webinars in creating a module? I can't remember. Maybe, it's not a workshop, so maybe it's just a webinar.

Teacher E:
Actually, since this is my first year po and I only created modules for one quarter only; unfortunately, wala akong training. So binase ko yung module du'n sa mga previous modules na pinasa lang rin sa akin. And then I tried to improve [them] lang.

English Translation:
Since this is my first year, and I only created modules for one quarter only; unfortunately, I have no training. So, I based that module on the previous modules that were also passed on to me. And then I just tried to improve [them].

They also shared that there were limited resources and time for the teachers to create the mathematics modules.

Limited Resources and Time

Teacher A:
Actually, I don't rely more on modules. Kung ano yung mga difficulties na na-encounter ko sa modules, siguro yung paggawa ng module. Ayun, siguro yun 'yung pinaka-challenging para sa akin. Kasi, I think I have a limited access, 'yung mga [source], sa paggawa ng module. 'Yung, doon, kulang ako. So kulang ako ng mga [resource]. Kasi nga, di ba, 'andito lang tayo sa bahay. Kulang tayo sa access sa mga [reference] na pwede nating ilagay doon sa module.

English Translation:
I don't rely more on modules. One of the difficulties that I encounter is, maybe, preparing the module. Well, maybe that's the most challenging [thing] for me. Because I think I have limited access to the sources in making the module. So, I lacked resources because we were just here at home. We lacked access to references that we can include in the module.

Teacher D:
Kasi medyo mabilis nga, like what we have mentioned in the synchronous class; kasi, before, in the F2F class, 5 times natin sila nami-meet every week, a total of 5 hours. Unlike now, twice lang or 2 hours per week, and then sa hapon for ALA na iyon.

English Translation:
Because it is quite fast, like what we have mentioned in the synchronous class; because, before, compared to the F2F class, we met them 5 times every week, a total of 5 hours. Unlike now, only twice or 2 hours per week, and then in the afternoon we hold ALAs.

Also, teachers find it difficult to lessen the module activities due to numerous competencies.

Minimizing the Activities

Teacher A:
And also, yung sa paggawa ng module, isa sa mga difficulty na na-encounter ay kung paano siya gagawing brief, pero 'andun lahat. Kasi parang gusto mo na 'yung module pa lang can stand alone, that the student can learn from the module itself. 'Yung module lang, meron na silang matututunan; pero, parang napakahirap kasi kailangan siya na i-summarize mo. Tapos kaunti lang 'yung activities kasi you cannot expect them to finish din. Kasi nga ang dami din nilang modules [sa ibang subjects]. So ayun yung pinaka-challenge doon – 'yung paggawa ng modules.

English Translation:
And also, when making the module, one of the difficulties I encountered was how to make it brief but complete. Because we want the module to be a stand-alone that the students can learn from; even though they have modules only, they will learn. But it seems very difficult because you need to summarize a lesson, then only a few activities must be included because you cannot expect them to finish either. They also have many modules [in other subjects]. So, that's the most challenging thing there – the creation of modules.

Teacher D:
So sa [cons], hindi na siguro magiging [beneficial] ang module kapag it is very long. There is a tendency kasi na the students will not read it anymore. So as much as possible, we try to make a creative module, 'yung talagang kaunti lang.

English Translation:
So, for [cons], maybe the module will not be beneficial anymore when it is very long. There is a tendency that the students will not read it anymore. So as much as possible, we try to do a creative module that is short.

Lastly, teachers find it challenging if there are students who are not motivated to attend an online class. They noticed that there were a few students who were not attending the SLA meeting and who could not submit their module activities. Also, they observed that not all learning styles are catered to in the modules.

Students' Motivation and Learning Styles

Teacher D:
'Yung mga batang hindi ganoon ka-motivated to attend the online class, sila rin yung students na nagkakaroon ng difficulties during the ALA period or in submitting their deliverables. Kasi, we can check through their class notebook, kung nakapag-submit ba talaga sila. And as early as first quarter, nagbibigay na kami ng guidelines kung paano ang gagawin since the answer key is provided.

English Translation:
Those children who are not that motivated to attend the online class, they are also the students who have difficulties during the ALA period or in submitting their deliverables. Because we can check through their class notebook if they really submitted it. And as early as the first quarter, we are already giving guidelines on how to do it since the answer key is provided.

Teacher A:
And then for "not beneficial" naman: 'yung module natin ay hindi naka-cater [sa] lahat ng learning styles. Para sa akin, ha? Hindi naka-cater lahat ng learning styles. Naka-print e o kaya PDF e. Although, may mga YouTube video naman, pero would they try to open [them]? Baka 'yung iba, [papanoorin] na lang 'yung recorded meeting. So, I think na hindi…ganoon ka-wide yung nasasakop niya na learning styles ng students. Hindi siya applicable for all.

English Translation:
And then for "not beneficial": our module does not cater to all learning styles. For me, not all learning styles are catered for. The modules are either printed or in PDF format. Although there are YouTube videos, would they try to open them? Maybe others will just watch the recorded meeting. So, I think that modules do not cover the learning styles of students. It is not applicable to all.

For the students' part, teachers agreed that the number of activities hindered students from studying in advance for their math class.

Heavy Workload

Teacher E:
Actually, I ask some students kung bakit nga gano'n, and one of their concerns is that there are lots of assessments that they need to accomplish during the ALA period. That's why they don't have the time [for] advance reading. Parang [sa] ALA nila, actually, nag-aaral nga rin sila tuwing gabi. Kinakaya na lang kasi nagsasagot nga sila ng mga [assessment] or ng activities ng previous topic pa. So kahit i-assign mo nang advance, kahit 'yung mga magagaling nag-struggle din lalo na kapag nag-assign ka ng advance reading tapos sinabay mo pa sa mga [assessment].

English Translation:
I ask some students why, and one of their concerns is that there are lots of assessments that they need to accomplish during the ALA period. That's why they don't have the time to do advanced reading. Aside from their ALA period, they also study at night. They also answer the assessments or the activities of the previous topic. So even if you assign a reading in advance, even the model students struggle, especially when you assign advanced reading together with the assessments.

Theme 4: *Suggestions for improving the use of mathematics modules in flexible online learning.*

Teachers also gave suggestions to improve the math modules based on their experiences. In creating the math modules, they suggested lessening the module activities, adding a section for vocabulary words, indicating the duration of each activity, providing a link for a real-time record sheet, and giving more sample problems. They also suggested establishing routines for using the math modules in class and using them in peer learning and flipped learning. These are the sample quotes from teachers.

Add vocabulary Words	***Teacher A:*** *So maybe suggestion na lang is we can put vocabulary words, maybe, definition of terms; pero, may gano'n naman tayo sa ibang part.* English Translation: So maybe my suggestion is we can put vocabulary words, maybe, definitions of terms, although we have that already in other parts.
Lessen module activities	***Teacher B:*** *Recommended pero siguro modify ['yung modules]. Especially 'yung mga [activity]. May mga [activity] kasi nga di naman na ginagamit. So kung di naman na useful, huwag nating ilagay. Kasi last year, may Activity 1 tapos may 1.1, 1.2, and 1.3 pa. So siguro [isang activity] na lang.* English Translation: Recommended but maybe let's modify the modules, especially the activities that are no longer used. So, if it's not useful, don't put it. Because, last year, there was Activity 1; then, it was followed by Activity 1.1, 1.2, and 1.3, and so on. So maybe just put one [activity] only.
Add real-time record sheet	***Teacher C:*** *Siguro, we could have the scores kung saan nilalagay, or maybe…real-time na monitoring…for example, you [can] give the students…flexible time kung kailan nila ia-answer. Pero siyempre dapat may deadline pa rin. Yes, they are free to do it during their available time pero dapat meron pa ring certain time kung kailan dapat tapos na sila sa task na iyon. For example, lesson number, bibigyan lang si student ng a week. Maybe a week will do naman for him/her to do or finish 3 activities especially if 5 points or 5 items lang na activity iyan.* English Translation: Maybe, we could have the scores where they are supposed to be placed, or maybe real-time monitoring…for example, you [can] give the students… flexible time when they will answer. But of course, there should still be a deadline. Yes, they are free to do it during their available time, but there must still be a certain time when they must be done with that task. For example, in a lesson number, the student will only be given a week. Maybe a week will do for him/her to do or finish 3 activities, especially if that activity is only worth 5 points or 5 items.
Include time duration for each activity	**Teacher C:** Of course, as teachers, we know naman that they [students] can accomplish it, an hour would do. Pero yun nga, with a problem of students being not able to answer yung certain activity, siguro kahit module activities yan, dapat meron pa ring deadline na nakalagay. So if in the module kung may idadagdag man ako, siguro nga yun ay yung deadline, para din dun sa summative assessments masanay din sila na mayroong deadline na kailangan sundin. So not really a specific deadline naman na kunwari yung specific date ay ilalagay, but maybe in the activities, lalagyan ng time duration kung gaano katagal nila ianswer. Para masanay sila na may time monitoring din dapat sila on their own para kapag nagtake na sila ng summative assessments, sanay na sila. And together, nadedevelop na rin yung speed nila as they do those formative assessments. English Translation: Of course, as teachers, we know that they [students] can accomplish it, an hour would do. However, with the problem of students not being able to answer a certain activity, maybe even if it's just a module activity, there should still be a deadline. So, in the module, if I must add something, maybe that is the deadline for every activity so that in the summative assessments, they can also get used to having a deadline that needs to be followed. So not really a specific deadline as if the specific date will be set, but maybe in the activities, time duration will be set for how long they will answer. For them to get used to having time monitoring so that when they take summative assessments, they are used to it. And together, their speed is also developed as they do those formative assessments.
Provide more sample problems	**Teacher E:** Actually, maganda kasi yung module na naprepare ng school. Complete siya, meron siyang objectives, essential questions, lahat. So I think, walang pangit na feature yung module natin. But if you'll ask me if what are the things we need to improve in those modules is that yun nga, yung examples. Pili lang yung content na may mga examples. Lesser activities, wherein yung activities ay covered niya na karamihan ng competencies, hindi lang isang chunk or yung isang part. So lesser activities pero maraming competencies [na kasama]. English Translation: Actually, the module prepared by the school is good. It is complete, it has objectives, essential questions, and everything. So, I think, our module has no unlikeable features. But if you'll ask me what to improve in those modules is the examples. Only selected contents have examples. Lesser activities, in which the activities covered most of the competencies, not just a chunk or a part. So lesser activities but many competencies [included].

Table 11: Excerpt from Interview (Verbatim*)*

Discussion

The first aim of this study is to gain an understanding of how students manage their learning in a flexible online learning environment. The results showed that students attained the highest score in environment structuring. This result is aligned with the study of Nitcher (2021) and Kulusakli (2021) since students also obtained the highest mean score in environment structuring. It was also revealed that students often set goals, next to environment structuring, for their class, and they rarely used help-seeking and task strategies. This result is supported by the study of Martinez-Lopez et al. (2017) and Jurisevic et al. (2021). Since the transition from face-to-face to online learning was abrupt, students might have felt the need to focus first on environment structuring, and goal-setting strategies as these might have helped them in dealing with the situation effectively (Jurisevic et al., 2021). Also, students might have difficulty getting help from other people, such as their teachers and classmates, as they felt embarrassed (Kulusakli, 2021).

Based on the mean scores of each grade level per construct, grade 10 students often used help-seeking and self-evaluation strategies more than grades 7, 8, and 9 students. It was found that the mean value of grade level was significantly different between grades 7 and 10. The grade 10 students have higher mean scores than Grade 7 students. This result is in accordance with the results of the study of Kirkic & Demir (2022) and Babayigit and Guven (2020), wherein there was a significant difference between students' self-regulation and their age or grade level. A possible reason why grade 10 students' OSLQ mean score is higher than the grade 7 students' OSLQ mean score might be that adults and teenagers exercise greater control or agency through goal setting, deliberate learning strategies, and self-evaluation compared to young children (Moyer, 2018). Meanwhile, there was no significant difference between grades 7 and 8, grades 7 and 9, grades 8 and 9, grades 8 and 10, and grades 9 and 10.

The use of the mathematics modules in flexible online learning was assessed using qualitative data. The findings of the focus group discussion and interview revealed that different features of the mathematics modules, such as the pre-test, list of most essential competencies, module planner, practice exercise, answer key, and self-check activities, helped the students to use SRL strategies. These features were based on the three phases of Zimmerman's Cyclical Model of Self-Regulated Learning. A potential explanation for this is that the features of the mathematics modules contained prompts that allowed the students to engage in the different phases of self-regulation (Russo et al., 2020; Wong et al., 2019). However, van Alten et al. (2020) investigated the effect of video-embedded SRL support, which includes explicit instruction and prompts, on eighth-grade students' SRL in flipped learning. It was found that the video-embedded self-regulation support enhanced secondary education students' learning outcomes, but no significant difference was found between the SRL skills of the control and experimental group. According to the students' comments in this study, they generally disapproved of this type of SRL assistance. A possible reason for this is that students find it difficult to use SRL strategies since it requires effort (van Alten et al., 2020).

The qualitative data also revealed that mathematics modules were used as means to enhance the teaching-learning process in the flexible online learning environment. This finding is supported by the study of Dangle & Sumaoang (2020), where it was revealed in the result that modules helped students acquire better learning skills. Laureano et al. (2015) stated that utilizing materials in teaching is a supporting component that enhances the educational and instructional environment, promotes effectiveness, and encourages learning persistence. It is also important to take note that, through individual interviews, it was found that by using mathematics modules, the class discussion time can be maximized. There is a possibility that the modular approach increases the chance that students will engage in class and do the given tasks right away (Ambayon, 2020).

The quantitative data revealed that students used the least help-seeking strategies, such as asking for help from teachers and classmates. However, findings from the qualitative data revealed that students do not ask for help from other people since they use different supplementary materials as a form of help-seeking. This is an example of strategic help-seeking wherein a learner seeks assistance to build his capacity to overcome challenges on his own in the future and, as a result, become an independent learner (Algharaibeh, 2020). Also, teachers mentioned that students were taught what to do if they found the lessons in the modules difficult. Explaining to students the process of employing self-regulation strategies and their importance is another kind of self-regulation support that could be beneficial among the students (van Alten et al., 2020).

Despite the advantages, students still face challenges in using mathematics modules. One of these is the heavy workload. This is in accordance with the study by Dangle & Sumaoang (2020). There is a possibility that students felt that they must learn everything in the mathematics module alone. Also, online learning involves a substantially greater mental workload than traditional face-to-face learning (Widyanti et al., 2020). In addition, the irrelevance of the activities might also be a reason for students not to use self-regulation strategies such as task strategy. Students have a high possibility to use self-regulation strategies only if they believe that the tasks in online learning are valuable (Lee et al., 2020).

Another challenge mentioned is about teachers, specifically teachers' approachability. Aside from the use of modules, the teacher still has an influence on students' self-regulation (Guo et al., 2019; Jayawardana et al.,2017; Zee & de Bree, 2017). They are still effective agents who can promote and support students' self-regulation (Alvi & Gillies, 2020). On the other hand, student motivation is one of the teachers' challenges in supporting students' self-regulation through mathematics modules. Moreover, it was mentioned by the teachers and students that not all learning styles are catered to in the mathematics modules. According to Keshavarz & Hulus (2019), a possible reason why students are not motivated is that their learning styles are not addressed.

One of the recommendations of the teachers in using mathematics modules is to establish routines. These routines include the location of their modules, and the way students pass their module activities. This might be because routines are important in reducing students' cognitive load (Russo et al., 2020).

Overall, the findings of the study revealed that modules, through their different features, encouraged the students to experience the forethought, performance, and reflection phases of Zimmerman's Cyclical Model of Self-Regulation. The use of mathematics modules allowed students to use different strategies that helped them manage their learning in the flexible online learning modality.

Conclusions

The mathematics modules presented in this study are meant to provide students with learning materials to support them in using SRL strategies in the flexible online learning environment.

Overall, the students and teachers shared their positive experiences with the use of mathematics modules. Integrating features in the modules based on Zimmerman's Cyclical Model helped the students to self-regulate. Students were reported to have used different self-regulation strategies with the support of mathematics modules. Yet, according to the answers of the participants, the mathematics modules need improvement in some ways.

The result and findings of the study have led the researcher to conclude that modules are advantageous for students' self-regulation but must be properly designed to prevent students' dissatisfaction which might negate its benefits. There are many different factors to be considered in designing the modules to support students' self-regulation. The grade level and self-regulation of the learners may be taken into consideration in designing a module. Since the result of the study showed that there is a significant difference in the OSLQ mean scores of grades 7 and 10 students, and the mean score of grade 10 students is higher than the mean score of grade 7 students, more SRL support must be given explicitly among the grade 7 students. Also, a heavy workload hinders students from using self-regulation strategies. Hence, the relevance and number of activities per module need to be considered.

The study explored how the students managed their learning using the mathematics modules and assessed the use of mathematics modules in supporting JHS students' self-regulation. The researcher used an explanatory sequential design. For the quantitative data, the researcher used Online Self-Regulated Learning adapted from Barnard et al. (2009) to describe students' self-regulation using mathematics modules in a flexible online learning environment. It does not quantitatively measure the impact of mathematics modules on students' self-regulation. Hence, for future studies, researchers can use experimental design and use the modules as an intervention to improve students' self-regulation. Also, they may use an additional qualitative approach, such as observation, to get a deeper understanding of the data.

It is also important to note that the current study focuses only on the mathematics modules. Future studies on using modules may be extended to other subject areas across different grade levels. Furthermore, this study focuses on using mathematics modules for a flexible online learning environment. Similar research may be done in face-to-face learning. Students' self-regulation strategies in an online class utilizing modules may be compared with students' self-regulation strategies in face-to-face learning. Several follow-up studies may be considered, such as integrating modules into different teaching and learning methods, such as differentiated instruction and collaborative learning. It is also recommended that future studies may focus on how students may improve on task strategies and help-seeking strategies which are the least used self-regulation strategies in a flexible online learning environment.

This study revealed that different features of the mathematics modules allowed the students to use different self-regulation strategies. Thus, the following recommendations are hereby presented. Curriculum and instructional developers may use the study's findings in creating or improving learning materials, such as textbooks, modules, and online learning packages for the students. They may also use the findings to plan for education in emergencies. This can be a good beginning point for analyzing the quality of education in emergency situations. Moreover, training for pre-and in-service teachers on how to create and use modules in the class may also be conducted. Similarly, students may also be trained on how to use self-regulation strategies using their modules.

Modules may be used to redesign educational experiences. Since the modules helped to maximize class time, they may still be used in face-to-face learning, and the number of school days may be lessened so that students may be given more flexibility regarding their schedule and environment. Based on the findings, the module may be modified while considering the ideas of the students and teachers. Also, to assist faculty members in delivering lessons using the modules, a teacher manual may be created.

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Contact emails: riojaned90@gmail.com
riojane.diaz.gs@ust.edu.ph
easongco@ust.edu.ph

The Effect of Educational Technology Program Approach on Students' Attitude Towards Problem Solving

Sabariah Sharif, University Malaysia Sabah, Malaysia
Thiwagar Muniandy, University Malaysia Sabah, Malaysia
Muralindran Mariappan, University Malaysia Sabah, Malaysia

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Abstract
Integration of educational technology program has become an essential element of education in Malaysia due to its positive impact. Despite its implementation, students are unable to fully realize its potential benefits. This study investigated the effect of an educational technology program approach on students' attitude towards problem solving. The educational technology program approach that has been used in this study was robotics program. Quantitative research with the quasi-experimental model (pre-test & post-test) was used in the study to outline the research design and questionnaire test technique was administered for data collecting from experiment and control group. The samples were 10 years old (Year 4) primary schools' students from West Coast of Peninsular Malaysia (Selangor & Malacca state) with a total sample of 500 students. Inferential statistical test, Multivariate Analysis of Variance (MANOVA) with significance value 0.05 was performed using SPSS 25 to analyze the data. Based on data and discussion that have been accomplished, it can be concluded there is a significant difference on students' attitude towards problem solving in experimental group after attending robotics program over control group who participated in traditional learning method only. The robotic program is suggested as one of the innovative STEAM program, based on constructivism which is advised for enhancing problem solving skills. Excellent problem solving skill will assist students in resolving contextual and complex problems.

Keywords: Education Technology, Robotics, Attitude, Problem Solving, Students

Introduction

One of the most frequent challenges faced by teachers is encouraging active participation from all students in class activities to improve their attitude towards 21st century skills, as learning is scrutinized closely. According to Lowry-Brock (2016), students who were previously perceived as more capable by their peers tended to dominate the class, while those with weaker academic histories often opted out of participation. Previous research suggests that enhancing student engagement through educational technology program can lead to improved behaviour among students (Hirtz, 2020). Nevertheless, the shift towards online learning in response to the COVID-19 pandemic has presented a challenge in terms of student engagement, as recognized by Farooq et al. (2020), Nickerson & Shea (2020), and Perets et al. (2020). Kukard (2020) has noted that during the global pandemic, one of the most difficult aspects of teaching has been to sustain collaboration and engagement, which has resulted in students being unable to acquire 21st century skills.

In Malaysia due to its favourable outcomes, the assimilation of educational technology programs has become a vital aspect of education. Malaysia has been taking many initiatives to enhance students' attitude towards 21st century skills such as problem solving. The Malaysian government launched several programs and initiatives, mainly through the Science to Action (S2A) strategy in 2012, to encourage students' interest in 21st century skills and achieve a 60:40 sciences to arts ratio. However, despite these efforts, it has been unattainable in reality. As per the Organisation for Economic Co-operation and Development (OECD) 2019 report, more than 60% of Malaysian students fail to meet the minimum standard in mathematics required to actively and effectively participate in life. Moreover, according to Dato' Professor Dr. Noraini, the chairman of the National STEM Movement, stated that just 19% of students participate in STEM-related courses in middle schools and higher education institutions in 2020, and that children should be encouraged to take these courses beginning in primary school (Chonghui, 2020). This exemplifies the lack of enthusiasm and attitude among Malaysian students toward 21st century competences like problem-solving and other areas. Moreover, in the upcoming years, many professional and industrial occupations will require workers with expertise in the fields of Science, Technology, Engineering, and Mathematics (STEM) (Sima et al., 2020; Marsili, 2005).

As a result, the researcher is suggested in order for students of the 21st century to be employable in the future, they must be equipped with STEM knowledge. Programs that use educational technology, like those offered in schools such as robotics, are one of the greatest ways to achieve this. Robotics is a modest, hands-on subject that prepares students with problem solving skills and for careers in STEM field. In 2014, the Malaysian Ministry of Education implemented integrated science and problem-solving lessons, namely *Reka Bentuk dan Teknologi (RBT)* and *Teknologi Maklumat dan Komunikasi (TMK)*, with the aim of stimulating students' interest and changing their attitudes towards 21st century skills. RBT pertains to the skills of planning and organizing materials using mathematical and scientific principles, and the RBT Standard Curriculum combines technical, agricultural, and scientific knowledge and skills to develop technological competencies. Meanwhile, TMK consists of five modules, namely the world of computers, multimedia exploration, network systems and the world of the internet, the world of databases, and programming. The subject aims to provide national school students with early exposure to Information and Communications Technology (ICT) before they proceed to secondary school, and the curriculum is designed to align with the students' capacity level. These changes were introduced as part of the

Malaysian Ministry of Education's efforts to foster a positive attitude among students towards 21^{st} century skills.

Despite the implementation of these initiatives, research conducted by Muniandy et al. (2022), Sahaat et al. (2020), and Mohd Zukilan Zakaria (2015) indicates that the majority of students do not believe that the subjects covered in these programs will be beneficial in their future lives. Furthermore, since these subjects are not included in primary school examinations, they have not had a significant impact on students' attitudes towards 21st-century skills. Additionally, Professor Dato' Dr. Noraini, the head of the National STEM Movement, noted in 2020 that the enthusiasm of students towards science and mathematics was already waning in elementary school due to a lack of participation in classroom instruction and learning. Compared to secondary and tertiary education, elementary schools provide fewer hands-on activities and opportunities to incorporate educational technology tools and programs that emphasize 21st-century skills, such as problem-solving and critical thinking (Chonghui, 2020). Hence, the aim of the study is to determine the effects of robotics program on students' attitude towards problem solving. Therefore, in order to gain a deeper understanding, the present study was guided by the following research questions:

1. Is there a difference in the mean score of student's attitude towards problem solving in pre-test, post-test 1 and post-test 2 for the experimental group?

2. Is there a difference in the mean score of student's attitude towards problem solving in pre-test, post-test 1 and post-test 2 periods for the control group?

Many previous studies have focused on effectiveness of educational technology program on students' academic achievements. However, far too little attention has been paid to evaluate changes in students' attitude after attending educational technology program such as robotics. For example, researcher Muhamad Shakir Bin Saad (2018) studied effectiveness of robotics program Matriculation students' achievement in Biology subject topic Respiratory Cell. Thus, taking into consideration there are dearth study related to students' attitude, researcher has studied on the effect of educational technology program on students' attitude towards problem solving. The starting point of this paper is a review of the relevant literature pertaining to the study. Subsequently, the methodology employed in the research is outlined, followed by the presentation of the results. The findings are then analysed and discussed, leading to the final section of the paper which presents the conclusions.

Theoretical Discussion

In the design of an educational technology program for robotics, numerous learning and behavioral theories were taken into account. These included Piaget and Vygotsky's constructivism theories, the Constructionism theory, the Operant Conditioning theory, and Ajzen's Theory of Planned Behaviour. The robotics program utilizes a combination of educational philosophy derived from Piaget's theory, known as constructionism. This approach is based on constructivism, which emphasizes the importance of personal interaction with objects and events in the development of understanding and problem-solving abilities. Furthermore, the challenges presented by the program encourage students to repeatedly engage in tasks, facilitating the assimilation of information and knowledge. This repetitive behavior is believed to enhance the learning process, as suggested by Kalyuga and Plass (2009).

Educational Technology Program

Integrating educational technology into the classroom environment can enhance students' access to instruction and alleviate feelings of social and academic isolation. This approach also facilitates participation in a diverse range of academic activities and settings (Lynch et al., 2022). An example of such a program is the robotics program, which teaches students about robotics development, design, and construction, as demonstrated by Belmonte et al (2021). This engaging and educational science toy provides an opportunity for children to develop their imagination and problem-solving skills while engaging with realistic scenarios, as highlighted by Shih et al (2013).

In recent years, teachers in many countries have been exploring the incorporation of educational technology programs that utilize robotic activities to facilitate learning in the areas of mathematics, science, and engineering. (Hallak et al., 2019; Bratzel, 2005). Moreover, the integration of games into classroom activities has become increasingly common in educational technology programs (Mee et al., 2020; Challinger, 2005; Arkin, 1998). By utilizing the mechanical and dynamic principles inherent in gaming processes, the educational system can motivate students and develop their 21st century abilities while promoting information discovery, as noted by Losup and Epema (2014). Rogers and Portsmore (2004) and Yang and Baldwin (2020) suggest that educational technology programs can improve students' scientific and mathematical abilities, as well as their behavior and 21st century skills. Programs like robotics that incorporate problem-solving, experimentation, and inquiry skills can help students learn scientific and mathematical principles.

Moreover, the use of educational technology in the classroom not only enhances students' ability to learn math problems but also reduces their academic and social isolation, while providing access to a complete academic curriculum and various educational programs (Lynch et al., 2022). One such program that aims to teach problem-solving concepts, hands-on development, design, and construction to students is the robotics program (Belmonte et al., 2021). By using this entertaining and informative scientific toy, students can improve their creativity and problem-solving skills by recreating real-world scenarios (Shih et al., 2013). Therefore, in this particular study, researchers utilized the RoboBuilder RQ+110 robotic set, developed by a South Korean research group, to conduct a robotics program. The program included practical exercises such as assembling and disassembling robots, troubleshooting, and learning how to create robots using scientific principles. This program was held for one hour after school, in groups of three to four children.

Attitude Towards Problem Solving

Ocak et al. (2021) defined problem-solving as a process that involves creative thinking and going beyond the application of previously taught concepts or principles to resolve an issue. Similarly, Roslina et al. (2010) emphasized that addressing problems is a crucial skill that students acquire as they are trained to become social human capital (Rahman, 2017). Problem-solving is a crucial and integral component of any study of mathematics. To retain knowledge, it is essential to apply techniques, tools, and the ability to assess one's own performance (Sturm, 2019; Adams, 2015; Charles et al., 1997). In Malaysia, the Ministry of Education mandated in 2003 that schools incorporate more problem-solving strategies such as generating charts and diagrams, forecasting, simplifying problems, modeling issues, and drawing conclusions. Developing sequencing processes that go beyond sequence execution is essential for effective problem-solving (Cambaya, 2022 & Hammouri, 2003).

The Ministry of Education Malaysia has taken the initiative to equip students with 21^{st} century skills and foster their problem-solving attitudes by introducing reformed syllabus through *Kurikulum Standard Sekolah Rendah (KSSR)* for primary schools and *Kurikulum Standard Sekolah Menengah (KSSM)* for secondary schools. The Malaysia Education Blueprint 2013-2025 encourages teachers to engage in self-improvement activities and enhance their teaching abilities to meet the demands of the 21^{st} century (Mahanani et al., 2022; Ministry of Education, 2013). Incorporating technology into classroom instruction has also become a mandatory task for educators (Rusdin, 2018; Amran & Rosli, 2017; Langworthy, 2013). Rahim and Abdullah (2017) suggest that using Information and Communication Technology (ICT) in pedagogy and teaching techniques can motivate and assist students in improving their problem-solving skills and excel in 21st-century learning. Instructors' teaching techniques in the classroom significantly influence 21^{st} century learning outcomes and students' attitudes (Langworthy, 2013; Amran & Rosli, 2017).

Research Design

In this research, a quantitative approach was utilized through a quasi-experimental study to enhance the ecological validity of the research (Roger, 2019; Gill & Johnson, 2010; Mohd Majid, 2005). The data were collected through questionnaire techniques, where a set of instruments were given to the respondents, as the final data obtained in this study was numerical and analyzed statistically. This method is consistent with the explanations of Borgstede and Scholz (2021), Noyes et al. (2019), and Sugiyono (2017), who stated that quantitative research methodologies are utilized to resolve research problems using data in the form of values and statistical methods. Furthermore, a questionnaire was utilized to evaluate the type of activity that has developed into a communal practice. According to Adiyanta (2019) and Gürbüz (2017), a questionnaire can measure multiple desirable variables using numerous questions in an instrument.

Research Onion Model

The design of this research was guided by the theoretical model of "Research Onion," as suggested by Saunders in Figure 1 (Saunders et al., 2018). The research onion provides a comprehensive description of the necessary layers or stages that must be accomplished to develop a successful methodology (Mardiana, 2020; Raithatha, 2017). The first layer of the research onion is the research approach, which outlines the circumstances and realities (ontology), origins, sources of evidence or facts (epistemology), and values, beliefs, and research ethics (axiology). For this study, the researcher opted for positivism as a philosophy because it involves testing hypotheses, collecting data, and utilizing numerical analysis to produce systematic and generalizable findings. (Junjie, 2022 & Ary et al., 2010).

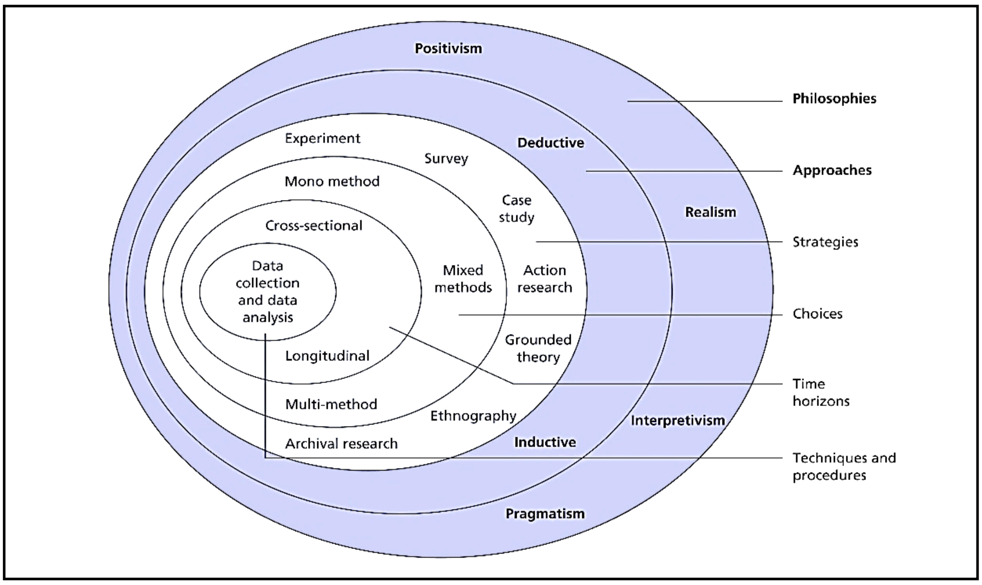

Figure 1: Research Onion Model

The second layer of the research onion pertains to the study approach, which includes the Inductive Approach for qualitative research and the Deductive Approach for quantitative methods (Saunders et al., 2009). Therefore, this study has adopted the Deductive Approach. The third layer of the research onion is the research strategy, which is a comprehensive approach that assists the researcher in selecting the primary data collection technique or group of procedures to address the research question and achieve the research objectives (Wimalaratne, 2022; Saunders et al., 2018). Consequently, this study has employed the survey (questionnaire) technique to gather data from participants. The fourth layer of the research onion is the methodological selection, which refers to the use of mixed methods (quantitative and qualitative research techniques), multi-methods (a combination of both in a simple or sophisticated manner), or mono-methods (either quantitative or qualitative methods) (Saunders et al., 2018). As the data collected from the participants is quantitative in nature, this study has utilized the quantitative technique. Specifically, the mono-method was applied in this study, utilizing an experimental study methodology involving quasi-experiment nonequivalent groups and pre- and post-tests.

The fifth layer of the research onion focuses on the time horizon, which includes the cross-sectional time horizon and the longitudinal time horizon. In this research, the longitudinal research technique was employed because the researcher collected data periodically over an extended period, including pre-test, post-test 1, and post-test 2. Finally, the sixth layer of the research onion pertains to data collection and analysis. For this study, the Solving Problem Survey questionnaire, developed by Susan Barkman and Krisanna Machtmes at Purdue University in 2002 (Barkman S. & Machtmes, K., 2002), was administered to participants to gather data on the effects of an educational technology program (robotics) on the attitude of Malaysian students towards problem-solving skills. Additionally, the collected data were analyzed using the SPSS 25 software, involving descriptive analysis and inferential statistical tests, including the Multivariate Analysis of Variance (MANOVA) test.

Participants & Sampling Method

For this study, a purposive sampling method was utilized to select the sample, which is commonly used to investigate the effectiveness of an intervention or program (Bernard, 2002). This sampling method is advantageous as it enables the researchers to choose participants who can provide useful information, knowledge, or experience (Sharma, 2017). The sample comprised 500 government school students in year 4, aged 10, with 300 students in the treatment group receiving a robotics program and 200 students in the control group receiving conventional learning methods. The selection criteria required students to possess moderately or good reading and understanding skills to answer questionnaires and have a good attendance record to ensure their participation in the researcher's program without absenteeism. All students were provided with a consent form to participate in the study, and they were briefed on the research project during the initial briefing, given the option to transfer to other classes if they did not wish to participate. This was to ensure that the students were aware that their involvement was completely voluntary, and there were no consequences if they did not wish to participate.

Implementation of Educational Technology Program (Robotics Program)

The study lasted for a total of 12 weeks, with the intervention being implemented over 9 weeks, spanning from the 2nd to the 5th week and from the 7th to the 11th week. Before the program began, the researcher held a meeting with the trainer, headmaster of the school, curriculum head teacher, co-curriculum head teacher, as well as the RBT and Mathematics teachers who were designated as facilitators for each class. The purpose of the meeting was to inform and discuss the class groups involved in the program. The trainer and facilitators received clear instructions and guidance on the procedure to conduct the program one week prior to its start. The researcher utilized the ROBOBUILDER RQ+110 robotics set, along with the instruction manual and module provided by the manufacturer. Additionally, a list of topics from year 4 subjects, such as Mathematics and RBT, were provided by the researcher to be incorporated into the robotics program. The selection of topics was carried out by the school subject class teachers and verified by the respective head teachers.

The experimental and control groups will receive a normal classroom learning process simultaneously during the predetermined week. Prior to the program, all students will take a pre-test using the Solving Problem Survey questionnaire, which will be used to ensure that the sample is homogeneous. Subsequently, the experimental group will receive robotic program treatment after school, while the control group will attend traditional revision classes after school on the selected topics. Both groups will participate in after-school programs for 12 weeks, with each session lasting for one hour. The experimental group will be engaged in hands-on activities such as robot assembly, algorithm and pseudocode learning, as well as coding to solve assigned problems. The trainer and facilitators will also explain the underlying theory of mathematics problems at the end of each class task. Meanwhile, for the control group, the trainers will conduct traditional teaching revisions on science and mathematics problems without incorporating robotics programs every week for 12 weeks. Table 1 shows study procedure and intervention of the study carried out:

Table 1: Study Procedure and Intervention

Week	Activity
1	• Introduction to Robotics Program & Components of Robot. • Pre-Test (Solving Problem Survey)
2	• Treatment 1: - Creating Robots Utilizing Reusable Materials & Revision on the scientific skills and elements of design topics
3	• Treatment 2: - Assemble Punching Bot Robot Base & Revision on Length topic
4	• Treatment 3: - Assemble Punching Bot Robot and it's sensors & Revision on Mass
5	• Treatment 4: - Connect the wires to the battery and use the controller to guide the robot to the finish line as per the instructions, which include making the robot turn clockwise, move forward towards the final line, turn 360 degrees counterclockwise, and finally stop. - Revision on Time topic
6	• Post – Test 1 (Solving Problem Survey)
7	• Treatment 5: - Get introduced to algorithms, pseudocode, flowcharts, SCRATCH coding, and learn to move your robot based on written pseudocode, with instruction turning on the robot, moving it forward by 10 steps, and stopping it. Revision Coding
8	• Treatment 6: - Compose algorithms, pseudocode, flowcharts, and create a 4-line SCRATCH code to guide your robot's movement in a given coordinate set. The robot should turn on, move 5 steps along the x-axis, then 10 steps along the y-axis, and finally stop. - Revision on Coordinate topic.
9	• Treatment 7: - Create algorithms, pseudocode, flowcharts, and use 5 lines of SCRATCH code to move the robot and turn on the LED light. The robot should be turned on, moved forward for 10 steps, wait for 3 seconds, turn on the LED for 5 seconds, and then stop. - Revision on Coding topic.
10	• Treatment 8: - Create algorithms, pseudocode, flowchart, and implement a 6-line SCRATCH code to move your robot, activate the LED light, and sound the buzzer. The robot should turn on, move forward for 10 steps, wait for 3 seconds, turn the LED on for 5 seconds, activate the buzzer for 3 seconds, and finally stop.- Revision Coding
11	• Treatment 9: - Create algorithms, pseudocode, and flowchart to program your robot using SCRATCH to execute instructions for specific problems. These instructions include turning on the robot, turning on the LED and buzzer for 5 seconds, moving forward for 10 steps, rotating clockwise 360 degrees, waiting for 2 seconds, activating the buzzer for 3 seconds, moving forward for 5 steps, moving backward for 3 steps, rotating anticlockwise 360 degrees, and finally stopping the robot.- Revision on Time & Angle topic.
12	• Post – Test 2 (Solving Problem Survey)

Instrument - Solving Problem Survey

Participants were given the Solving Problem Survey questionnaire, developed by Susan Barkman and Krisanna Machtmes at Purdue University in 2002 (Barkman S. & Machtmes, K., 2002), to gather data on the impact of an educational technology program (robotics) on students' attitude towards problem-solving. The questionnaire consists of 24 items with a 5-point scale ranging from always, often, sometimes, rarely, and never. Prior to use, the questionnaire underwent a pilot test with the study population, achieving a Cronbach's alpha reliability coefficient of 0.88. The researcher also conducted a Confirmatory Factor Analysis (CFA), specifically Bartlett's Test, to confirm that the Kaiser-Meyer-Okin (KMO) value of the Solving Problem Survey instrument was above 0.50, as required for validity (Husain, 2022; Hair et al., 2018). In this pilot study, the KMO value obtained was 0.808, which indicates that the instrument is valid and suitable for use in this study.

Data Collection Procedure

Once the researcher had obtained approval from the schools, they arranged a meeting with the headmasters and appointed teachers (facilitators) of each respective school to discuss the classes involved in the control and experimental groups. The program was conducted over a 12-week period, beginning with two briefing sessions in the first week for trainers, facilitators, and students (sample) to introduce the program before administering a pre-test using the Solving Problem Survey for 15 minutes. The intervention activities involving robotics for the experimental group and posttest 1 for both control and experiment groups took place in weeks 2 to 5. From weeks 7 to 11, the robotics program continued for the experimental group, and on the 12th week, the Solving Problem Survey was distributed to both groups for post-test 2 to evaluate students' attitudes.

Data Analysis

The study employed Descriptive & Inferential statistical testing for data analysis. The data from the questionnaires were processed using the Statistical Packages for the Social Sciences (SPSS Version 25.0 for Windows) software. The researcher conducted a Multivariate Analysis of Variance (MANOVA) with a significance value of 0.05 to compare the mean scores of the post-test 1 and post-test 2 between the control and experimental groups.

Results

This research adopts a quantitative methodology and employs questionnaires as the primary data collection tool. A total of 500 students participated in the study, with 300 in the experimental group and 200 in the control group. Each participant received a similar instrument to evaluate the effect of educational technology program used (robotics program) on students' attitude towards problem-solving. The descriptive analysis indicates that the pre-test mean scores for the control and experimental groups were 3.2807 and 3.0228, respectively. The experimental group had a higher mean score in post-test 2 at 3.7684, reflecting a gain of 0.3828, while the control group exhibited a lower mean score in post-test 2, indicating a drop of 0.2651. These descriptive findings suggest a significant improvement in the mean score of the experimental group students across the three-time test intervals, while a decline was observed for the control group from pre-test to post-test 2. Table 2 below shows complete descriptive analysis:

Table 2: Descriptive Statistics Score of Attitude Towards Problem Solving by Study Sample

Parameter	Control Group			Experimental Group		
	Pre	**Post 1**	**Post 2**	**Pre**	**Post 1**	**Post 2**
N	200	200	200	300	300	300
Mean	3.2807	3.1222	3.0156	3.0228	3.7509	3.7684
Standard Deviation	.7233	.7228	.7209	.8430	.5577	.5576

Prior to analyzing the hypotheses regarding the dependent variable of the mean score of attitude toward problem solving, the researcher conducted several tests to confirm that the Multivariate analysis of variance (MANOVA) criteria were met. To determine the normality of the data from the pre-test, post-test 1, and post-test 2 of attitude toward problem solving, the Kolmogorov-Smirnov Test was employed. The results of the test showed that the three sets of data were normally distributed, as all scores had a significance level of $p > 0.05$. A significance level below 0.05 would indicate that the data is not normally distributed (Graveter and Wallnau, 2004). Additionally, the researcher conducted Levene's Test of Homogeneity of Variance to determine if the samples in both groups were homogeneous. This test examines whether the variances of two samples are similar.

If the value obtained from this test is not significant, it indicates that the variances of the samples are not different and are equal, as per Abdullah and Muda (2022). Since the sample size was large, the researcher set the significance level at 0.01. The results of Levene's Test indicated that $F(1, 372) = .642$, $p = .363$, and the non-significant value suggests that equal variances exist between both sample groups. Once all the criteria were met, the MANOVA test was conducted to address the research question and test the null hypotheses 1 and 2, which assert that there is no significant difference in the mean score of student's attitude towards problem solving in three time periods for both the experimental and control groups. The significance level used for the MANOVA test was $\alpha = .05$. The results of the MANOVA test for the experimental and control groups are presented in Tables 3 and 4, respectively.

Table 3: Multivariate Test for Experiment Group

Effect		Value	F	Hypothesis df	Error df	Sig.
Attitude Towards Problem Solving	Pillai's Trace	.406	127.28	2.00	205.00	0.00
	Wilks' Lambda	.594	127.28	2.00	205.00	0.00
	Hotelling's Trace	.684	127.28	2.00	205.00	0.00
	Roy's Largest Root	.684	127.28	2.00	205.00	0.00
X	Pillai's Trace	0.48	10.15	2.00	205.00	0.00
	Wilks' Lambda	0.53	10.15	2.00	205.00	0.00
	Hotelling's Trace	0.90	10.15	2.00	205.00	0.00
	Roy's Largest Root	0.90	10.15	2.00	205.00	0.00

Table 4: Multivariate Test for Control Group

	Effect	Value	F	Hypothesis df	Error df	Sig.
Attitude Towards Problem Solving	Pillai's Trace	.171	5.67	2.00	60.00	0.08
	Wilks' Lambda	.809	5.67	2.00	60.00	0.08
	Hotelling's Trace	.230	5.67	2.00	60.00	0.08
	Roy's Largest Root	.230	5.67	2.00	60.00	0.08
X	Pillai's Trace	0.40	3.28	2.00	60.00	0.08
	Wilks' Lambda	0.51	3.28	2.00	60.00	0.08
	Hotelling's Trace	0.72	3.28	2.00	60.00	0.08
	Roy's Largest Root	0.72	3.28	2.00	60.00	0.08

The results of the MANOVA analysis indicate that the experimental group has a significant value of .00 (as seen in Table 3), which is lower than the set significance level of .05. This finding suggests that the educational technology program, specifically the robotics program, has caused significant changes in the students' attitude towards problem solving. Therefore, the null hypothesis 1 can be rejected. In contrast, the MANOVA test conducted on the control group produced a significant value of .08 (shown in Table 4), which is higher than the set value of 0.05. This result implies that the control group did not exhibit any improvement in their attitude towards problem solving when subjected to the conventional revision method without the robotics program as an after-school activity.

Discussion

The results of this study align with those of Gratani et al. (2021), who found that educational technology programs such as robotics can have a significant impact on students' computational thinking and problem-solving abilities. In this study, the experimental group students collaborated to understand the challenge and apply mathematical and reasoning skills to build a robot that moves accurately. The use of robots in education can increase student engagement and improve their attitudes towards problem-solving (Gorakhnath et al., 2017 & Cielniak et al., 2013). The implementation of an educational technology program, such as robotics, can encourage students to engage in critical thinking and take an active role in their learning. Compared to traditional learning methods, the use of robotics in teaching can make the learning experience more enjoyable for students. This enjoyable learning experience can help students feel more comfortable with studying, ultimately increasing their motivation and passion for learning (Schwinger & Otterpohl, 2017; Kryshko et al., 2022). As a result, students are more likely to be motivated to recall previously learned concepts in order to complete assignments (Zheng & Zhang, 2020; Tsai et al., 2020; Van Alten et al., 2020). Increased student motivation can facilitate the flow of instructional methods, leading to the achievement of learning objectives and the acquisition of 21st-century skills such as problem-solving. The study concludes that the robotics program has a significant impact on learning outcomes.

In contrast to traditional learning, teaching with educational technology allows students to actively participate, use creativity, and engage in the learning process. This approach integrates problem-solving skills with other 21st-century skills. Students need to have the confidence and ability to analyze what they have learned, which enhances their motivation and learning outcomes while developing their problem-solving skills (Tsai et al., 2020; Van Alten et al., 2020; Carpenter et al., 2020). Educational technology programs that are effective create a positive classroom environment, which is more dynamic and encourages students to be more independent and responsible for their tasks (Marzuki & Basariah, 2017; Safaruddin et al., 2020). In addition, the incorporation of educational technology programs such as robotics allows students to explore and learn in a genuine and intriguing manner, which can enhance their involvement in the learning process and enhance their knowledge and problem-solving abilities. The educational technology program has facilitated students' learning, leading to an impact on their motivation to learn and the development of 21st-century skills (Tsai et al., 2020; Van Alten et al., 2020) and learning (Andujar & Nadif, 2020; Zheng & Zhang, 2020; El Sadik & Al Abdulmonem, 2021).

Conclusion

The results of this study have significant implications and advantages for various stakeholders, including the Ministry, teachers, and students. The impact is reflected in the areas of study, practical applications, and models. From a theoretical perspective, this study contributes to the literature on the use of robotics programs as research models to enhance students' problem-solving attitudes. Furthermore, this research supports the 21st century learning model and the concept of technology-assisted learning, which, when implemented effectively, can enhance students' attitudes towards learning. The findings also demonstrate that the robotics program can positively impact students' attitudes. Che Noh et al. (2021) revealed that teachers in Malaysia still predominantly employ traditional teacher-centered teaching methods, and therefore need to develop a thinking mentality to improve education competitiveness. The results of this study have made a significant contribution to the literature by demonstrating that the robotics programme can improve students' attitudes towards problem solving. Students' attitudes toward problem-solving were influenced by several factors, including teacher recognition for introducing innovative activities, active participation in the robotics programme, the usefulness of the knowledge gained. These factors encouraged students to become enthusiastic about the subject, motivating them to study in advance and prepare. The small sample size of this study limits the generalizability of the findings. Nevertheless, the study's results are significant in informing the application of educational technology programs as a pedagogical approach, especially in addressing problem-solving attitudes.

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Contact email: thiwagarsmc@gmail.com

Transforming Undergraduate Research Experiences With Experiential Learning

Rachel Burcin, Carnegie Mellon University, United States
Vishwas Mruthyunjaya, Megagon Labs, United States
John M. Dolan, Carnegie Mellon University, United States

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Abstract
Science and technology drive innovation, create economic opportunity, and are critical to national security. With increased competition for a skilled STEM workforce, high barriers to participation in STEM, the missing millions (Gershenfeld et al., 2021), and the longstanding underrepresentation of minoritized US communities, collective action is urgently needed to expand STEM education and training. Strengthening and expanding STEM education is necessary to meet critical workforce demands and to fortify the national research pipeline. Undergraduate research experiences, long recognized as a high-impact education practice (Kuh & Schneider, 2008), are critical to growing the nation's research and science communities. Universities, therefore, are launching additional undergraduate research opportunities. However, the constraints inherent in the traditional 10-week summer undergraduate research model may limit the impact and outcomes for participating students, faculty, and organizations. This paper explores the adoption of inclusive learning frameworks and David Kolb's Experiential Learning Theory (ELT) as a potential way to capture the lost potential of summer research experiences and transform undergraduate research experiences. To do so, we use the evolution of Carnegie Mellon University's (CMU) Robotics Institute Summer Scholars (RISS) program as a case study, offering our experience as an example of how the adoption of inclusive learning frameworks and ELT can improve summer undergraduate research experiences and undergraduate success more broadly.

Keywords: Experiential Education, Undergraduate Research, Collaborative Research, STEM Education, Learning Theories, National Research Pipeline, STEM

Introduction

Science and technology drive innovation, foster economic growth, and are critical to national security. Indeed, the World Bank posits that the number of domestic Ph.D. graduates is indicative of a nation's future innovation potential (Velez Bustillo & A. Patrinos, 2023). Historically, the United States's higher education institutions have relied upon global Science, Technology, Engineering, and Mathematics (STEM) talent to fill engineering and computer science graduate programs. While the number of US students enrolling in computing undergraduate programs is expanding, only a small portion of these students continue on to graduate programs in computing (DesJardin & Libeskind-Hadas, 2021). Because of increased global competition for skilled STEM workers and various barriers along all segments of the STEM pipeline, meaningful and sustained action is required to expand US student engagement in STEM and to specifically address the long-standing underrepresentation of marginalized domestic US communities (Gershenfeld et al., 2021). The National Science Foundation (NSF), in fact, states that expanding access to undergraduate research experiences (REU) is an immediate priority (DesJardin & Libeskind-Hadas, 2021). The Computing Research Association (CRA), moreover, reports that undergraduate students with formal research experience (REU) are twice as likely to pursue graduate studies (Tamer, 2019).

In 2006, as an effort to provide these recommended early research experiences for students, Carnegie Mellon University's Robotics Institute launched a summer undergraduate research robotics program, the RI Summer Scholars Program (RISS). Over time, RISS became a platform to design, pilot, and evaluate educational interventions and learning approaches that could increase student interest and launch students into graduate school. An analysis of student outcomes showed that more than seventy-five percent of RISS alumni from 2012 to 2018 pursued graduate studies in STEM. In this paper, we discuss how the reimagining of CMU's RISS program's undergraduate research learning community structure and goals, which was informed by David Kolb's Experiential Learning Theory (ELT) and learning styles, increased student participation in STEM graduate programs by focusing on the individual learner and peer experience. We use RISS as a case study to explore how coupling educational frameworks more closely with REU programs can improve student researcher outcomes and continuation in STEM studies.

Background & Motivation

Ensuring that more US students successfully enter graduate STEM programs is essential for our national security and therefore must be a significant part of national STEM education and workforce policies (Alper & National Academies of Sciences, Engineering, and Medicine (U.S.), 2016). US STEM graduate programs at top-ranking research universities, however, are seemingly not as accessible for American students as they used to be. In the CRA study entitled "Addressing the National Need for Increasing the Domestic Ph.D. Yield in Computer Science," the authors noted that the United States has been increasingly relying "on international students to drive innovation and leadership in computing research" (Hambrusch & Pollock, 2020). There is an observable trend of a decreasing ratio of US residents to non-resident students, which rises with each rung of higher education (Table 1).

Table 1: *Percentage of Enrolled Students who are US Residents in Bachelors, Masters, and Ph.D. Programs*

Year	Bachelors	Masters	Ph.D.
2012	n/a	n/a	40.20%
2013	92.50%	42.40%	39.90%
2014	91.70%	42.30%	38.30%
2015	90.90%	38.60%	39.50%
2016	90.00%	35.00%	36.60%
2017	88.00%	38.50%	36.80%
2018	88.40%	41.20%	37.40%

Note. The data are obtained from CRA's Taulbee survey, which is the principal source of information on the enrollment, production, and employment of Ph.Ds in information, computer science and computer engineering. (Steed, 2023). The data report enrollment as a US resident or Non-resident Student. The data from the year 2012 are missing enrollment numbers for bachelor's and master's programs for US residents by ethnicity groups to determine the actual percentage of US residents that enrolled in bachelor's and master's programs.

The CRA, therefore, recommends increasing funding and availability of undergraduate research to expand access and participation in undergraduate research programs (Hambrusch & Pollock, 2020). Similarly, the National Science Foundation (NSF) Computer and Information Science and Engineering (CISE) Advisory Committee identifies expanding access to early research experiences as a top strategy to strengthen the national research and innovation pipeline (Figure 1). Another way to help ensure more students are enrolled in STEM graduate programs is establishing REU programs that focus on the learning experience, mentorship, and post-program support. Engaging in REUs has a definitive positive impact on student interest in pursuing graduate studies, as seen in Table 2, making them an essential focus for higher education institutions (Table 2). Clearly, REUs are a high-impact education intervention, but also are not infinitely scalable without a loss of quality and diminishing learning outcomes (Kuh & Schneider, 2008).

Figure 1: *Growing and Diversifying the Domestic Graduate Pipeline*

NSF Recommended Strategies

1. Increase awareness and outreach,
2. Encourage recruitment of diverse students to PhD programs,
3. Expand access to early research experiences, and
4. Facilitate collaborations with industry to support graduate study

Note. NSF Computer and Information Science and Engineering | Advisory Committee Report 2019 (DesJardin & Libeskind-Hadas, 2021)

Table 2: *Undergraduate Research Participation as a Driver for Graduate Study Interest*

Graduate School Application Status	Undergraduate Research Experience Categories	Total Percentage
Applied to Graduate School	**Without** a formal research / REU experience	15%
	With a formal research / REU experience	31%
	With CMU RISS participation	90%

Note. The data percentage reflects numbers reported by CRA and RISS for the year 2018. The CRA percentage was calculated on a total number of participants of 793 (Wright, 2020). The RISS percentage was calculated on a total of 35 participants in 2018.

Undergraduate Research Experience Program Impact & Potential

Expanding the availability of undergraduate research experiences aligns with the policy recommendations across national agencies and leading research units to increase domestic participation in STEM. We observe a tremendous gain in interest to pursue graduate studies after participating in a formal research experience (31% versus 15% per a CRA study) (Tamer, 2019). However, more attention should be paid to identifying models and practices that will increase this number to closer to 100%. We are losing too much talent and must discover where the pipeline leaks and ultimately shatters. Reimagining how we think about and design REU programs and learning experiences could increase REU scholar interest and participation in graduate studies.

CMU's RISS as a Case Study

Launching: Beginning with a Traditional REU Site Model

In 2006, Carnegie Mellon University's Robotics Institute launched a summer undergraduate research program, the CMU Robotics Institute Summer Scholars (RISS), to provide early robotics research exposure. RISS followed the traditional undergraduate research experience (REU) site model, coupling experts (science faculty) with undergraduate students to enable involvement in a research project, providing communications and graduate school preparation workshops, hosting social activities and an end-of-program poster session. The initial RISS program model reflected the traditional REU model: short in length, project-focused, typical closing activities, the cliff of engagement after the program, and no longitudinal data studies.

Reimagining the REU Model

We established the REU program with good intentions, a strong commitment to broadening participation, and outstanding scientific content expertise to guide students. However, we soon observed that the traditional 10-week summer undergraduate research program model (henceforth referred to as the traditional REU model) artificially limited the impacts and outcomes for participating students, faculty, and organizations and could even cause harm to students from communities under-represented in STEM. The traditional REU model is often structured in a banking-style model, with the research mentor assigning articulated problems without an intentional framing of the larger problem, its importance, or its impact. The compressed time frame does not allow sufficient exploration of mentees' prior experience, interests, or knowledge. REU experiences can be isolating when individual scholars are matched with an individual mentor or small lab without the benefit of multiple layers of mentorship and peer engagement to cultivate a reflective practice. Because of the traditional REU model's short time frame and limited post-program engagement, the model inevitably yields a high-stakes race to produce a poster or paper rather than providing an opportunity to thoughtfully examine the research's interactive process and collaborative nature.

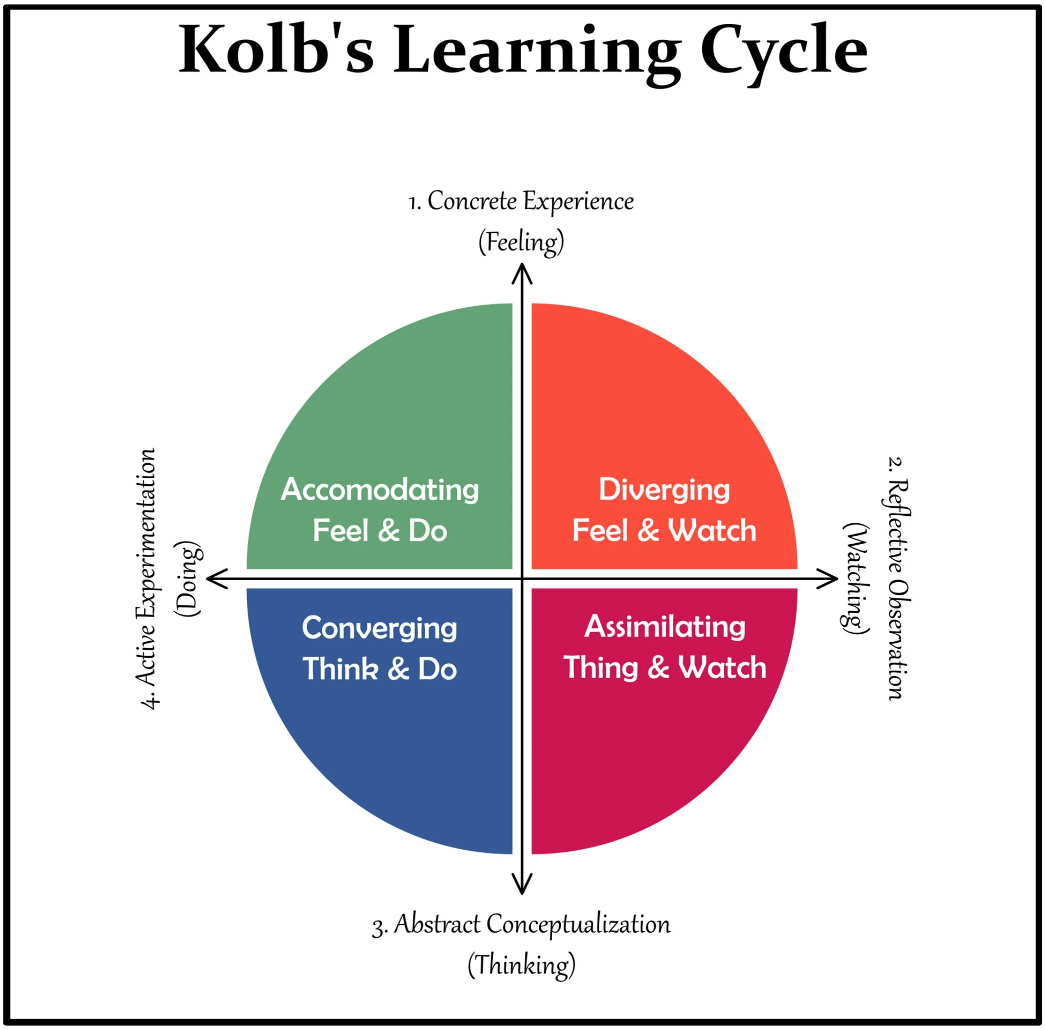
A Guiding Framework: Experiential Learning Theory (ELT)

Reimagining the undergraduate research program model is central to developing approaches and practices to effectively increase awareness, access, and participation in robotics. To further this goal, we began with a study of education learning theories and evidence-based student development practices that could be applied to the summer research experience. Experiential learning, dialectical method, peer engagement, and research on the science of effective mentoring in STEM emerged as promising approaches to address long-standing underrepresentation from the traditional science establishment and transform the traditional undergraduate research model. Ultimately, we used David Kolb's Experiential Learning Theory (ELT) as a compass to guide the reimagining of our traditional REU model.

David Kolb's Experiential Learning Theory (ELT) presents a framework that supports developing learning identities, flexibility, and resilience. ELT presents learning as a process of creating knowledge through experience and interacting with one's environment. ELT, with its grounding in social justice, democracy, and constructionist theory, strongly influenced the development of Carol Dweck's seminal work on growth versus fixed mindsets. Through a four-part learning cycle (concrete experience, reflective observation, abstract conceptualization, and active experimentation) (figure 2), the learner grasps and transforms experiences. The learner's unique approach is influenced by what Kolb presents as the nine learning styles. According to Kolb, "learning styles are influenced by culture, personality type, educational specialization, career choice, and current role and tasks" (D. A. Kolb, 2015). Drawing upon Kolb's ELT, the RISS program seeks to create a consciousness of one's learning process, help participants develop intentional learning goals, and create a positive learning environment. As described by Kolb, an ideal learning environment should seek to create psychological safety, foster empathetic engagement with and between peers and mentors, provide positive reinforcement, and actively guide the student through the learning cycle (experience, observe, integrate, experiment). This process helps students develop a strong learning identity, better navigate barriers, develop a sense of belonging, reduce imposter syndrome, and ultimately persist in STEM (D. A. Kolb, 2015).

Critics state that Kolb's experiential learning theory can be overly simplistic, may fail to reflect global cultural learning traditions sufficiently, and crowds out other learning theories. However, for our purposes of developing metacognition, empathetic mentoring, and a safe learning environment, ELT, its underpinnings, and its learning cycle provided a clear compass for reimagining RISS's purpose, approach, and process for organizers and participants.

Figure 2: *David Kolb's Four-Stage Learning Cycle*



Note. The graph represents David Kolb's two continuums. The horizontal axis is called the processing continuum and the vertical axis is called the perception continuum (D. A. Kolb, 2015).

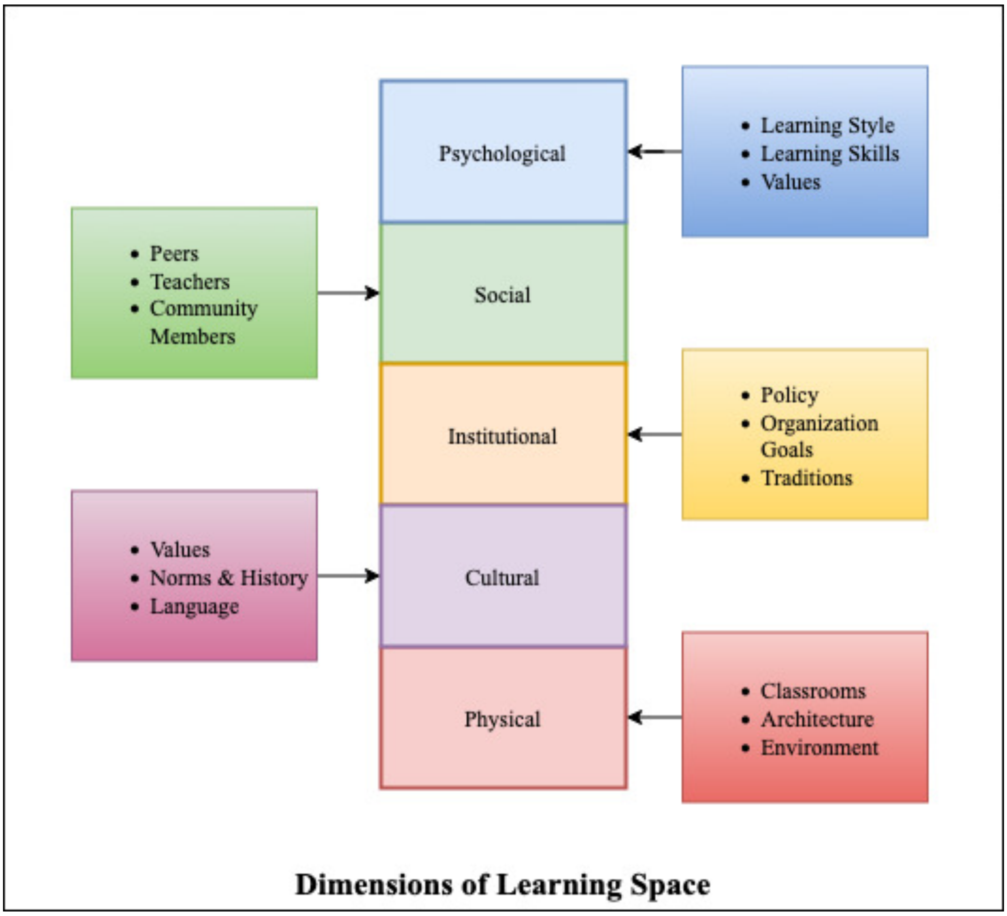
Kolb also stresses the importance of the learning space attained through creating safety, integrating multiple forms of supportive mentorship, facilitating peer engagement and dialectical methods, reducing the risk of failure, and showing the relevance of the activities and framework. The learning space and approach must be adjusted to meet the learner's needs and acknowledge their prior experiences, cultural backgrounds, and identities. The RISS program reframed its purpose to nurture future roboticists from all backgrounds.

Based on Kolb's dimensions of learning space (Figure 3), RISS, iteratively, has embedded the following elements to make the learning proactive and continual:

- Creating Safety
- Ensuring Positive Mentorship
- Facilitating Peer Engagement & Learning
- Reducing Risk of Failure
- Communicating Values
- Showing Relevance of Process and Outcomes
- Creating Space for Reflection

The above-mentioned elements form a guiding checklist to quickly identify gaps in each workshop, process, and experience. Additionally, it allows organizers to modify the language, actively model values and group norms, and place the activity within the Scholar Development Roadmap.

Figure 3: *David Kolb's Dimensions of Learning Space*



Note. The figure represents David Kolb's Dimensions of Learning Space. The five dimensions come together in the experience of the learner (D. Kolb & Kolb, 2013).

Our approach was reframed to facilitate high-quality immersive undergraduate research experiences, professional development, inclusive mentoring, and service learning that can transform lives and open doors. Exploring David Kolb's Dimensions of the Learning Space, we created four distinct phases to the program. The first phase is pre-arrival (setting the foundation, developing a group agreement, use of intentional language, and discussing learning. The second phase is the summer research immersion (reinforcement of group values, norms, and intentional use of language including scholars in the theory). The fourth phase is the wrap-up and launch where we use intentional language to ensure support, discuss iteration, share examples of resilience, and provide one-on-one support. The fifth phase is the post-program support, which has focused on graduate and fellowship application support.

Our vision of engagement is to begin before the program and continue post-program to surround each student with support, just-in-time interventions, and ongoing coaching. Year-round RISS activities focus on education, access, and engagement to co-create expansive and inclusive learning opportunities to support scholar development. Post-program support is essential for processing the summer experience and integrating new knowledge, paths, and ways of being into our individual identities and pathways. However, this fifth phase of scholar engagement is the least developed, funded, and studied.

During the summer portion of the RISS experience, the RISS team, alums, and community of advocates work together to enable students to

1. strengthen their academic foundation (knowledge, skills, and build an influential network of robotics innovators),
2. explore using robotics to impact the world, and
3. craft personalized learning and career roadmaps with multiple pathways and opportunities in robotics.

The 100-plus RISS mentor community that enables this high-touch experience now draws from faculty from the Robotics Institute, Mechanical Engineering, and Electrical Engineering Department, current graduate students, alums, and leaders from across campus and the Pittsburgh community.

Multiple layers of mentorship and engagement in diverse research discussions have been essential to supporting the scholar's identity development. Further, a major aspect in the reframing was the inclusion of research methods and approaches in the discussions (e.g, direct discussions of expectations, approaches, failure, reframing, and iteration on a regular basis). This has been critical in helping the scholar learn and address the objectives and outcomes of their research with active feedback. Consequently, this created a unique space for researchers (mentors and scholars) from across different experience groups to form a free-flowing synergetic collaborative dialogue space where scholars were able to not only learn but also impart their learnings to their fellow peers in other research projects.

RISS is about discovery, growth, and learning. Therefore, we have reframed the traditional REU products and research posters as learning opportunities, not the goal or measure of success. The research products are artifacts that demonstrate scholars' experience, showcasing their research experience and contributions. This reframing combined with the use of intentional language describes the learning experience and exploration as the most important outcomes. This approach encourages active experimentation and iteration rather than creating high-stakes environments in which students are paralyzed by the fear of failure. The greater gain and value is the learning of the subjects, self, and community.

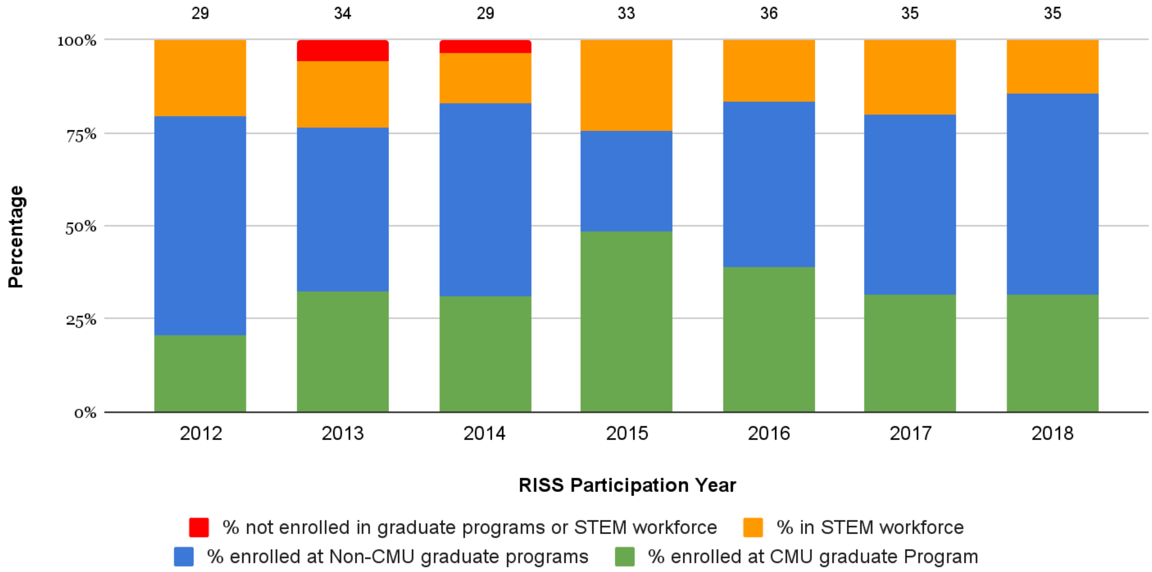
Combined, this framework and the scaffolded experiences allow the scholars to practice key elements of being a researcher or academic in a guided, safe environment with space for reflection, experimentation, and iteration. Table 3 shows a major finding from the ELT case study among students who attended RISS between 2012 and 2018, nearly 80% ended up enrolling in graduate and doctoral programs and 19% of the remaining ended up in the STEM workforce. Thus, establishing the effectiveness of applying the ELT lens in constructing the REU learning space.

Table 3: *Post-RISS Graduate School Participation & STEM Workforce Engagement*

Post-RISS Outcomes	Outcome Categories	Total Percentage
RISS alumni graduate school participation	Percentage of students who attended CMU graduate programs	33.77%
	Percentage of students who attended non-CMU graduate programs	46.75%
RISS alumni direct to the workforce *(without attending graduate school)*	Percentage of students working in a STEM field	18.18%
	Percentage of students that do not work in a STEM field	1.30%

Note. The table shows the numbers collected from the RISS program between 2012 and 2018. The total number of students who attended RISS from 2012 to 2018 is 231. The percentages represented are with respect to n=231.

Figure 4: *Yearly Breakdown of Post-RISS Outcomes*



Note. The stacked bar graph is a breakdown of post-RISS outcome categories from (Table 3) for each year from 2012 to 2018. At the top of each bar, the total number of RISS participants is listed.

Conclusion

Undergraduate research experiences represent a tremendous resource and opportunity to strengthen the national research pipeline and expand the participation of students from underrepresented backgrounds. Expanding access, increasing funding, and studying learning models that support scholar development are essential for the nation's future health, security, and prosperity. However, we need more than expanding access to realize the full potential of these programs. The traditional REU program model can be transformed by adopting a student-centered approach, more effective and supportive mentoring, and systematically applying multiple layers of experiential learning theory. By becoming practitioners and students of ELT design, student outcomes and our understanding of effective learning environments will strengthen.

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Contact emails: rachel@cmu.edu
vishwas.mruthyunjaya@gmail.com
jdolan@andrew.cmu.edu

School for Social Justice: Pedagogical Reflections on Equity in Education in Gramscian Perspective With a Focus on the Italian Context

Valerio Ferrero, University of Turin, Italy

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Abstract

The role of school for social justice is supported internationally (Connel, 1993; Hytten & Bettez, 2011; Pearson & Reddy, 2021): everyone must be included in democratic participatory processes (Bauman & Tester, 2002; Gerwitz, 2006) and have the cultural and political tools to change History (Bell, 2007; Hackman, 2005). Taking equity in education (Rawls, 1972; Nussbaum, 2013; Sen, 2009; Kanor, 2021) as a horizon of pedagogical meaning means ensuring excellence for all and the acquisition of the capabilities to exercise citizenship. Focusing our analysis on the Italian context, old and new inequalities reverberate on students' educational pathways (OECD, 2022; INVALSI, 2022). Social reproduction is still active, but non-traditional factors of inequality emerge (Ferrer-Esteban, 2011; Ferrero, 2022; Granata & Ferrero, 2022): they are produced by school culture and the structure of the school system and cause unprecedented forms of injustice. Re-reading the challenges of this context through the philosophical work of Antonio Gramsci (1919; 1975; 1996; 2022) is useful to give depth to the reflection, given the topicality of his thought: schooling should not crystallize social differences but be a vector of emancipation to guarantee people equal cultural and political dignity. Schooling make it possible to transcend forms of subalternity and hegemony, even those that are presented as traditional and therefore socially accepted: it is necessary to make people aware that there is nothing natural or predetermined about social organization, that it is possible to unhinge existing relations of dominance and power in favor of a more democratic and fair social order.

Keywords: Antonio Gramsci, Social Justice, Equity, School, Inequalities

Introduction

The school's contribution to the realisation of the democratic project is inescapable for our Constitution (Ferrari et al., 2019), according to which excellent education and training for all is an indispensable condition for a more just, cohesive and inclusive society. In this sense, Article 34 outlines the idea of a democratic school that is attentive to guaranteeing everyone the opportunity to develop their potential, talents, aptitudes and aspirations; Article 3, which is not specific to schools, also emphasises how the state must assume a decisive role in reducing inequalities between citizens and guaranteeing them equal access to democratic participatory processes. A school that is an instrument of social justice is thus outlined (Cavaliere, 2021) thanks to an educational action that assumes equity as a horizon of inalienable pedagogical sense (Granata, 2016).

If the democratic project is an itinerary never concluded and to be built day by day responding to ever-new challenges, social justice is also an ideal never fully realised (Bauman & Tester, 2002), which requires a constant commitment so that each person is included in democratic participatory processes (Gerwitz, 2006) and exercises self-determination despite the interdependence that binds human beings (Bell, 2007). Access to knowledge and the acquisition of skills to critically analyse what is happening are essential elements for being actors in history, identifying and opposing forms of injustice and oppression (Hackman, 2005).

The school's commitment to social justice only becomes concrete if it acts under the banner of equity: the polysemy of the construct requires terminological discernment and subsequent positioning. Interpretations that are too oriented towards meritocracy (Nagel, 1991; Savidan, 2007) and negative freedom (Colombo, 2012; Van Hees, 1998) risk opening up to social reproduction dynamics, as they do not take into account how the different starting conditions reverberate on school paths; these two strands consider the results achieved without giving importance to the processes and paths that determine them and do not question the role of the school context in arriving at a precise *outcome*, reading those who do not achieve positive results in terms of a predetermined level as disadvantaged. The other three strands, namely equality of opportunity (Bourdieu, 1966; Rawls, 1971; Roemer, 2000), ability (Nussbaum, 2013; Sen, 2009) and social inclusion (Kanor, 2021; Taket et al, 2013), make it possible not to give in to a compensatory pedagogy according to which there is a norm to strive for and not to activate the commitment to equity only as a result of a worsening of the *status quo*; pluralism is thus understood as an everyday experience and the urgency of breaking the interdependence between students' *backgrounds* and educational paths is affirmed, emphasising the role of schools so that all realise their aspirations having acquired the necessary skills to lead fulfilling lives.

The positioning within the last three interpretations is a choice with a strong ethical value (Milani et al., 2021) that allows for the elaboration of a theoretical-practical definition of equity that interweaves the intercultural perspective (Fiorucci, 2020; Granata, 2016; Tarozzi, 2015) with the developments of *post-colonial studies* (Ashcroft et al., 2013; Burgio, 2022; Young, 2020) and intersectional theory (Crenshaw, 2017; Hill Collins, 2019). There is a need to ensure excellent education for all in terms of efficiency and effectiveness, aimed at acquiring the skills necessary to exercise citizenship understood as active participation in social, political, cultural, economic life on the local and global levels. Diversity must not turn into inequality: there is no norm to adhere to and pluralism is an opportunity to enhance people's strengths (Zoletto, 2020), without differences being read as factors of disadvantage.

The Constitution and the laws deriving from it promote this idea of equity, but in students' everyday experience it still remains an ideal that is difficult to realise (Crescenza, 2021; Crescenza & Riva, 2021; Gavosto, 2022). The dynamics of social reproduction, already denounced in the 1960s even beyond Italy's borders (Bourdieu, 1966; Bourdieu & Passeron, 1964; Don Milani, 1967), are still active (Gentili & Pignataro, 2020; Giancola & Salmieri, 2020): children replicate their parents' school and life trajectories. If socioeconomic and sociocultural *status* represent classic factors of inequality, new ones emerge today, defined as non-traditional because it is the school itself that creates them due to its organisational choices and its functioning (Ferrer-Esteban, 2011; Granata & Ferrero, 2022). The ethnography of education has long emphasised the distorting effects in terms of equity of school culture (Gobbo, 2008; Goldring, 2002): everyday educational practice, organisational aspects at the school level and national education policies generate dynamics of inequality. In fact, these non-traditional factors are numerous and, acting under the radar, difficult to detect: their diversity from one context to another requires lenses of investigation and specific actions to overcome them. Classical and non-traditional factors combine, giving rise to unprecedented forms of injustice that affect all students and bend their schooling in a direction of inequality (INVALSI, 2022; OECD, 2022).

It is therefore urgent to bring back to the forefront the reflection on the role of the school for social justice: thematising the issue is a precise ethical commitment, even more so in a historical moment in which various emergencies (pandemic, geopolitical crisis, economic crisis) intersect, exacerbating social inequalities (CENSIS, 2022; ISTAT, 2022). It is not just a matter of transmitting to the younger generations technical skills that they will be able to spend in an increasingly competitive labour market, but of seeing the school as a laboratory of citizenship in which to acquire those fundamental skills to lead a life in which one's own voice can be heard, free from ideological conditioning and in possession of the cultural tools that represent a common heritage that each person can interpret and help to make grow.

Rereading Antonio Gramsci's ideas on schooling and education[1] from a pedagogical perspective seems absolutely useful to understand how a school system that acts in the name of fairness with a view to social justice leads to the development of an increasingly aware and democratic society: there can be no progress for the state without the personal growth of each citizen in terms of critical spirit, creativity and moral awareness.

For a democratic education: culture, school, freedom

The pedagogical use of Gramsci's work certainly highlights his commitment to overcoming forms of subalternity (Baldacci, 2017). Before delving into the reflection on Gramsci's thought on schooling, it is important to consider the philosophical tradition and the historical-cultural context in which his work takes shape. Gramsci places himself in the framework of Marxism, understood as a philosophy of praxis that allows for the interpretation of reality with a view to a radical transformation of capitalist society and a rupture of the relations of political and cultural hegemony in terms of the intellectual and moral direction through which a social group exerts power over the entire civil society (Petronio & Paladini Musitelli, 2001). On a historical level, Gramsci elaborated his thought after the defeat of the labour movement in the early post-war period and during the advent of the fascist regime (Canfora, 2012; Mordenti, 2007). The current historical, cultural and social background is certainly different, but the pedagogical reinterpretation of Gramsci proves to be important if we

[1] This paper offers excerpts from Gramsci's work. Translations are by the author.

consider the persistence of forms of subalternity, inequality and hegemony that it is crucial to overcome.

The relationship between culture, political power and emancipation assumes a particularly prominent place in Gramscian reflection (Benedetti & Coccoli, 2018): every human being must have the tools to deal with the problems that arise on the socio-political level thanks to his or her historical and social awareness. Culture is therefore something dynamic, which opens up to change that can be achieved through a search for solutions that should not only concern some, but all people.

> This word immediately conjures up [...] the image of the book and the coffee table. [...] Culture is not the possession of a well-stocked warehouse of news, but is the capacity our human mind has to understand life, the place we hold in it, our relations with other men. He has culture who has consciousness of himself and of the whole, who feels the immanent relationship with all other beings, what diversifies him from them and what unites him to them. [...] So that to be cultured, to be a philosopher, anyone can be. It is enough to live as men, that is, to try to explain to oneself the reason for one's own actions and those of others; to strive every day more and more to understand the organism of which we are a part; to penetrate life with all our forces of awareness, of passion, of will; never to fall asleep, never to become lazy. (Gramsci, 1919, p. 1)

A fairer and more democratic society cannot disregard the participation of everyone, no one excluded, in the construction of a common and shared cultural heritage and the acquisition of the ability to read reality, to place oneself in historical-social processes and to place oneself in an equal relationship with other human beings, in a continuous tension between the valorisation of one's own uniqueness as the promotion of pluralism and the affirmation of formal and substantial equality between people (Dei, 2018). The view of culture as the "organisation of oneself' and 'awareness of one's historical and social agency" (Benedetti & Coccoli, 2018, pp. 47-48) clearly fits into Gramsci's philosophy of praxis, in which intellectual activity has concrete reverberations in people's everyday lives and can alter power relations between them (Crehan, 2003). Culture understood in this way brings individuals closer together, preventing them from running the risk "of not knowing how to come out of their cultural shells and measuring the foreign[2] with a yardstick that is not their own" and fostering a gaze capable of "seeing difference under equal appearances and not seeing identity under different appearances" (Gramsci, 1975, p. 928).

School assumes a crucial role in the acquisition of these indispensable skills to live as free people (Baldacci, 2017). For Gramsci, it must educate and not simply instruct: it is a lexical choice that is not accidental, that wants to mark the urgency of overcoming a school system organised only to transmit notions that are not always useful for orienting oneself in the contemporary world in favour of a school whose aim is the integral formation of the person, highlighting the crucial role of teachers (Burgio, 2003).

> It is not entirely accurate that education is not also education: to have insisted too much in this direction was a grave error of idealistic pedagogy and one can already see the effects of this in the school reorganised by this pedagogy. For education not

[2] In the pedagogical and more appropriately intercultural sphere, we could replace the Gramscian expression 'the foreign' with 'the *other'*: cultural diversity is not just a matter of geographical origin but encompasses multiple variables. It is crucial not to reduce the complexity of pluralism.

> also to be education would require the learner to be mere passivity, a 'receptacle mechanism' of abstract notions, which is absurd and, moreover, is 'abstractly' denied by the advocates of pure education precisely against mere mechanistic education. The 'certain' becomes 'true' in the consciousness of the child.
>
> But the child's consciousness is nothing 'individual' (and even less individualised), it is a reflection of the fraction of civil society in which the child participates, of the social relations as they are interwoven in the family, in the neighbourhood, in the village... The individual consciousness of the vast majority of children reflects civil and cultural relations that are different and antagonistic to those represented by the school curriculum: the 'certain' of an advanced culture becomes 'true' within the frameworks of a fossilised and anachronistic culture, there is no unity between school and life, and therefore no unity between education and upbringing.
>
> Therefore, it can be said that in the school, the education-education nexus can only be represented by the living work of the teacher, insofar as the teacher is aware of the contrasts between the type of society and culture he represents and is aware of his task, which consists in accelerating and disciplining the formation of the child in accordance with the superior type in struggle with the inferior type. If the magisterial body is deficient and the education-education nexus is dissolved in order to resolve the question of teaching according to paper schemes in which educativeness is exalted, the work of the teacher will be even more deficient: we will have a rhetorical school, without seriousness, because the material body of the certain will be lacking, and the true will be true of words, precisely rhetoric. [...] In reality a mediocre teacher may succeed in getting his pupils to become more *educated*, he will not succeed in getting them to become more cultured.' (Gramsci, 1975, pp. 1541-1543)

It is impossible to clearly separate the instructional aspect from the educational one: the point is to avoid a divide between what is learnt at school and what is needed to interpret contemporaneity (Baldacci, 2019). Instruction is thus a fundamental but not exclusive part of education: it is up to the teacher to overcome this dichotomy, not reducing the teaching and learning process to pure notionism or empty rhetoric (Baratta, 1999) and building a "close and founding" relationship with the pupil (p. 47).

An effective school for democracy

A school system that crystallises and accentuates social inequalities without making changes to overcome *status* differences and build a fairer society certainly cannot be said to be equitable and democratically oriented (Saragnese, 2019). As we saw in the opening, even today our schools fail to be a *great equalizer* (Bernardi & Ballarino, 2016) that allows everyone to realise their aspirations and take an active, conscious and satisfying part in democratic processes. One hundred years ago, Gramsci strongly denounced how the structure of the Italian school system, which we pointed out as a non-traditional factor of inequality, produced cultural hegemony and subalternity.

> In today's school[3] , due to the profound crisis in the cultural tradition and conception of life and man, a process of progressive degeneration is taking place: schools of the professional type, i.e. concerned with satisfying immediate practical interests, are

[3] This writing dates back to 1932.

> taking over from the formative, immediately disinterested school. The most paradoxical aspect is that this new type of school appears and is preached as democratic, when in fact it is not only destined to perpetuate social differences, but to crystallise them in Chinese forms.
>
> [...] It is not the acquisition of management skills, it is not the tendency to form superior men[4] that gives the social imprint to a type of school. The social imprint is given by the fact that each social group has its own type of school, destined to perpetuate in these strata a certain traditional, directive or instrumental function. If this pattern is to be broken, it is therefore necessary not to multiply and graduate the types of vocational school, but to create a single type of preparatory school [...] that leads the youngster up to the threshold of professional choice, forming him in the meantime as a person capable of thinking, studying, directing or controlling those he directs. (Gramsci, 1975, p. 1547)

A school that acts *according to* and *for* democracy should guarantee an educational pathway of optimal quality for all, without the deception of an 'easy school' (Benedetti & Coccoli, 2018, p. 174) that in reality stratifies social and cultural differences by making them understood as traditional. We realise the relevance of Gramsci's reflection especially if we think about the division of pupils into chains in the second cycle of education and the presence of young women in STEM degree courses and young men in degree courses leading to educational and care professions (Benadusi & Giancola, 2020; Ghigli, 2019). In the first case, the children of parents with low or medium-low socioeconomic and sociocultural *status* tend to choose secondary education paths that do not open to an academic future (regional vocational courses) or that do not have it as an immediate consequence (vocational institutes), in contrast to the children of families with medium-high or high *status* who instead prefer technical institutes or high schools. In the second case, there is a strong gender segregation: young women prefer educational and care professions to engagement in STEM subjects, in contrast to young men. This result is the result of school experience: already during the primary school years, boys perform better in mathematics than girls, who instead score better in Italian than their male peers (INVALSI, 2022).

According to Gramsci (1975; 1996; 2022), in fact, an exclusively professional education inhibits people's creativity and potential, reducing human beings to means, experts in specialised knowledge incapable, however, of orienting themselves in the world; on the contrary, an exclusively humanistic education is a failure because it does not provide children with those skills that allow them to situate themselves in contemporary times and adapt to sudden changes (Benedetti & Coccoli, 2018). In essence, a school that does not guarantee excellence to all and, in Gramsci's words, the possibility of being part of the ruling class and controlling it cannot be said to be democratic: a real expansion of educational opportunities is not achieved by expanding the offer of technical and vocational schooling, but by eliminating the barriers that prevent everyone from improving their living conditions with respect to their initial family *status*.

> An important point in the study of the practical organisation of the unitary school is that concerning the school career in its various grades in accordance with the age and intellectual-moral development of the pupils and with the aims that the school itself

[4] A less pronounced and more topical lexical choice could be *people with highly specialised skills*: in continuity with Gramsci's denunciation, a school that is too focused on providing students with training that is spendable on the professional market risks neglecting the more properly educational and cultural aspects.

> wants to achieve. The unitary school [...] should aim to introduce young people into social activity after having brought them to a certain degree of maturity and capacity for intellectual and practical creation and autonomy in orientation and initiative. The setting of the compulsory school age depends on the general economic conditions, as these can force the demand on young people and boys to make a certain immediate productive contribution. In other words, it transforms the budget of the ministry of national education from top to bottom, extending it in an unprecedented way and complicating it: the entire function of the education and training of the new generations becomes from private to public, because only in this way can it involve all generations without group or caste divisions. But this transformation of scholastic activity demands an unprecedented enlargement of the practical organization of the school, i.e. of the buildings, of the scientific material, of the teaching staff... The teaching staff in particular should be increased, because the efficiency of the school is all the greater and more intense the smaller the relationship between teacher and pupils, which poses other problems that are not easy and quick to solve." (Gramsci, 1975, p. 1534)

Gramsci's reflections on a unified and democratic school focus on issues that are still relevant today, such as public spending on education, class size, the number of teachers and their training, and school construction. A genuinely democratic school ensures that all children can become leaders, so that even those who do not occupy that role will have the thinking and analysis skills to understand what is happening and the ways in which those in positions of public responsibility use power (Baldacci, 2017; 2019; Baratta, 1999; Borg et al., 2002): the division between leaders and subordinates is overcome thanks to education and, in particular, thanks to culture as we defined it in the previous paragraph.

Conclusion

Italian school reproduces and produces inequalities among students: in general, for children who come from families with low or lower socio-economic and socio-cultural *status,* school success often remains a chimera. The current historical, social and cultural context has obviously changed compared to the years in which Antonio Gramsci developed his philosophy of praxis within the framework of Marxism; his ideas on education and schooling are certainly affected by the climate of the time, however their reinterpretation is useful today as our school system is far from being that *great equalizer* sanctioned by the Constitution and has old and new criticalities that Gramsci's view helps to put into perspective in order to see the implications on a social and cultural level.

In essence, a democratically oriented school guarantees all people a common path of education and emancipation that allows them to find space and voice in their everyday reality. This idea of equity as an indispensable instrument of social justice can be found in the reasoning of Gramsci, who advocates the need for equal cultural dignity of individuals: everyone must know how to be an actor in History, identifying power dynamics and power relations and exercising his or her own judgement with respect to the ways in which the ruling class performs its duties of responsibility. The school can only counter cultural hegemony and subalternity if there is a priori an organisational effort to make it truly adherent to the social context in which it operates: ultimately, inequalities between students are reduced by overcoming the gap between what is learnt at school and what is needed in life.

In this sense, a school that is ‘open to all’ is obligatorily unitary, inclusive: the division into branches and directions opens up choices on the part of families and students that are not always aimed at indulging inclinations and aspirations; the existing social order is thus reproduced, with children replicating their parents’ educational and professional paths. It is not only a matter of giving a new structure to the school system, but above all of acting on the level of teacher training, on their number, on the ways of *doing school*, on learning environments, on public spending on education that should be seen as an investment for the growth of the state.

At a time of severe crisis in the school institution, which is unable to be a social lift, Gramsci’s reflections, which predate the Constitution and thus the birth of the democratic republican school, echo in their topicality and represent a perspective of meaning to look at in order to imagine a school that is truly ‘open to all’, which breaks down dynamics of cultural hegemony and subalternity that lead to social, political, economic and cultural impoverishment. The attempt not to bend to market and productivity logics but to have social justice as the ultimate goal is a complex task to be taken on at a systemic level, as individual schools, as teachers and headmasters: it is the only way to break power dynamics and power relations and build a genuinely democratic society.

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Contact email: valerio.ferrero@unito.it

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Alyson da Silva Leal, Unifenas, Brazil
Virgínio Cândido Tosta de Souza, Universidade Vale do Sapucaí, Brazil
Kátia Rejane Rodrigues Leal, Unifenas, Brazil
Carolina Rodrigues Leal, Unifenas, Brazil

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Abstract
Around the 1950s, in the so-called "post-industrial era", science and the University, given the technological impact of knowledge, underwent substantial changes in their statutes, by marginalizing the theoretical framework provided by the philosopher, relegating ontological issues to the sidelines and prioritizing gnosiological issues. From the moment that the metaphysical framework of modern science was invalidated, concepts dear to modern thought such as "truth", "subject", "totality", "reason", "progress" give way due to disbelief in the face of philosophical-metaphysical metadiscourse, with timeless and universalizing pretensions (LYOTARD, 1998). The pursuit of university efficiency and excellence can no longer be based on the traditional alchemy of cost-benefit calculation with increased productivity (manpower production that meets market needs). Success evaluation criteria begin to incorporate dimensions that go beyond the economic organization that sees the University as a company that must be guided by managers, but that concern social, cultural life and environmental preservation. It can be said that efficiency is not just "doing things well", according to market rules, but "doing good things" according to ethical principles. It is the duty of the Academy to bring to those who enjoy it directly or indirectly the *eudaimonia* that is not based on riches, nor pleasures, nor on honors but on a virtuous life, raising the thought for the common good, in which one stops seeking one's own pleasure and elevates the thought of the common good, bringing enthusiasm in living.

Keywords: Postmodern Time, University, Ethics, Citizenship, Philosophy

Introduction

Since their inception, Universities represented a unique product of Western civilization, with a remarkable associative spirit between masters and students, researchers, artists and philosophers, who led man in the search for solutions to his broadest interests, for the formulation of answers to enable the resolution of common problems. The University, prior to the modern era, was faced with a context where the whole was more important than the part, in an organization that overlapped with the freedom of men, who, in fact, were not masters of their destinies.

Currently, with society in constant change, in a logic marked by democratic individualism, where all individuals are, in principle, free and equal, the University must adapt to the new imperatives linked to the challenges of the 21st century, in a model completely revolutionary.

If before the education offered to the great masses of society was reduced to the dissemination of skills such as reading, writing, performing calculations, sufficient to work in a factory or in the field, today this is no longer sustainable: humanity needs other skills, more complex and capable of responding adequately and satisfactorily to problems in the social, health, food, and ecological fields.

It is in this paradigm that the research on screen proposes a hermeneutics about the socio-cultural responsibility of the University committed to the Ethics of values and responsible Citizenship in postmodern time.

Theoretical foundation

The work presented is an analysis and discussion of the role of the University in the face of instability in the postmodern era. It seeks to explain the role played by Higher Education for the consolidation of a critical and humanist spirit, thus enabling the establishment of a productive dialogue with the aim of contributing to the formation of an ethical individual with full citizenship.

Methodology

The methodology of the research on screen is theoretically based, qualitative, bibliographical, dissertative, not systematized, directed towards an approach to the University, Ethics and Citizenship in Postmodern time.

Discussion

The times we live in: divorce between scientific and humanistic culture

The progress of knowledge, science and technology has been shown to be uncoupled from politics, ethics and thought. What in times of Modernity the reason seemed to be a certain promise of a human flourishing, in postmodern times, paradoxically, reverts to questions that generate multiple regressions that go back to barbarism.

The development of society, leveraged by reason, brings with it scientific, medical, technical and social progress, as well as destruction in the biosphere, new inequalities, new servitudes replacing former slavery, threat of annihilation (nuclear, ecological) and frightening powers of manipulation (MORIN, 2011).

Since modernity, science and technology have become productive forces, ceasing to be a mere support of capital, becoming agents of its accumulation. Scientists and technicians gradually became key players in capitalist strength and power, which are based on the monopoly of knowledge and information (CHAUÍ, 2003).

The point is that science is not seen as an enterprise that develops on some higher moral or spiritual level, but shaped by economic, political and religious interests, where most scientific studies are funded not by mere altruism, being unable to establish your priorities or determining what to do with your findings. Indeed, this cycle between science, empire and capital was the main engine of history in the last five hundred years (HARARI, 2021).

Harmful symptoms of postmodern ideology

The current model of capital accumulation, called neoliberalism, marked by the vertical disintegration of production, electronic technologies, speed in the qualification and disqualification of labor, acceleration of the turnover of production, trade and consumption due to the development of information techniques and distribution, with the proliferation of the service sector, brings with it a by-product: the postmodern ideology (CHAUÍ, 2003).

Post-modernity relegates to the condition of totalitarian Eurocentric myths the ideas spread during modernity: rationality, universality, history as endowed with immanent meaning. It is marked by a passion for the ephemeral, for fast images, for fashion and for the disposable. It affirms fragmentation as a way of being of society. It leaves behind the importance given to man and his values, the distinction between good and evil, the search for knowledge of virtue, knowing how to master one's impulses and the reflection of knowing oneself.

The individuals of this current society base their relationships on superficiality and solitude: a liquid society, where there is fear and apprehension of deep relationships. The search for the new (in goods and interpersonal relationships) is fostered by the psychology of consumer life that everything old is bad, as opposed to the stability and security of the past society of producers. The consumerist ethic exempted society from cultivating compassion and tolerance (BAUMAN, 2008).

Much more than the conquest of freedom and autonomy, there are the delights of narcissism and hedonism, with the promotion of permissive values. Modern individualism, far from being virtue and autonomy, means passivity and even apathy, in an era of empty men and focused on private and narcissistic choices (RUSS, 2015).

Two dimensions of modernity were lost in this process: the dignity of the citizen and the social contract. The values of modernity evaporate due to the commodification of everything: feelings, ideas, products and dreams. Love and idealism become innocuous words where what prevails is profit and personal gain (BETTO, 2011).

For an emancipatory, ethical and citizen reform of the University

For nearly a thousand years, the University has survived by adjusting to the changes and demands of the world: changes in teaching and research methods, in the contents of intellectual life, in the urgent need to readapt to the new knowledge and behaviors acquired by the human being.

The scholastic University evolved into the scientific, technical, market-oriented University, but little has changed in the basic features arising in Bologna, Paris, Oxford, at the beginning of the second millennium. Before your basic strategy was able to meet knowledge challenges.

Today, with the speed at which ideas evolve within each area of knowledge, with the speed with which knowledge spreads in the world directly, without the need for intermediation from the University, the crisis of hegemony that the University is going through is clear, among other factors, due to the contradictions between the traditional functions that it insistently refuses to maintain and those that postmodern society has been trying to attribute to it.

Starting with the need to break university isolation and its epistemology of separation, the result of modern rationality and the necessary resumption of the interconnectivity of knowledge.

In this sense, it is necessary to understand the University as a center for the production of epistemological and socially privileged knowledge. It has; therefore, more than any other incorporation, social responsibility, and it has the irrefutable commitment to accept being permeable to social demands. The University, with all the epistemology capable of producing, cannot be an island in itself.

Social responsibility presupposes, in this case, much more than responsible action by the University that acts correctly, considering awareness and commitment to social change. Such practices and social objectives cannot be mixed with commercial and economic interests, in which all the benefits of performing acts that contribute to society in a proactive way in the fight against social problems are indirectly reversed in the medium and long term.

It is fundamental, therefore, to observe one of the varied roles to be played by Universities in the process of development and social justice: which implies stepping out of their isolation in relation to the most needy masses at an economic and cultural level.

If in the Greek academies teaching was done individually, between the master and the student, the new technologies allow the transmission of knowledge on a planetary scale, not being restricted to the use of the word, authorizing an unprecedented range of free, creative, knowledge, without attachment to dogma.

Without isolation, the post-university will be related in a network formed not only by specific teaching and research centers, but in any higher education promotion unit (industry, houses, laboratories, offices). Wherever there is a thinking person, there will be the University connected in this knowledge generation network (BUARQUE, 2020).

The University without walls in the 21st century is not restricted to the use of technology. In a practical example, the reform of the University must give a broad meaning to extension activities: through them the University starts to have an active participation in the construction of social cohesion, in the deepening of democracy, in the fight against social exclusion and the environmental degradation and the defense of cultural diversity.

Its recipients are the most varied: popular social groups and their organizations; social movements; local or regional communities. For the extension to fulfill this function, it must have as a priority objective, to provide solidary support to the resolution of problems of social exclusion and discrimination (SANTOS, 2021).

To the extent that it provides an evolution of the means of communication and information technologies, postmodern society also influences the conduct of the academic world, since academic acts become increasingly public and, therefore, noticed, demanding a greater care with the zeal for the practice of knowledge without any reprehensible conduct such as abuse of the environment, exploitation of its employees and faculty.

But it must be said that the social responsibility of Universities must be more than a concern that could scratch the image and harm interests that are undeniably aligned with the market, and, rather, start from a voluntary integration, not limited to respecting and fulfilling the needs legal but privilege the vision of the mission as a responsible part of an environment and a society.

The pursuit of university efficiency and excellence can no longer be based on the traditional alchemy of cost-benefit calculation with increased productivity (manpower production that meets market needs). Success evaluation criteria begin to incorporate dimensions that go beyond the economic organization that sees the University as a company that must be guided by managers, but that concern social, cultural life and environmental preservation. It can be said that efficiency is not just "doing things well", according to market rules, but "doing good things" according to ethical principles.

It so happens that many businessmen in the educational sector still insist on basing their ideas on the STOCKHOLDER THEORY (MILTON FRIEDMAN), according to which shareholders acquire company shares with the sole purpose of maximizing the return on their investment, with managers task, making the company obtain the highest possible profit.

This results in an individualistic view, where the directors of a company feel obliged to prioritize the interests of shareholders, who do not see at first that business can coexist with ethics and that such a partnership is necessary and beneficial to the lives of human beings and companies, above the issue of profit.

According to Santos (2021, p. 90), social responsibility does not remove university autonomy and academic freedom, since society is not an abstraction and the contextual challenges depending on the region where Universities are located must be faced by them.

It is worth resuming here the teachings of Hans Jonas, by emphasizing that the development of knowledge must be attentive to the individual, and not the opposite: it is up to the University to act in such a responsible way that it does not contribute to jeopardizing the indefinite continuity of the Earth (not only the physical destruction of humanity but its essential death arising from deconstruction and the random technological reconstruction of man). The knowledge produced and offered in academic spaces should also privilege future generations, helping in the exercise of curatorship of natural resources.

Another point of extreme relevance to be reflected by Universities is the epistemology of separation, noted and rooted in the traditional and fragmented way of transmitting knowledge.

Education in post-modernity must favor knowledge together with realities and their problems in a multidisciplinary, transversal, multidimensional, global and planetary way. Knowledge must be recognized in its historical, economic, sociological, religious dimension, fighting what has long been engraved in the knowledge process, leading to the reduction, separation, simplification and concealment of major problems (MORIN, 2014).

It is the role of the University and educators to work on training individuals in a changing world. In this, it is necessary to recognize a positive influence with the end of metanarratives that erase important differences and obfuscate complexities and nuances of interests, cultures, places. Individuals should be prepared for the transience of all aspects of life, with the need for constant updating and emancipation as historical subjects. The new reality demands educational attributes such as vision of the whole, autonomy, flexibility, initiative, analytical reasoning, skills to interpret and reinterpret situations, skills to process information and make decisions, skills for political activities, to learn about other cultures, about advances in technology, about social changes and constant changes in professional activities (PEREIRA, 2000).

It is necessary to rethink the role given exclusively to science and technology, leaving a secondary role for the humanist culture on the social and human consequences of its applications. The University is being called upon to rebuild a more fraternal society, capable of reinventing a more humane culture.

It is necessary to reconsider the knowledge offered by the University, which cannot essentially focus on production and the market. The Academy should provide students and their surroundings (local, regional and universal) with their ability to reflect on the major axes of current culture, thus ceasing to submit to the system, having to submit to debate (both from the point of view of scientific-technological point of view, as well as from the humanistic-cultural point of view) (GOERGEN, 2000).

Education, at all levels and segments, cannot be reduced simply to getting information or getting a job. Education is about healing and wholeness. It's about empowerment, liberation, transcendence, it's about renewing life's vitality. It's about finding and reclaiming ourselves and our place in the world (PALMER, 2017).

In this sense, post-modernity and its side of disastrous consequences bring to the agenda of the University the irrefutable fact about the indispensability of working for the formation of individuals, deepening the democratic claims arising from modernism, in the search for social justice, freedom and critical citizenship: the University was born by the humanities and for humanity.

Without sectarianism, the University will need to modify the cold scientific method and incorporate feelings and moral commitments: ethics becomes part of knowledge itself, relating rationality to moral values. Legislative codes are overshadowed by culturally accepted behaviors, according to which engineers will feel the need to protect the environment, economists not to cause unemployment to increase wealth, biologists not to induce biological mutation for the benefit of only a part of the population (BUARQUE, 2020).

On this basis, the University must be a place that, in fact, confronts preconceived ideas, rationalizations based on arbitrary premises, the inability to self-criticize, paranoid reasoning, arrogance, refusal, contempt, fabrication and the condemnation of culprits, egocentrism, ethnocentrism, sociocentrism, the nurturing of xenophobia and racism. It is necessary to combat the reducing and simplifying spirit, the possession by an idea, a faith, an absolute conviction of truth, which generate misunderstanding (MORIN, 2011).

University professors should be democratic educators, making room for learning to take place in the most inclusive way, placing themselves in front of students with confidence and openness to listen to them, respecting their freedoms, contrary to the authoritarianism that, in the academic space, makes the repressive and oppressive, dehumanizing study. Democratic educators must work to find ways of teaching and sharing knowledge in a way that does not reinforce existing structures of domination (hierarchies of race, racism, gender, feminism, class and religion), which generates significant impact far beyond the academic space (CASSIO, 2019).

The ethics of understanding must be reinforced: an ethics that calls for arguments, refutation, rather than excommunication and anathematization; understand why and how one hates or despises oneself; it is to understand the error, the deviations, the ideologies, the drifts, avoiding the peremptory condemnation, as if the individual himself had not already known the weakness or committed a mistake (MORIN, 2011).

Multidisciplinary and humanist integration is incomplete if the University does not leave political sectarianism: it needs political practice and must be a field for confrontation in the formulation of doubts and alternative thoughts. Passivity and the absence of civilized dialogue on how to make politics with a sense of responsibility and proportion, not being seen as a struggle between good and evil, only empower the digital environment more, which generates extreme politicization and alienation.

Returning to Aristotle's "Nicomachean Ethics", the University must contribute to the pursuit of happiness, since all practical rationality is teleological, oriented so that the individual develops in his fullness, being able to use all his capacities and possibilities.

It is the duty of the Academy to bring to those who enjoy it directly or indirectly the eudaimonia that is not based on riches, nor pleasures, nor on honors but on a virtuous life, raising the thought for the common good, remembering that the happiness that comes from the carnal life , where you have satisfaction with sex, drugs, shopping, passes quickly; the happiness generated by political life (or ethical life), in which one stops seeking one's own pleasure and elevates the thought of the common good, brings enthusiasm in living; finally, the happiness that comes from the contemplative life comes from the ability to get rid of material things and, therefore, smaller ones.

The Aristotelian conception of golden mean, also called average in "Nicomachean Ethics" has never been so pressing and necessary: the University must walk imbued with those who benefit from it, emphasizing that the search for virtue lies in the practical wisdom of a life prudent and balanced, guided by good habits, which depends on an excellent education: the average means reaching the right mean, balance, avoiding both lack and excess, in each individual's search for excellence in doing what must be done in a well-done manner, where there is the virtue for the citizen endowed with prudence and educated by habit in its exercise, with conscience and firm character to choose well.

Conclusion and Final considerations

Given the scenario presented, the University is required to question its identity and reposition its mission for the coming decades, through a new model that can meet the demands of post-modernity.

It is necessary to understand the University as a center for the production of epistemological and socially privileged knowledge. It therefore has social responsibility, with the irrefutable commitment to accept being permeable to social demands. Its social practices and objectives cannot be exclusively aimed at commercial and economic interests.

Education in post-modernity must favor knowledge together with realities and their problems in a multidisciplinary, transversal, multidimensional, global and planetary way. Knowledge must be recognized in its historical, economic, sociological, religious dimension, fighting what has long been engraved in the knowledge process, leading to the reduction, separation, simplification and concealment of major problems (MORIN, 2014).

The University was born by the humanities and for humanity: it must be a place that, in fact, confronts preconceived ideas, rationalizations based on arbitrary premises, the inability to criticize oneself, paranoid reasoning, arrogance, refusal, contempt, the fabrication and condemnation of culprits, egocentrism, ethnocentrism, sociocentrism, the nurturing of xenophobia and racism. It is necessary to combat the reducing and simplifying spirit, the possession by an idea, a faith, an absolute conviction of truth, which generate misunderstanding (MORIN, 2011).

Priority must be given to the humanities, philosophy and social sciences, which must be linked to the development of new technologies at all times. It is not enough for the University to teach the individual a specialty. In order for it to perform its social function, it must provide rational and humane training, so that its graduates acquire personality, with a sense of what is morally correct and fraternal.

The countless answers to be found in the face of the new imperatives linked to the imminent challenges in postmodern times can only be achieved with the development of a critical spirit in intelligence, in a thought that does not compartmentalize or separate but that reconnects what is separated, multidimensional and systemic, in an ethics committed and responsible with the whole present and with what is to come.

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Contact email: alyson.leal@unifenas.br

The Role of Artificial Intelligence in the Development of Teaching Effectiveness: A Tool for Personalization of Learning in Higher Education

María Inés Valencia Chica, Universidad Tecnológica Empresarial de Guayaquil, Ecuador
Mara Cabanilla Guerra, Universidad Tecnológica Empresarial de Guayaquil, Ecuador
Galo Cabanilla Guerra, Universidad Tecnológica Empresarial de Guayaquil, Ecuador

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Abstract
Artificial Intelligence (AI) has become one of the most important sustainable technology tools today because it offers several advantages for teachers and students that allow them to improve their performance in their academic and professional activities. Through the use of this tool people can automate repetitive tasks and free up time for more meaningful learning. There are many advantages to using artificial intelligence to improve efficiency, personalize learning and improve teaching in higher education, but it is important to carefully consider its implications and use it responsibly. Additionally, artificial intelligence can have both positive and negative effects on teacher effectiveness. On one hand, AI can assist teachers in grading and assessment, freeing up time for other tasks, and providing personalized learning experiences. On the other hand, AI can also be a source of bias, limit the creativity and critical thinking skills of students, and reduce the human interaction and mentorship that is important in education. The impact of AI on teacher effectiveness ultimately depends on how it is used and integrated into the teaching and learning process. Artificial intelligence (AI) has the potential to greatly enhance the effectiveness of teaching. One way this can be achieved is through the use of AI-powered educational tools, such as personalized learning platforms that can adapt to the unique needs and learning styles of individual students. However, it is important to note that AI should be used as a tool to support teachers, not replace them.

Keywords: Artificial Intelligence, Education, Teaching

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Introduction

The purpose of researching the role of artificial intelligence (AI) in the development of teacher effectiveness in higher education is to explore how AI can be used as a tool to personalize learning and improve the quality of education. This research seeks to detail how teaching and learning can be improved. It is known worldwide that AI can help teachers personalize education, adapting materials and teaching strategies to the individual needs and abilities of students. Research on this topic can provide insights into how AI can improve the quality of education and promote more effective learning.

Research can help identify best practices and approaches for the design and development of AI-based educational tools. These tools may include intelligent tutoring systems, adaptive learning platforms, and automated assessment systems, among others. Investigating the role of AI in the development of these tools can drive the creation of more effective and efficient solutions.

The introduction of AI in higher education may have implications for the interaction between teachers and students. Research on this topic can help to understand how AI affects the dynamics of teaching and how teachers can take advantage of it effectively to improve their performance and the relationship with students. In the course of the research, challenges and ethical considerations associated with the use of AI in higher education will be addressed. This can include issues such as data privacy, equity in access to education, algorithmic bias, and teacher accountability in an environment where AI plays a significant role. Research on these aspects can help ensure responsible and ethical use of AI in education.

Artificial Intelligence for Education and Teaching

The role of Artificial Intelligence (AI) in the development of teaching effectiveness is a topic of growing interest, particularly in the context of higher education. Here are some relevant issues that can be summarized on this topic:

Category	Description
Personalization of Learning	AI can be used to create personalized learning experiences by analyzing student data and tailoring instruction to individual needs. This can result in better learning outcomes and increased student engagement.
Adaptive Learning	AI-based systems can adapt to a student's learning style and pace, providing the necessary support and resources to help them succeed. This can lead to improved retention rates and better student performance
Intelligent Tutoring Systems	AI can be used to create intelligent tutoring systems that can provide immediate feedback and guidance to students. This can help students to learn at their own pace and improve their understanding of complex concepts.

Predictive Analytics	AI can analyze large amounts of data to predict student performance, identify at-risk students, and provide early interventions to help them succeed.
Ethical Concerns	The use of AI in education raises ethical concerns, such as the potential for bias in the algorithms used, data privacy concerns, and the possibility of replacing human teachers with machines.
Professional Development	AI can be used to enhance professional development for teachers, by providing personalized feedback and resources to help them improve their teaching practices.

Table #1. Categories of activities to develop with AI

Overall, AI has the potential to revolutionize teaching and learning in higher education. However, it is important to address ethical concerns and ensure that the technology is used in a responsible and effective manner. The personalization of learning through artificial intelligence is developed through the collection and analysis of data about the performance and user preferences in a learning environment. First, data is collected from multiple sources, such as test results, online interactions, and teacher feedback. This data is then used to create an individualized learning profile for each student.

Artificial intelligence algorithms are then used to analyze the data and determine patterns and trends in student performance. Algorithms can identify areas of strength and weakness, and recommend learning activities and resources to help the student improve in specific areas. In addition, artificial intelligence systems can adapt the pace and level of difficulty of learning activities based on the student's level of skill and understanding. (Renz, 2020) This allows each student to learn at her own pace and level, which can increase the effectiveness of learning. It is relevant to mention that the personalization of learning through artificial intelligence involves the collection and analysis of data to create individualized learning profiles, and the use of algorithms to adapt learning resources and activities to the needs and preferences of each student.

Through personalized teaching methodologies, adaptive learning is emerging because through artificial intelligence it will be developed using machine learning algorithms and data analysis techniques to adapt the learning experience to the individual needs and preferences of each student. The first step to adaptive learning is the collection of data from multiple sources, such as test results, online activities, interactions with teachers, and student behavior. This data is used to create a learning profile for each student.

In developing these activities, data analysis techniques, such as data mining and machine learning, will be used to analyze the data collected. Machine learning algorithms can identify patterns and trends in data and provide valuable insight into student performance. Once the information has been collected and analyzed, it is used to personalize the student's learning experience. For example, learning materials can be adapted to make them easier or more challenging, depending on the student's ability level. The pace of learning can also be adapted to suit the student's level of understanding.

AI can also be used to monitor student progress and provide feedback in real time. For example, personalized messages can be sent that motivate the student and guide them on their learning path. In short, adaptive learning through artificial intelligence involves data collection and analysis, tailoring of the learning experience, and real-time monitoring and feedback to improve student learning.

Over the course of the next few years, not too distant, intelligent tutoring systems will begin to use artificial intelligence to provide personalized feedback and guidance to students. In case a teacher wishes to use artificial intelligence to create an intelligent tutoring system, it is important to start from the identification of the student's needs (Russel, 2010). It should be emphasized that it is important to understand the needs of the student. This can be done by collecting data from multiple sources, such as responses to tests and quizzes, performance in learning activities, and feedback from teachers.

Once the data has been collected, machine learning algorithms can be used to create a user model that represents the student's needs and preferences. This model will be used to personalize the student's learning experience. Using the user model, recommendation algorithms can be developed to suggest learning resources and activities that fit the learner's needs (Vij, 2020). For example, if the student is having difficulty understanding a particular concept, the system may recommend specific videos or exercises that focus on that concept.

Smart tutoring systems can also provide personalized feedback to the student. This can be done by using natural language processing algorithms to analyze student responses and provide detailed feedback on performance and errors. Once the system is up and running, it is important to monitor student performance and adjust the system accordingly. This can be done through continuous data collection and feedback from teachers and students themselves. To develop an intelligent tutoring system through artificial intelligence, it is important to identify student needs, create a user model, develop a recommendation system, incorporate personalized feedback, and continuously monitor and adjust the system.

All these aspects allow us to identify the large amount of data that can be handled through the use of artificial intelligence tools. Another relevant aspect is the predictive analysis of student performance in the area of education that can be performed using artificial intelligence techniques. To do this, supervised machine learning algorithms can be used, which are capable of analyzing large amounts of student data, such as their grades, attendance, class behavior, among others, to predict their future performance (Roll, 2016). To carry out a predictive analysis of student performance in the area of education, it is considered that the data of the students of interest should be collected, which includes their academic history, attendance, demographic information, among others.

At the same time, it is important to carry out data cleaning and transformation tasks, such as eliminating missing values, transforming categorical variables into numeric ones, among others. Therefore, select a set of relevant characteristics to predict student performance. This can be done using automatic feature selection techniques such as principal component analysis (PCA) or decision tree-based feature selection.

Artificial Intelligence in Higher Education: Benefits and Ethics

Different areas of knowledge have been adapting the use of artificial intelligence in their activities. However, it is important to mention certain ethical concerns that arise in its use. The use of artificial intelligence (AI) in education can raise various ethical concerns, particularly regarding data privacy and the potential replacement of human teachers by machines. Finally, artificial intelligence (AI) can be used for the professional development of teachers in education in various ways. AI can be used to analyze teacher performance data, such as teacher grades, feedback, and student evaluations, to identify areas where teachers need to improve, and to provide personalized feedback for professional development.

AI-powered online learning platforms can provide teachers with access to courses and learning resources tailored to their needs and professional development goals. These resources may include tutorials, guides, assessments, teaching materials, among others. Therefore, it can also be used to customize teaching models to the needs and preferences of teachers, taking into account their teaching style, skills and previous experiences. Importantly, the use of AI for teacher professional development must be guided by an ethical approach, and ensure that the privacy of teacher and student data is adequately protected (Yang, 2012) .Furthermore, AI should not be a substitute for personalized interaction and feedback provided by other teachers and mentors. An important aspect to consider before making use of artificial intelligence tools is that the teacher who is going to start carrying out tasks based on the use of these tools must know in depth how to use them out of ethics and professionalism.

As a first point, it is important to identify suitable areas in which teachers can determine the specific areas where AI can add value to teaching and learning. This could include personalized learning, adaptive assessment, intelligent tutoring, data analysis, or automated grading. Assess the needs and goals of your students and identify the areas where AI can enhance their learning experience. The action of choosing appropriate AI Tools allows to put in practice research and evaluate different AI tools and platforms available for education. Consider factors such as functionality, ease of use, compatibility with existing systems, data privacy and security, and vendor reputation. Select tools that align with your teaching objectives and provide a user-friendly experience for both teachers and students.

Begin by introducing AI tools in a targeted and controlled manner. In this regard it is important to implement them in specific areas or subjects where you believe they can have a significant impact. Starting small allows you to evaluate their effectiveness, assess student feedback, and make necessary adjustments before scaling up their usage. And all these aspects go hand in hand with the training of the work staff. It's totally important to offer training sessions or resources to help teachers and students understand how to effectively use the AI tools. This includes demonstrating the features, explaining the benefits, and addressing any concerns or questions. Ongoing support and access to technical assistance will encourage successful adoption and implementation.

Promote Ethical Use of AI is totally important in terms of educate students about the ethical considerations surrounding AI and the responsible use of technology. Discuss topics such as data privacy, algorithmic bias, and the importance of human oversight in decision-making processes. Encourage critical thinking and ethical discussions related to AI applications. It is considered important to remember that while AI tools can offer significant benefits, they are not meant to replace human teachers (Cukurova, 2018). The role of the educator remains crucial in creating a supportive learning environment, facilitating discussions, and providing guidance to students. AI tools should be seen as complementary resources that enhance teaching effectiveness and personalize learning experiences.

AI in Online Learning

The role of artificial intelligence (AI) in online classes for students has the potential to greatly enhance the learning experience. AI technology can be utilized in various ways to support and augment traditional teaching methods, providing students with personalized and adaptive learning opportunities. One significant advantage of incorporating AI into online classes is its ability to provide individualized learning experiences. With AI algorithms, educational platforms can analyze vast amounts of data on student performance, learning styles, and preferences. This information can then be used to tailor the content and pace of instruction to suit each student's needs. By adapting to their unique requirements, AI can help students grasp concepts more effectively and progress at their own pace, maximizing their learning potential.

Moreover, AI-powered chatbots and virtual assistants can offer real-time assistance to students during online classes. These intelligent systems can answer questions, provide clarifications, and offer additional resources to supplement the material being taught (Aggarwal, 2018). This instant feedback and support can foster a more interactive and engaging learning environment, even in remote settings. Students can receive immediate guidance and overcome obstacles more efficiently, promoting a sense of independence and self-directed learning.

Furthermore, AI can assist teachers in evaluating student performance and providing feedback. Automated grading systems can analyze assignments, quizzes, and exams, saving teachers valuable time and allowing them to focus on providing more personalized feedback. Additionally, AI algorithms can detect patterns in student performance, helping identify areas of improvement and allowing teachers to offer targeted interventions to struggling students.

However, it's crucial to acknowledge the potential limitations and ethical considerations of AI in online classes. Privacy concerns, data security, and the potential for algorithmic biases need to be carefully addressed. AI should complement human instruction rather than replacing it entirely, as human interaction and guidance remain vital for fostering critical thinking, creativity, and social-emotional development. The following table shows different aspects of interaction to consider compared to traditional online learning and online learning with artificial intelligence tools.

Aspect of Interaction	Traditional Online Learning	AI-Enhanced Online Learning
Personalization	Limited personalization options due to large class sizes and limited instructor capacity.	AI algorithms can analyze learner data and provide personalized recommendations, adaptive assessments, and tailored feedback to individual learners. Instructors can also receive insights on learners' strengths and weaknesses, enabling more targeted interventions.
Feedback and Assessment	Delayed feedback due to manual grading processes.	AI-powered systems can provide instant feedback on assignments, quizzes, and exams, allowing learners to receive immediate insights and make necessary improvements. Additionally, AI algorithms can assess and analyze learners' progress more efficiently, providing instructors with actionable data for targeted interventions.
Virtual Assistants	Lack of immediate support and guidance outside of scheduled instructor availability.	AI-powered virtual assistants can be available 24/7 to answer learner questions, provide explanations, and offer guidance. Learners can receive instant assistance, reducing dependency on instructor availability and enhancing their learning experience.
Intelligent Tutoring Systems	Absence of personalized tutoring and adaptive learning experiences.	AI-driven intelligent tutoring systems can adapt to individual learners' needs, providing personalized instruction, adaptive content delivery, and customized learning pathways. These systems can identify knowledge gaps and provide targeted remediation, improving learner outcomes.

Natural Language Processing	Limited ability to analyze and understand learners' written responses and provide relevant feedback.	AI algorithms powered by natural language processing can analyze learners' written responses, identify patterns, provide constructive feedback, and even engage in automated discussions. This enhances the quality of interactions and promotes deeper learning.
Data Analytics	Limited insights into learners' progress and engagement patterns.	AI-based data analytics can track learners' progress, engagement, and performance metrics in real-time. Instructors can identify struggling learners, recognize patterns, and adjust instructional strategies accordingly, leading to more effective interventions and improved learning outcomes.
Content Recommendation	Generic course materials that may not cater to learners' specific interests and needs.	AI algorithms can analyze learners' preferences, behavior, and performance data to recommend relevant and personalized learning resources, such as articles, videos, and supplementary materials. This enhances learner engagement and motivation.
Accessibility and Inclusion	Challenges in catering to diverse learning needs and accommodating disabilities.	AI technologies can offer accessibility features such as real-time closed captioning, text-to-speech conversion, and adaptive interfaces to support learners with disabilities. These technologies promote inclusivity and provide equal learning opportunities.

Table #2. Aspects of Interaction

In conclusion, the participation of artificial intelligence in online classes holds immense promise for enhancing the learning experience. By leveraging AI technology, students can benefit from personalized instruction, instant feedback, and individualized support. However, it is important to strike a balance and ensure that AI is used responsibly, in conjunction with human teachers, to create a holistic and effective educational environment.

The present research, through the information provided, raises awareness about the importance of generating professionals in the area of big data and data sciences. At present and in the short term, it is the professionals in the area of programming and tics who will become the most demanded in different markets of the world because they are the ones who, through their knowledge, allow us to make use of capable platforms to store and manage information. in a more flexible and dynamic way. However there are several areas of knowledge where artificial intelligence (AI) tools can leverage their capabilities more effectively:

In-demand Careers	Description
Data Analysis and Pattern Recognition	AI excels at processing and analyzing vast amounts of data. It can identify patterns, trends, and correlations that might not be immediately apparent to humans. This ability makes AI particularly valuable in fields where large datasets are available, such as finance, healthcare, marketing, and scientific research.
Natural Language Processing (NLP)	NLP is an area of AI that focuses on understanding and generating human language. AI-powered NLP tools can process and analyze written or spoken language, enabling applications like machine translation, sentiment analysis, chatbots, and virtual assistants. NLP is beneficial in fields like customer service, content generation, language learning, and text analysis.
Image and Video Recognition	AI algorithms can analyze and interpret visual data, making them useful in image and video recognition tasks. AI-powered tools can identify objects, faces, emotions, and scenes, enabling applications like facial recognition, object detection, autonomous vehicles, and surveillance systems. Industries such as retail, security, healthcare, and manufacturing can benefit from these capabilities.
Recommendation Systems	AI-based recommendation systems can analyze user preferences, behavior, and historical data to make personalized recommendations. This is widely used in e-commerce platforms, streaming services, social media, and content platforms to suggest products, movies, music, articles, and more. Recommendation systems leverage AI's ability to understand user preferences and make tailored suggestions.

Predictive Analytics	AI can leverage historical data and machine learning algorithms to make predictions and forecasts. This is useful in various domains, such as finance, weather forecasting, supply chain management, and sales forecasting. AI tools can identify trends, anomalies, and make predictions based on patterns found in data.

Table #3. The 7 Most In-demand Data Science Careers

While AI can be applied to various fields, its impact and effectiveness depend on the availability and quality of data, the complexity of the task, and the domain-specific knowledge required. Each field may have its unique challenges and opportunities where AI can make a significant impact.

In my opinion, it is vital for individuals to develop knowledge in big data and data science due to the transformative impact these fields have on our society. The exponential growth of data in various industries presents immense opportunities for innovation and problem-solving. By acquiring expertise in big data and data science, individuals can unlock the potential of this wealth of information and extract meaningful insights that drive decision-making and foster growth. In an increasingly data-driven world, those with proficiency in these fields gain a competitive advantage in the job market and contribute to advancements across sectors. Moreover, the interdisciplinary nature of big data and data science promotes collaboration, allowing individuals to bridge gaps between technical expertise and domain-specific knowledge, leading to more effective solutions to complex challenges.

By developing knowledge in big data and data science, individuals demonstrate a commitment to lifelong learning, adaptability, and staying at the forefront of technological advancements. Ultimately, fostering a broader base of individuals with expertise in big data and data science empowers our society to address critical issues, drive innovation, and create positive societal impact.

Conclusion

There are several important characteristics to consider regarding the role of artificial intelligence (AI) in the development of teacher effectiveness in higher education. Firstly, AI should be viewed as a tool that complements and supports teachers, rather than replacing them. While AI can automate certain tasks and provide personalized feedback, the human element of teaching, such as building relationships, understanding individual student needs, and providing mentorship, remains crucial for effective education.

Secondly, AI should prioritize personalization and adaptability. Every student has unique learning styles, abilities, and preferences, and AI can play a significant role in tailoring educational experiences to meet these individual needs. By leveraging AI-powered algorithms and data analytics, teachers can gain insights into students' strengths, weaknesses, and progress, allowing for personalized instruction, targeted interventions, and adaptive learning pathways.

Another critical characteristic is transparency and explainability. AI algorithms should be designed in a way that is transparent and understandable to teachers. It is essential for educators to have insights into how AI systems make recommendations, provide feedback, or assess student performance. This transparency enables teachers to effectively interpret and utilize AI-generated insights, fostering trust and informed decision-making.

Furthermore, ongoing professional development and training are crucial. To fully harness the potential of AI, teachers need opportunities to develop the necessary skills and knowledge to effectively integrate AI tools into their teaching practices. Continuous training programs should be provided to enhance teachers' AI literacy, enabling them to leverage AI tools appropriately and make informed decisions about their implementation in the classroom.

Ethical considerations are also paramount. As AI becomes more prevalent in education, it is important to ensure student privacy, data security, and fairness in the use of AI technologies. Teachers should be aware of the ethical implications of AI in education and be actively involved in defining policies and guidelines for its responsible use.

Lastly, collaboration and partnership between AI developers and educators are crucial. Effective integration of AI in higher education requires close collaboration between technologists and educators. Teachers should actively participate in the development and evaluation of AI tools, providing valuable insights and feedback based on their practical experiences. This collaborative approach ensures that AI technologies are aligned with the specific needs and goals of higher education institutions and contribute to enhancing teacher effectiveness and student learning outcomes.

In conclusion, the role of AI in the development of teacher effectiveness in higher education should prioritize teacher support, personalization, transparency, ongoing professional development, ethical considerations, and collaboration. By embracing these characteristics, AI can be a valuable tool in empowering teachers, enhancing their instructional practices, and ultimately improving the quality of education in higher education settings.

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Improving Master's Students' Information Literacy Through Online Instruction

Esther Argelagós, Universidad Internacional de La Rioja, Spain
Consuelo García, Universidad Internacional de Valencia, Spain
Jesús Privado, Universidad Complutense de Madrid, Spain
Iwan Wopereis, Open Universiteit, Netherlands

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Abstract
The ability to manage information obtained from the internet for learning purposes represents a difficult task for most students, even in higher education, where this ability takes on major importance for the writing of academic texts. The Information Problem Solving (IPS) model breaks down this ability into five different skills: defining research questions; planning research activities; searching for and locating sources; processing the information found; and organizing and presenting this information. In this study, an IPS training course was designed, implemented, and evaluated in order to train master's students to conduct a literature review task and write their final thesis. Since the university where this course took place is completely virtual, all instruction was offered online. In addition, this pilot course was based on the Four-Component Instructional Design (4C/ID) model, which includes the following components: learning tasks, supportive information, procedural information, and part-task practice. Twenty-five master's students participated in the full two-month course and fifty-five acted as a control group. The findings of this quasi-experimental study indicate that, upon completion, the group of students that had completed the course obtained statistically better results in activities involving the following skills: defining initial questions; planning research and conducting searches on the internet or other sources; and processing the gathered sources and materials. In terms of the ability to organize and present information, no differences were observed between the two groups. Nevertheless, the online course proved to be an excellent tool for improving students' IPS skills.

Keywords: Information Problem Solving (IPS) Skills, Information Literacy, Four-Component Instructional Design (4C/ID) Model, Instruction, Higher Education

Introduction

University students frequently use the internet to find the information they need for their studies. Indeed, libraries have largely been abandoned in favor of massive research databases and academic search engines that provide students with the necessary information to complete their academic tasks. However, most higher education students have yet to master the skills required to find the information they need and put it to good use (Lam & Zhou, 2019). This lack of information skills entails a great deal of effort from teachers, who have to invest a lot of time and resources to bring students up to speed (Lanning & Mallek, 2017). While this kind of training typically falls on the shoulders of information and library management professionals, the information skills required for higher education programs are becoming increasingly specific (Taylor, 2012). Thus, experts from other academic fields are being called upon to impart these skills to students.

These complex cognitive skills are often referred to as information literacy (IL) or information problem solving (IPS) and have already been discussed widely in literature, using a variety of theoretical perspectives and approaches (ACRL, 2016; Brand-Gruwel et al., 2009). IL involves more than a simple internet search. It is a complex process that always leads to a specific objective (Garcia & Badia, 2017). Figure 1 illustrates this process.

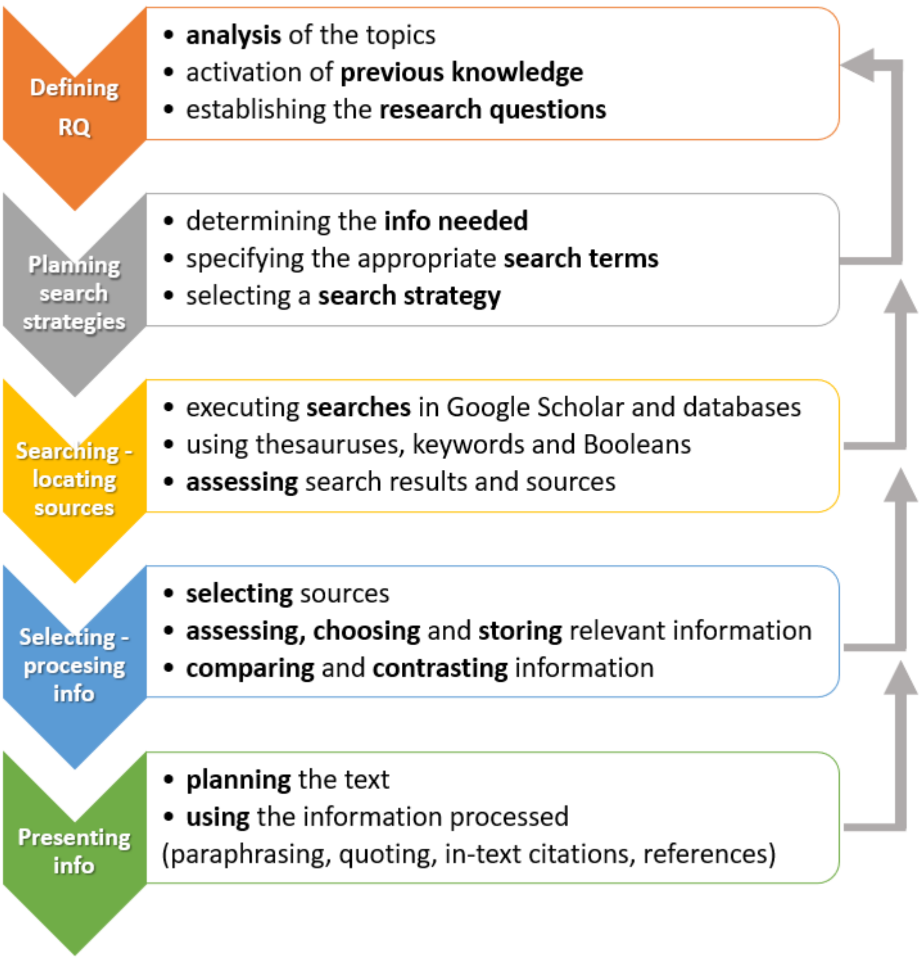

Figure 1: Information problem solving (IPS) skills to review scientific literature (inspired by Brand-Gruwel et al., 2009; adapted from Garcia et al. (2021) and Argelagós et al. (2022).

In this context, the 4C/ID model is a learning method whose primary purpose is to help teach complex skills or competencies (Van Merriënboer et al., 2002). It is a task-centered learning model (Francom, 2016) that moves away from knowledge fragmentation and instead strives to form a seamless integration and connectedness between knowledge, skills, and attitudes (Van Merriënboer & Kirschner, 2018). It is based on four main components, as shown in Figure 2.

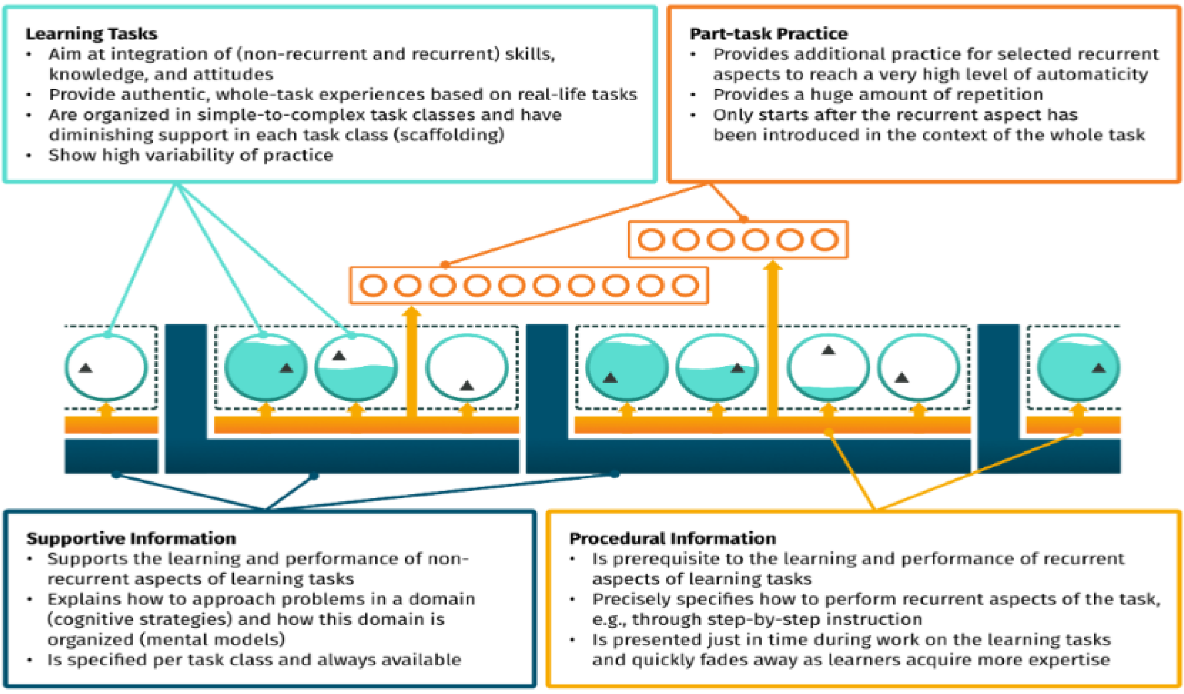

Figure 2: The Four-Component Instructional Design (4C/ID) model.
Extracted from Van Merriënboer and Kirschner (2018).

In this study, an IPS course based on the 4C/ID model was conducted to help master's students improve their skills in using the internet and databases to collect information and write their final thesis. Our hypothesis was that this course would effectively improve participant's IPS skills.

Method

Participants

The participants of this quasi-experimental study were 80 master's students (66 female), mean age 36.86 years (SD = 8.44). The students were divided into two groups: the experimental group consisted of 25 students and the control group consisted of 55 students. The participants were studying for a master's degree in educational sciences at the Universidad Internacional de La Rioja, a fully online university. The students resided in Spain (17%), Colombia (41%), Ecuador (39%), and other countries (3%).

Course and materials

An online course consisting of five different learning tasks was designed to develop the IPS skills needed to conduct an academic literature review in a digital context that culminated in an academic paper. The course had a 60-hour study load. Figure 3 offers an overview of the learning tasks completed during the course. Each learning task was based on authentic professional topics in the domain of educational sciences. In addition, each task was considered a “whole task,” because all five IPS skills (see Figure 1) were needed to complete each of them.

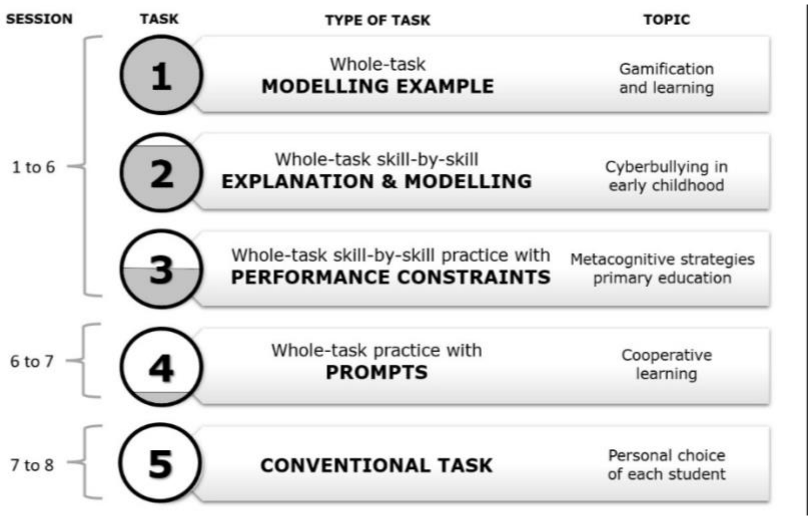

Figure 3: Tasks carried out during the eight sessions of the course; the gray area in each circle shows the level of support given.

The course was divided into three broad phases. The first phase covered the first six sessions, which involved working on three learning tasks. All the sessions were conducted synchronously using the Adobe Connect software tool.

- **Phase 1. Session 1**. **Task 1.** In the first session, the overall task of reviewing literature and writing an academic text was presented. The topic of this task was related to gamification and learning. During the online class, an expert carried out the task from start to finish, including the execution of the five IPS skills (see Figure 1). Throughout the performance of the task, the expert verbalized his actions, thoughts, emotions, and questions, as well as how he managed and resolved the issues encountered. During the first session, the five IPS skills needed to successfully complete the whole task were demonstrated. In addition, a recording of the modeling example was provided, which could be watched by learners as many times as needed after the session, during individual study and consolidation. The modeling example was a whole-learning task, rich in both supportive and, above all, procedural, information. According to Frerejean et al. (2018) the modeling example “presented as a screencast of an expert thinking out loud” (p. 688) is an element that facilitates the teaching of IPS skills.

- **Phase 1. Session 1. Task 2.** At the end of the first session, Task 2 was presented, which was explained skill-by-skill. The subject of Task 2 was cyberbullying in early childhood. This task was a part-task, since it was demonstrated progressively over the course of the sessions. Skill 1—“how to define research questions”—was presented in a detailed and clear way (see Figure 2). Building on this presentation, students were given a homework task for the following session where they were encouraged to develop their understanding of Skill 1. Students were asked to draw on the materials provided for this assignment, which included supportive information, procedural information, and the Skill 1 modeling example.

- **Phase 1. Session 1. Task 3.** As part of their homework task, participants were also expected to independently apply this first skill to the topic of metacognitive strategies in primary education. Task 3 was also conceived as a skill-by-skill activity, and was aimed to help students perform the task in phases. An important issue arose at this stage: Skill 2 could not be mastered if Skill 1 had not already been fully understood and consolidated (performance constraints principle of the 4C/ID model).

- **Phase 1. Session 2. Tasks 1–3.** In Session 2, Skill 1 of Task 3 carried out by the students as homework was discussed, together with any questions or difficulties encountered, and feedback was given so that students could check the task had been completed successfully, and to encourage the assimilation and transfer of knowledge for use in future tasks. After giving feedback on Skill 1, Skill 2 was explained through Task 2, which had been started in the previous session. In this way, Task 2 was used to present a skill, and Task 3 was used to practice it. After each session, each student reviewed and worked through the accompanying materials, which contained supportive and procedural information on the corresponding skill, and the instructions needed to practice it (see Figure 4).

- **Phase 1. Session 3–6. Tasks 1–3.** In this way, the five skills were developed in a progressive manner during the six sessions of the first phase. The range of tasks involved, combined with the opportunity to analyze and practice them, helped students consolidate the routines needed to carry out a task and, more importantly, to transfer what they had learned to tackle new tasks and situations.

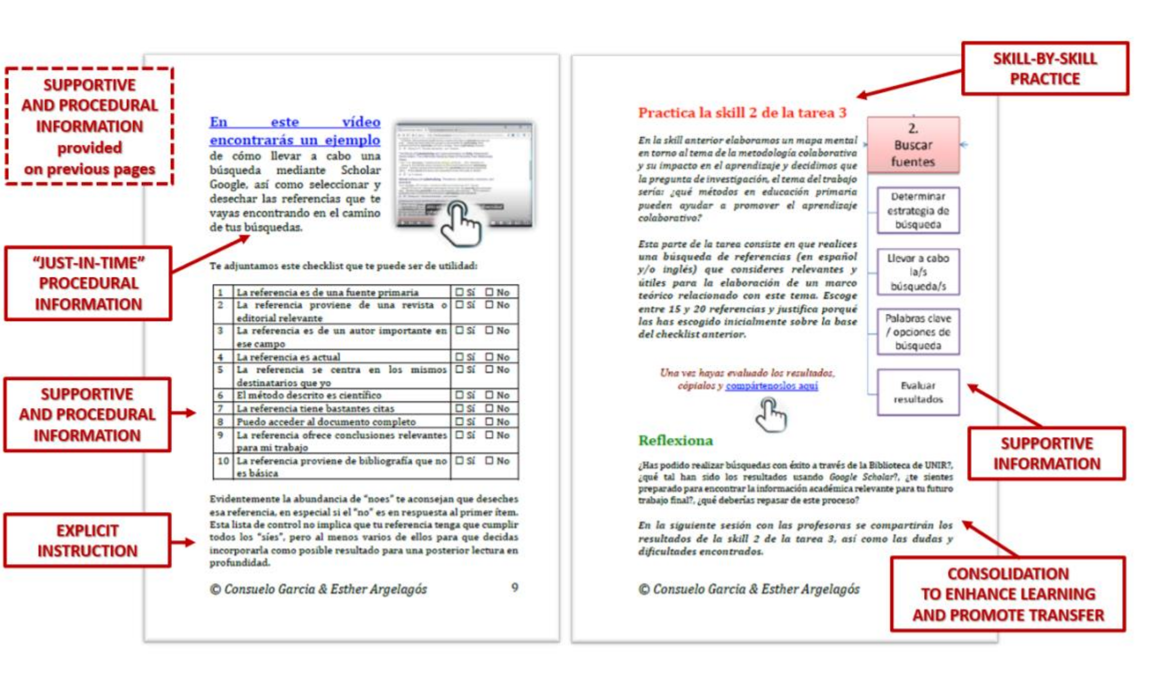

Figure 4: Screenshot of a handout for studying and practicing IPS skills.

- **Phase 2. Sessions 6–7. Task 4.** The second phase included Task 4, which was presented to students at the end of Session 6, once the five skills had been worked on and practiced in a progressive manner. Task 4 required each student to perform a whole task, from start to finish, using a guide, template, and prompts. The topic of this whole task was cooperative learning. The task was practiced again, this time in its entirety. In the seventh session, any questions and difficulties encountered in Task 4 were shared and feedback was given, again using the supportive and procedural information provided.

- **Phase 3. Sessions 7–8. Task 5.** The third and final phase in this IPS skills training course involved the completion of Task 5. At the end of Session 7, this task was presented as a conventional task without any kind of assistance, allowing the student to select a topic of their choice. After performing this task, in the final session of the course, any questions and difficulties encountered in Task 5 were shared and feedback on the task was given. Once again, the use of the supportive and procedural information was encouraged, centered around task practice, to foster consolidation and transfer of learning.

Design and evaluation method

This study used a non-equivalent control group pre-test post-test design to assess the effectiveness of the course, utilizing two tests to measure instruction effects. To evaluate the IPS skills, the Procedural Information Problem-Solving Knowledge Evaluation in Education (PIKE-E) test was used (Garcia et al., 2020), which is a Spanish adaptation of the PIKE-P (Rosman et al., 2016).

Data collection and analysis

The pre-tests consisted of an online form to collect demographic data, and which included the PIKE-E. The post-test, conducted upon completion of the online course, also included the PIKE-E. Data analysis involved calculating the distribution of scores on the PIKE-E, as well as assessing the effectiveness of the course by means of a mixed analysis of variance (ANOVA) using group (experimental and control) as an intergroup factor, and the pre-test and post-test results of the PIKE-E as an intragroup factor. Statistical Package for the Social Sciences (SPSS; v.18) software was used to perform these analyses.

Results and conclusions

Results indicate that the online course helped the participating students to improve their IPS skills. This improvement was observed as a general factor, that is, for the IPS process as a whole (see Figure 5). In addition, as shown in Figure 6, the students who received online instruction were able to improve all five IPS skills. However, only the two skills related to search actions (that is, “planning search strategies”; and “searching and locating sources”) showed statistical significance ($p < .005$). In the case of the “presenting info” skill, no differences were found. Statistical differences are indicated by asterisks.

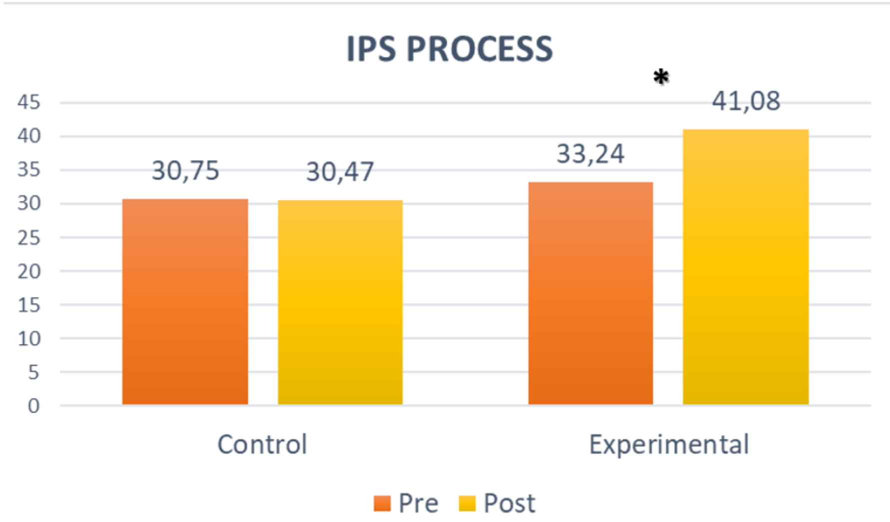

Figure 5: Results of the mixed ANOVA for the IPS process.

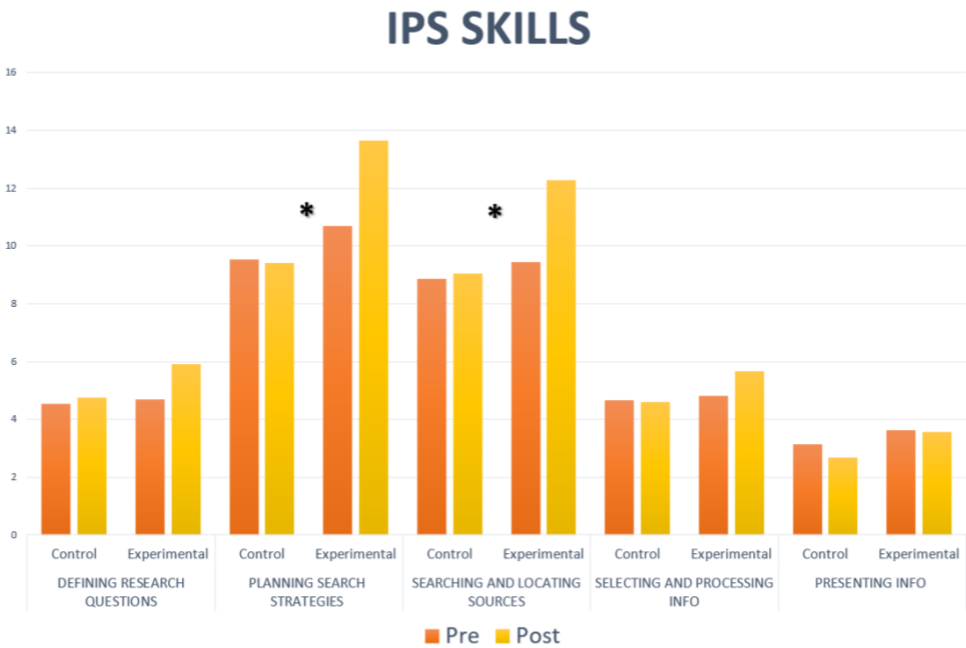

Figure 6: Results of the mixed ANOVA for the IPS skills.

These findings are in line with previous studies that have highlighted the need for instruction to improve IPS skills (Argelagós & Pifarré, 2012; Brand-Gruwel et al. (2009), Frerejean, Velthorst, et al., 2019; Garcia & Badia, 2017; Leichner et al., 2014, Rosman et al., 2018; Squibb & Mikkelsen, 2016), In particular, the 4C/ID model has proven effective in this regard (e.g., Argelagós et al., 2022; Frerejean, Van Merriënboer et al., 2019; Wopereis et al., 2015, 2016).

In terms of the “organizing and presenting information” skill, no differences were observed between the two groups, which prompted us to conduct a more in-depth analysis to highlight potential areas of improvement for the design and implementation of this course. The activities related to the “presenting information” skill are usually as follows: planning the text; utilizing the processed information; and accurately integrating it into the text through paraphrasing, quoting, in-text citations, references, etc. One possible explanation for the lack of improvement observed is the need to dedicate more time to teaching this skill. In addition, our course did not factor in other specific academic writing abilities that are necessary to produce high-quality work (Cassany; 2015; Castelló, 2014; Castelló et al., 2012; Hyland, 2016; Mitchell et al., 2021; Swales & Feak, 2004).

While this study demonstrates the effectiveness of the course, integrating IPS instruction within an educational and curricular program would offer more opportunities for practice, and over a longer period (Frerejean, Van Merriënboer et al., 2019; Wopereis et al., 2016). Nevertheless, the online course proved to be an excellent tool for improving students' IPS skills.

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Contact emails: esther.argelagos@unir.net
esther.argelagos@udg.edu

Double Didactics to Prepare Future Educators

Judith Hanke, University of Flensburg, Germany

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Abstract
Reading strategies are very important for students to obtain as they can foster reading comprehension. Additionally, it is not only essential to teach students reading strategies, but also that they know how to use them. The university class discussed in this article is for education students, who want to become teachers or work in the educational sector. The class's focus is reading support in which reading strategies and methods are incorporated. One important focus is the content. The first sessions of the class are destined to give the students an overview of the definition of reading, reading models, their own reading history, etc. The second target of the class is the student-centered learning approach in the form of a double didactics design. After the basics are covered, a prototype of a *group of experts*, which is a student-led class session is presented and explained. A group of experts, composed of students, do research and teach the given topic. The students need to plan *their lesson* by selecting appropriate reading material and determining methods. This means that the student-centered learning approach puts the students in the position of the teacher/lecturer, by having them teach their fellow students. A discussion follows after each session, in which the implementation of the reading strategy and applied reading methods are discussed. This intends that the students do not just give a regular presentation, but that they acquire knowledge, skills, and experience on how to actually implement reading strategies and reading methods in their future classroom.

Keywords: Double Didactics, Student-Centered Learning, Student-Led, Expert Groups, Reading Support, Reading Strategies

Introduction

The acquisition of reading strategies plays a vital role in enhancing students' reading comprehension abilities. Extensive research studies, such as the PIRLS (Progress in International Reading Literacy Study) conducted by Mullis, I. V. S., and Martin, M. O. (2019), and the RAND Reading Study Group conducted by RAND & Snow (2002), have underscored the significance of students learning and effectively applying reading strategies. These studies have shown that students who possess a repertoire of effective reading strategies demonstrate higher levels of reading proficiency and comprehension.

As a result, it is essential for teachers to possess a deep understanding of how to teach these strategies to their students. They must be adept at integrating these strategies into their instructional practices, ensuring that students have sufficient opportunities to practice and apply them (Lauth et al. 2004). Additionally, teachers should guide their students on when and how to utilize these strategies based on the demands of different reading tasks and materials.

The class discussed in this paper is specifically designed for university students who aspire to become teachers or pursue careers in the educational sector. It aims to equip them with the necessary knowledge and skills to effectively teach reading strategies to their future students. Through a comprehensive exploration of various reading methods, the class empowers students with a selection of instructional techniques that can be employed to support students' reading development.

By emphasizing the importance of reading strategies (Banditvilai 2020) and methods, the class prepares aspiring educators to create engaging and meaningful learning experiences that foster their future students' reading comprehension, critical thinking, and overall literacy skills. The ultimate goal is to empower students with the tools they need to become proficient and confident readers, enabling them to succeed academically and beyond. The incorporation of double didactics is essential in achieving these goals. Moreover, through the student-led and student-focused nature of the class, students not only gain teaching experience and reflect on this but also engage in reflection throughout the class, particularly regarding their own learning and reading practices.

Goals and Competencies

The course's focus is on professional, methodical, social and self-competency while incorporating a wide range of teaching methods.

Professional competencies within the class revolve around developing a comprehensive understanding of reading and effective reading support. Students are guided to acquire a deep and valid understanding of the complexity involved in the act of reading.

Through theoretical discussions, practical exercises, and hands-on experiences, students become knowledgeable about various strategies and techniques that can enhance reading support. They learn to identify and utilize beneficial strategies tailored to different reading contexts and diverse learner needs. This includes techniques such as pre-reading activities, active reading strategies, metacognitive approaches, and effective comprehension monitoring.

Moreover, students are encouraged to internalize reading theories and models that provide insights into the reading process. They explore different theoretical frameworks and models, such as the Dual-Route Model (Coltheart et al. 2001) Reader-Response Theory (Mart 2019), or the interactive model of reading introduced by Rumelhart (1985). By familiarizing themselves with these theories, students gain a deeper understanding of the cognitive, linguistic, and socio-cultural aspects of reading.

In order to apply their knowledge effectively, students engage in practical exercises that allow them to implement and adapt reading support strategies in real-world contexts. They explore case studies, analyze reading interventions, and design reading support activities tailored to specific learners or instructional settings. By actively applying their knowledge and reflecting on their experiences, students develop the professional competence to provide targeted and effective reading support.

Throughout the class, students also engage in critical analysis and evaluation of current research and developments in the field of reading support. They explore empirical studies, scholarly articles, and professional literature.

By developing these professional competencies, students are equipped with the necessary tools and skills to support individuals in their reading journey. They become proficient in selecting and implementing appropriate strategies, adapting to different contexts, and continuously refining their approaches. The students will be able to make a meaningful impact as reading support professionals and promoting literacy.

The class incorporates **methodical competencies** throughout, including criteria-led discussions of theories, models, and research results. These competencies aim to provide students with the skills necessary to critically analyze and evaluate various academic concepts and findings.

During these discussions, students are encouraged to apply specific criteria to assess the strengths, weaknesses, and applicability of theories, models, and research results. They learn to identify key components, analyze underlying assumptions, and evaluate the validity and reliability of the information presented.

By engaging in these discussions, students develop their analytical thinking, argumentation, and reasoning skills. They learn to construct well-supported arguments, consider alternative perspectives, and make informed judgments based on evidence.

Furthermore, these methodical competencies foster an environment of collaborative learning and intellectual exchange. Students are encouraged to actively participate in discussions, share their insights, and respectfully challenge each other's viewpoints. This interactive approach promotes a deeper understanding of the subject matter and encourages critical thinking from multiple perspectives.

Overall, the inclusion of methodical competencies, such as criteria-led discussions, enhances the learning experience by promoting a deeper engagement with theories, models, and research results, and by equipping students with valuable skills applicable in academic and professional contexts.

Social and self-competence play a crucial role in fostering independent study skills within the class. Students are encouraged to engage in extensive research by exploring a range of research work, articles, chapters of books, and practical reports relevant to the subject matter.

As part of their learning process, students are tasked with constructing their own lessons. This involves conducting thorough research, synthesizing information, and creating a comprehensive handout and presentation adhering to the standards set by the lecturer. Additionally, students are responsible for designing an activity that will actively involve their peers during the class session.

Throughout this process, the lecturer acts as a guide and facilitator, providing necessary support and guidance as required. The students are encouraged to take ownership of their learning journey, fostering their self-competence by independently seeking resources, critically analyzing information, and presenting their findings in a coherent and structured manner.

To prepare for each class session, students are expected to engage in extensive reading of texts presented in various formats, including articles, studies, and chapters of books. These pre-reading materials serve as the basis for in-depth discussions and analysis during the class sessions. The students actively participate in these discussions, sharing their insights, raising questions, and collectively exploring the key concepts and findings.

By emphasizing social and self-competence, the class cultivates essential skills for lifelong learning. Students develop the ability to conduct independent research, critically evaluate information, and effectively communicate their knowledge to others. Furthermore, the collaborative nature of the class enhances social competence by promoting a supportive and interactive learning environment where students learn from one another's perspectives and contributions.

Overall, the integration of social and self-competence in the class empowers students to take ownership of their learning, strengthens their research and presentation skills, and promotes active engagement and collaboration within the academic community.

The class incorporates various **teaching and learning approaches**. It primarily consists of seminars, with the initial three seminars being predominantly led by the lecturer and focusing on discussions and student self-reflection. The remaining sessions are divided into two parts: a teacher/lecturer-led segment with discussions, and a student-led segment. Throughout the seminars, students engage in introspection, reflecting on their own understanding of reading and reading support, their personal reading experiences, and their reading abilities.

Relevant Criteria of Good Teaching

The seminar is characterized by a high level of structure and organization, with each session building upon the previous ones throughout the semester. A key aspect of the seminar is providing a framework for university students to engage in self-reflection. In the initial session, students are prompted to review their own reading habits and experiences through a questionnaire. They are asked about their enjoyment of reading, the number of books they have read, and how they perceive themselves as readers, among other questions. Furthermore, students are encouraged to create a reading biography, incorporating questions that explore their earliest reading experiences and other relevant aspects.

In the subsequent session, students participate in a word-per-minute (wpm) test (Bamberger 2006), allowing them to reflect on their own reading speed and feelings associated with timed reading activities. These activities aim to deepen their understanding of their own reading habits and experiences, while also fostering empathy and understanding towards struggling readers or those who have difficulty finding enjoyment in reading.

Towards the end of the seminar, the students revisit the initial questionnaire and reading biography, leading to a class discussion on any changes or new insights gained throughout the class. This reflection process enables students to evaluate their personal growth and share their thoughts with classmates.

A fundamental methodology employed in this class is the continuous emphasis on student-centered learning. From the very beginning, the class design prioritizes the needs and perspectives of the students. The entire seminar is designed to be interactive, learner-centered, reflective, and focused on preparing students for their future roles as teachers, equipping them with the necessary skills and knowledge to create engaging learning environments for their own students.

Design

The class is structured to encompass a total of 11-13 sessions, depending on the length of the semester, with each session spanning 90 minutes. Given the class's primary focus on reading support, the students' own reading practices hold great significance. They are provided with pre-reading materials for each session as well as in class literature.

As mentioned earlier, the initial three sessions serve as an introduction to the topic, aimed at building the students' foundational understanding and knowledge. The first session covers organizational aspects such as the expert groups, class expectations, and the essay assignment. It also includes engaging activities like a metaphor exercise and a mind map activity focused on reading. Through the mind map activity, students reflect on the multifaceted nature of reading, recognizing that it contains numerous elements. Additionally, students get the opportunity to experience a wpm test, gaining insights into the perspective of a student taking a reading assessment and prompting them to reflect on their own reading abilities.

Throughout the first session and the following two sessions, students receive essential information about reading while engaging in activities that foster self-reflection on their personal relationship with reading. They are provided with the previously mentioned questionnaire that prompts them to consider aspects such as their enjoyment of reading, their self-perceived reading proficiency, the number of books they possess, and the time they allocate for reading. Furthermore, students are tasked with crafting a reading biography, which includes questions as a starting point for their writing, such as their first book read or their initial reading experiences.

These activities are designed to support students' future work in enhancing the reading abilities of their own students. However, for the students to become effective educators, it is crucial for them to develop a comprehensive understanding of their own feelings and experiences with reading, including what has aided their reading progress and what challenges they have encountered. By engaging in these activities, they can engage in honest and meaningful conversations with their future students about reading. These methods are also discussed and analyzed during class sessions. In the final class, students revisit their reading questionnaires and reading biographies, reflecting on any changes or insights gained, and considering how these reflections can inform their future teaching practices.

Topics

The class centers around the significant theme of **reading support**, exploring how teachers can best assist students in their reading journey. The significance of reading support is thoroughly examined, exploring various aspects that contribute to fostering successful reading experiences.

Throughout the class, a wide range of crucial topics related to reading are explored, including **reading engagement** (Rieckmann 2020)**, reading motivation** (Goy et al. 2017)**, reading culture** (Garbe et al. 2010; Nickel-Bacon & Wrobel 2012), and **the socialization of reading (**Garbe 2020; Garbe et al. 2010; Steinbrecher 2007). These discussions intertwine with the core concept of reading support, highlighting the interconnectedness between these elements and their collective impact on students' reading development.

Furthermore, the class presents and discusses essential **reading strategies** (Banditvilai 2020; Dretzke & Keniston 1989), **models** (Baha 2017), and **methods (**Garbe 2020). The lecturer and students collaborate to examine and share effective approaches for supporting students' reading abilities. They examine the practical application of various strategies, exploring their benefits and limitations. Moreover, reading models are discussed, providing valuable insights into different theoretical frameworks of the reading process. By addressing these components, the class equips students with a comprehensive understanding of the multifaceted nature of reading support and empowers them with practical tools to implement in their future teaching endeavors.

The focus of reading support lies primarily on the implementation of **reading strategies** (Armbruster et al. 2001; Mastropieri et al. 1999; Mullis & Martin 2019; RAND & Snow 2002). Throughout the class, students are introduced to various reading strategies, including ***previewing*** (Kruse et al. 2015; Li 2021; Miqawati & Sulistyo 2014; Neuland & Peschel 2013; Zhaohua 2004), ***thinking aloud*** (Konrad 2010; Sönmez & Sulak 2018), ***predicting*** (Duke et al. 2022; Hußmann et al. 2017; Neuland & Peschel 2013; Park & Kang 2018; Sumirat et al. 2019), ***questioning*** (Clark et al. 1984; Lindauer et al. 2012), ***summarizing*** (Gold 2007; Hußmann et al. 2017; Idris et al. 2008; Müller 2014; Neuland & Peschel 2013; Spörer et al. 2009), ***making inferences*** (Kruse et al. 2015), ***goal setting*** (Barzen 2012; Sächsisches Bildungsinstitut 2016; Wittwer et al. 2019), as well as ***modeling*** (Armbruster et al. 2001), ***scaffolding*** (Gibbons 2015; Klewitz 2017; Kniffka 2010; Wessel 2015), and ***feedback*** (Butler 2005; Ryssel 2012).

In terms of content, the students delve into different reading models such as ***the multilevel of reading*** proposed by Rosebrock and Nix (2020), ***the situation model*** developed by Lenhard (2013), and ***the interactive model of reading*** introduced by Rumelhart (1985), among others. Furthermore, they explore reading theories like ***the reader-response theory*** (Mart 2019) and the ***Dual-Route Model of Reading*** by Coltheart (Coltheart et al. 2001). The class also covers topics such as ***self-regulated strategy developmen***t (Graham et al. 2007), ***reading culture*** (Garbe et al. 2010; Nickel-Bacon & Wrobel 2012), the ***reader's self-concept*** (Garbe 2020; Goy et al. 2017), ***brainstorming*** (Ghabanchia & Behroozniab 2014), ***KWL-strategy*** (what I know, what I wonder, and what I learned) (Sholeh et al. 2020), ***self-monitoring*** (Cola et al.

2021; Mayer & Marks 2018), ***Jigsaw*** (Rahmatina 2019), ***anticipation guides*** (Evans et al. 2022), ***Directed Reading Thinking/Activity*** (DRT/A) (Erliana 2011), q***uestion-answer relationships***, ***inquiry charts***, ***think-pair-share*** (Mundelsee & Jurkowski 2021), ***graphic organizers*** (Bonyadi, 2013; Culbert et al. 1998; Roozbeh et al. 2016) (e. g., story sequence (Gouldthrop et al. 2017), story wheel), ***reciprocal teaching*** (Pilten 2016; Spörer et al. 2009), ***rubrics*** (De Silva. 2014; English et al. 2022; Jescovitch et al. 2019), ***reading guides***, ***Gradual Release Model*** (Frey & Fisher 2013), ***the workshop method*** (Hill & Crevola 1999), ***the grid method*** (Ostrowski 2020), ***reflection*** (Jenert 2008), ***SQR3*** (Anjuni & Cahyadi 2019; Koch 2017), and ***concept sort***, among others.

Through this comprehensive exploration, students gain a deeper understanding of the diverse strategies, models, theories, and instructional approaches related to reading. These insights equip them with a broad repertoire of tools and techniques that can be applied in their future teaching practices to effectively support their students' reading development.

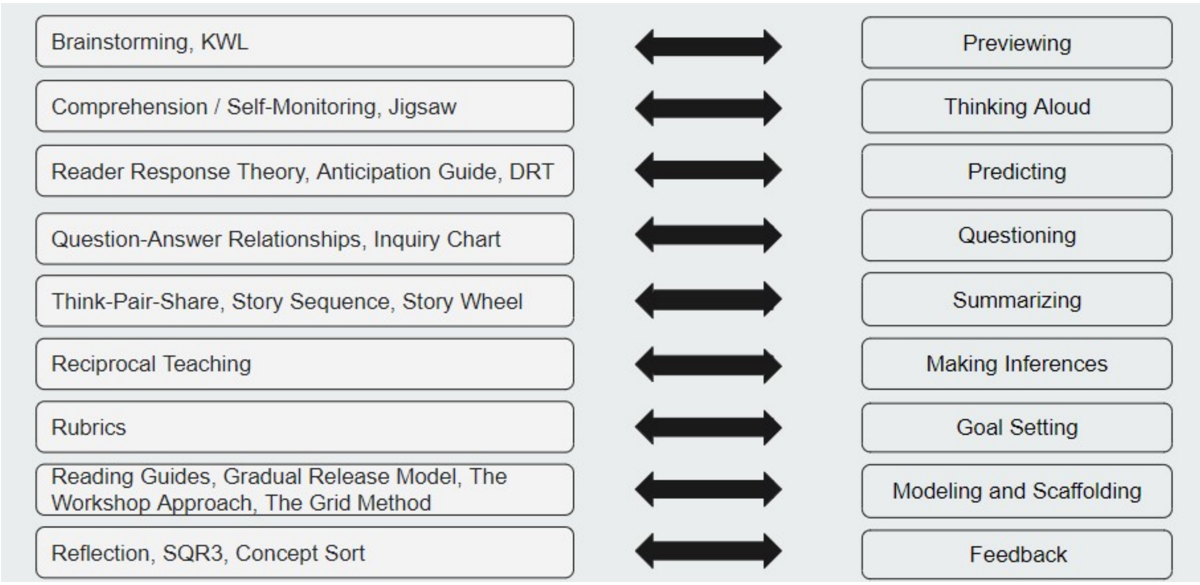

Figure 1: Topics, Reading Strategies aligned with Strategies and Methods, Hanke, J.

Example of Expert Groups

The lecturer provides an illustrative example of an expert group, demonstrating to students the expectation and utilizing the strategy of modeling. Throughout the class, students have the opportunity to inquire about reading strategies and their integration into future classroom settings.

The example of the expert group begins like every session, with the students preparing for class through pre-reading material. This material is specifically related to the topic of schemas or graphic organizers, as this is the strategy chosen for the example of an expert group. The pre-reading materials enable students to establish a foundational understanding of the topic, upon which they can further build during the session.

During the session, students are introduced to the definition, theory, and historical context behind the reading strategy. They are then presented with an overview of different groups or classifications of graphic organizers, accompanied by illustrative examples. The advantages and disadvantages of employing graphic organizers are also discussed. While reading strategies are undoubtedly helpful, teachers must ensure they are taught at the appropriate moments, effectively integrated into lessons, and students are guided on when and how to use them. Additionally, teachers need to consider the time required to adequately prepare and utilize graphic organizers.

Following this theoretical discussion, the example of the expert group transitions into an activity where students receive a graphic organizer, specifically a story map, from the lecturer. This story map is specifically created for the session and serves a crucial purpose. Rather than using graphic organizers simply for the sake of using them, they are thoughtfully incorporated into the session to fulfill a higher purpose. In this particular activity, students are tasked with reading a short text on reading engagement, and the story map serves to enhance reading comprehension and retention.

Through the modeling of an expert group, the students have a better understanding of the expert group and can plan their own.

By providing practical examples and opportunities for application, the class equips students with the necessary skills and understanding to effectively implement reading strategies, such as graphic organizers, in their future classrooms.

Expert Groups

The central focus of each session revolves around the expert groups, which serve as a cornerstone of the dual didactic approach implemented in the seminar. The seminar itself is designed to be learner-centered and student-led, creating an interactive and engaging learning environment.

During the expert group sessions, the seminar time is divided into two distinct halves. The first half is dedicated to the lecturer's guidance, where they cover the pre-reading material that is relevant to the entire session. This ensures that all students have a shared foundation of knowledge and understanding. The lecturer facilitates discussions with the class, delving into topics that align with the specific reading strategy to be presented by the expert group on that particular day. For instance, if the expert group is focusing on the reading strategy *previewing*, the lecturer may engage the class in discussions on related techniques such as brainstorming (Ghabanchia & Behroozniab 2014) and the KWL-strategy (what I know, what I wonder, and what I learned) (Sholeh et al. 2020).

The expert group experience goes beyond mere presentation or discussion. Students are tasked with planning and designing their own class, mirroring the responsibilities they will face as future educators. They conduct in-depth research on their assigned reading strategy, exploring various teaching methods and approaches that can effectively integrate the strategy into the classroom. Moreover, they carefully select appropriate texts for their classmates to read, considering the relevance and engagement level of the materials. This comprehensive preparation ensures that the expert group session is not only informative but also actively involves the participants. To solidify their plans, students are required to create a handout, prepare presentation materials, and design an interactive activity. These materials are then submitted to the lecturer one week prior to their designated teaching day, allowing for constructive feedback and quality control.

On the teaching day, students take on the role of instructors, delivering their prepared class to their fellow students who assume the role of eager learners. This provides them with a valuable opportunity to put their teaching skills into practice and examine the effectiveness of their chosen reading strategy. Following the presentation, a collaborative discussion ensues, where participants reflect on the strengths of the class, brainstorm potential implementation scenarios, and consider the optimal contexts in which the reading strategy can be employed. The lecturer also contributes to the discussion, offering valuable feedback to the expert group, highlighting areas of improvement, and providing guidance for future development.

This structured approach to the expert groups encourages active engagement, practical application, and continuous feedback, equipping students with the necessary skills and knowledge to excel in their future roles as educators. By actively involving students in the learning process and providing them with hands-on teaching experiences, the seminar empowers them to become confident, competent, and reflective practitioners in the field of education.

Conclusion

Overall, reading support is a crucial subject for both students and educators.

The class under discussion is specifically tailored to enrich students' comprehension of reading support while equipping them with the necessary tools, guidance, and hands-on experience to effectively implement reading support strategies. The integration of double didactics plays a key role in realizing these objectives. By adopting a student-led and student-centered approach, the class empowers students to actively participate in their own learning journey as a student but also as a future teacher and develop a deep understanding of reading support principles and practices.

Throughout the course, students not only acquire valuable teaching experience but also engage in continuous reflection, particularly in relation to their own learning and reading habits. This reflective component fosters self-awareness and a critical examination of their instructional approaches, enabling students to refine their strategies and enhance their effectiveness as future educators. By actively analyzing their experiences, strengths, and areas for improvement, students become active agents in their own development, cultivating a sense of ownership and autonomy in their learning process.

Furthermore, the incorporation of double didactics ensures that students receive comprehensive guidance and exposure to diverse teaching methods. This approach allows them to explore various instructional techniques, assess their efficacy, and adapt them to meet the unique needs of their future students. As a result, students complete the course not only with theoretical knowledge but also with practical skills and a deep understanding of how to provide effective reading support in educational settings.

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How Highly Achieved Students Differ From the Others? A Text-Mining Approach to Personal Learning Goals

Hilary K. Y. Ng, Hong Kong Metropolitan University, Hong Kong SAR
Lester C. H. Chan, Hong Kong University of Science and Technology, Hong Kong SAR

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Abstract
People often set goals at the start of a new event in their life. Goals are related to performance across different domains, including sports, psychotherapy, leadership, health care, as well as education. Those students who set learning goals are found to have higher learning motivation, more persistence in learning, better course attendance, and better academic performance than their counterparts. Previous studies showed students benefited most from setting specific, challenging, measurable, and achievable learning goals than their counterparts did. While goal-setting activity appears to be an effective and inexpensive way to enhance learning performance, how learning goals vary as a function of students' course grades remains under-explored. Rather than classifying students' learning goals into pre-established categories for summative investigation, the present study adopts a text-mining approach to examine whether learning goals associate with course grades. There were 192 university students who set three different learning goals at the beginning of a semester. Results from 552 valid responses indicated that highly achieved students differ from their counterparts in expressing their personal goals. The present finding provides an opportunity for us to learn from the highly achieved students. Other theoretical advances and practical advances in education, teaching and learning will also be discussed.

Keywords: Learning Goals, Text-Mining, Learning Performance

Introduction

People usually set new goals when they want to achieve certain things, regardless of sports (Gunn et al., 2023), leadership (Rosch et al., 2014), healthcare (Lorig & Holman, 2003), and education (Elliot & McGregor, 2001). These goals are useful to guide their actions to achieve the designated outcomes. Research indicates that there is a range of benefits for students to set learning goals. Learning goals can provide students with a clear and measurable target to strive for. Therefore, setting specific, proximal goals can facilitate students to stay focused and motivated in learning (Bandura, 1986), such as their ability to manage their time, stay organized in their learning, and improve their resilience when facing academic setbacks and challenges. Achievable learning goals and action plans can also increase students' self-awareness to monitor their progress and adjust their strategies (Schunk, 1990). Setting goals can also provide students with opportunities to reflect on their own strengths and weakness (Morisano et al., 2010), which may also help them to develop learning strategies that are effective to them. In the long term, students can be trained to prioritize their tasks and manage their time more effectively. Thus, the benefits of goal setting are not only in the immediate term, but also in a longer term to improve their academic performance and increase the completion rate of academic journey (e.g., Bandura, 1986; Morisano et al., 2010; Schunk, 1990). Thus, additional research in understanding the goal-setting activities is required and would be fruitful.

In addition to the myriad of benefits associated, research has suggested that the way in which goals are framed or communicated to students can also have an impact on their motivation and achievement (Chang et al., 2011). For example, research has highlighted framing goals in terms of learning and growth rather than solely focused on achieving a certain grade or score can influence how students' approach to learning (Chang et al., 2011; Dweck, 2017). This provides the possibility for the struggling students to learn from the goals set by the highly performed students, and to base on the features of the goals that set by highly performed students to develop their own goals. Previous research has been relied mostly on surveys and questionnaires (for a review: Wigfield & Cambria, 2010). The understanding about the different features of the goals, including wordings, specificity, difficulties, and even tonal nuances have been comparatively less studied. Hence, they fall short in capturing the essence of goals of how different students set goals and fail to answer the question – whether learning goals differ between the highly performed students and the struggling students?

To answer this question, the present study attempts to explore whether learning goals vary by the course grade. Instead of collecting quantitative responses from students, we collect qualitative responses and then conduct thematic analysis to understand students' learning goals. Text mining is a process of analyzing and extracting information from large volumes of unstructured data using computational methods (Ferreira-Mello et al., 2019). It can facilitate us to discover intricate patterns and relationships inside the text, such as word frequencies, collocation of terms, and topics (Daines et al., 2018). That is, the text-mining approach will be useful for us to understand whether there are similarities and differences among highly performed and struggling students.

Data Collection and Analysis

The data was collected from a group of 192 students attending a course at a university in Hong Kong. In the first tutorial lesson, they were asked to respond to the open-ended questions: *What are your learning goals in this course?* in Traditional Chinese. To respond to this question, they completed three different statements about their goals that begin with *I want to*. After they had filled in their responses on an online platform, they received an email about these three goals such that they could check back regularly. Altogether, we have received 552 valid responses collected from 184 students. These responses were classified into four groups, The group 1 (first quartile group) are the 46 students obtained graded A and B+ in this course, group 2 (second quartile group) are the 46 students obtained B to B+ in this course, group 3 (third quartile group) are the 45 students obtained B to B-, and finally group 4 (forth quartile) are the 46 students obtained B- to F in this course. All the students provided informed consent before they completed the goal-setting activity.

We analyzed the data with the open-source online text-mining tool Voyant Tool (Sinclair & Rockwell, 2023). As we want to retain the usage of original language, tokenization and lemmatization were not applied during the analysis. We specifically focused on two different levels, one is at the overall course level and another one is quartiles based. Focusing on the former would be useful to provide a general picture of all responses while the latter would be useful to understand the specific features of each quartile.

Results and Discussion

At the overall course level, the fifteen most used words by the students in this course is summarized (see *Table 1*). For the sake of presentation, word clouds are generated with the most frequently occurred words appearing larger and more prominent in these word clouds. As students completed the goal-setting activity in their native language, another word cloud with the translated English is also provided (see *Figure 1* in Chinese and *Figure 2* in translated English).

After identifying the general trend of the usage of words, we compared the usage of words at the quartile level, the first quartile and fourth quartile. By doing this, we can reveal the quartile-based characteristics, and thus move a step forward to answer the research question – whether differences exist between highly performed (first quartile) and struggling groups (fourth quartile). Tables 2 and 3 showed the frequency distribution of the fifteen most commonly occurred words for the first quartile and forth quartile respectively.

Ranking	Terms	Translation	Frequency
1	社會學	Sociology	126
2	教育	Education	106
3	社會	Society	97
4	學習	Learning	56
5	更多	More	50
6	認識	Knowing	49
7	科	Subject	48
8	知識	Knowledge	40
9	合格	Pass	39
10	這	This	37
11	與	And	35
12	問題	Problem	32
13	關係	Relationship	31
14	考試	Examination	26
15	對	Towards	26

Table 1. Frequency Distribution of the Fifteen Most Commonly Occurred Words

Figure 1. A Word Cloud of the Fifteen Most Commonly Occurred Words in Traditional Chinese

Figure 2. A Word Cloud of the Fifteen Most Commonly Occurred Words in Translated English

Students with A and B+ (n = 46)		
Terms	Translation	Frequency
社會學	Sociology	34
教育	Education	31
社會	Society	21
認識	Knowing	16
學習	Learning	16
知識	Knowledge	11
關係	Relationship	10
與	And	10
問題	Problem	10
科	Subject	9
理論	Theories	9
更多	More	9
合格	Pass	9
能力	Ability	7
更	More	7

Table 2. Frequency Distribution of the Fifteen Most Commonly Occurred Words of the First Quartile Students

Students with B- to F (n = 46)		
Terms	Translation	Frequency
教育	Education	32
社會學	Sociology	30
社會	Society	27
合格	Pass	15
認識	Knowing	13
科	Subject	12
更多	More	11
知識	Knowledge	10
學習	Learning	10
這	This	9
與	And	9
關係	Relationship	7
角度	Perspective	7
考試	Examination	7
對	Towards	7

Table 3. Frequency Distribution of the Fifteen Most Commonly Occurred Words of the Fourth Quartile Students

The comparison of the frequency distribution of the fifteen most occurred words of the overall course level yielded interesting findings, even though some similarities were observed. The fifteen most occurred words of the fourth quartile (struggling students) were directly equivalent to that at the overall course level. In contrast, the fifteen most occurred words of the first quartile (highly performed students) showed substantial differences to that at the overall course level. For example, compared to the overall course level, the word "Ability" only appeared in the first quartile (highly performed students). When comparing the frequency between the two groups, the use of the abstract word "This" and "Towards" are lower in the first quartile (highly performed students) than the fourth quartile (struggling students). That is to say, the vocabulary used by the first quartile (highly performed students) largely differs from other classmates. These findings showed that highly performed students have wider vocabulary and clearer expression of themselves when they were setting their learning goals. More importantly, it provides insight to the present research question that there are differences between highly performed students and struggling students.

Conclusion

While previous research usually adopts the "orientation" frameworks to classify goals into different categories, the present exploratory study adopts the text-mining approach to explore whether differences exist between the learning goals set by highly performed and struggling students. Both similarities and differences can be observed among the learning goals set by different students with varying course grades. While verbal or visual data are yet to be captured and considered, the present study is one of the first dives towards the context and individualization of student experiences that could influence their learning goals. Further investigations could be conducted to further examine the unique characteristics of the learning goals set by different students. With sufficient guidance, learning from the highly performed students may be able to help those struggling students to optimize their academic potential, which in turn provides a more equitable learning opportunity to everyone.

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Contact email: hilaryngnky@gmail.com

The Role of Knowledge Management Enablers in Higher Education Institutes on Institutional Accreditation: An Empirical Study of Business Graduation Association (BGA) Accreditation in China

Jing Wang, Japan Advanced Institute of Science and Technology, Japan
Kim Eunyoung, Japan Advanced Institute of Science and Technology, Japan

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Abstract
In the increasingly competitive and internationalized higher education, institutional accreditation has become a supportive role in higher education institutions' (HEIs) ranking and development. Institutional accreditation is a form of knowledge sharing and transfer in organizational management, research, learning and teaching, and networking. But how can such knowledge sharing be enabled within different higher education organizations? The main objective of this research is to explore the relationship between knowledge sharing enablers and institutional accreditation outcomes. Derived from in knowledge sharing enablers, this research builds a model of knowledge management (KM) enabler composed of organizational culture, trust, information technology and employee motivation. A cross-sectional scale questionnaire developed to investigate the relationship between KM enablers with institutional accreditation. Together these KM enablers, including organizational culture, trust, information technology and incentives, were identified to be predictive factors for organizational KM and positively related to institutional accreditation outcomes. This research contributes to the field of knowledge management and HEIs' organizational development, as well as KM enablers in higher education. It also provides practical insights to the higher education administrators and stakeholders involving in supporting educational internalization and regional accreditation.

Keywords: Knowledge Management Enablers, Institutional Accreditation, Knowledge Management, Accreditation Outcomes

1 Introduction

The increasing needs of globalization activities has led to the globalization of business education. Effective collaboration requires not only the ability of participants to communicate in a common language, but also the assurance of a common level of professional understanding (Moscinska, 2014). Accreditation may be "the most fully developed institutionalization of the idea of accountability in higher education" (Van Vught & Westerheijden, 1994). Institutional accreditation is one step towards demonstrating the high performance of a business school. Well-established international accrediting bodies provides global recognition to business schools. It works as a signal to students, employers, and other stakeholders that the school meets international standards of quality. Chinese universities seek international business accreditation to pursue accreditation from recognized international accrediting bodies (Zhang & Gao, 2012). International accreditation can enhance universities' reputation and the standard of a business school to attract students and faculty from around the world. It serves as a quality assurance mechanism for business schools. BGA accreditation set rigorous standards and criteria that business schools must meet to obtain accreditation (Miles et al., 2016). This process ensures that accredited schools maintain high educational standards, have qualified faculty, offer relevant and up-to-date curricula, and provide a supportive learning environment. Students, employers, and other stakeholders can rely on accreditation as an indicator of quality education.

Although institutional accreditation and knowledge management are distinct concepts, there is a relationship between institutional accreditation and knowledge management (Klein, 2014). In the accreditation process, it opens doors to networking and collaboration opportunities for business schools. Accredited schools become part of a network of peer institutions, allowing for knowledge sharing, research collaborations, and faculty exchanges (Gawor et al., 2021). These collaborations contribute to the overall improvement and advancement of business education. Although effective knowledge management practices can contribute to meeting accreditation standards by providing evidence of institutional quality, supporting data-driven decision-making, and facilitating continuous improvement efforts. Knowledge management can help institutions document and highlight their intellectual capital, demonstrate the impact of their research and teaching, and provide evidence of their commitment to enhancing educational outcomes.

Institutional accreditation and knowledge management are interdependent and interact in various ways. However, our principal concern in this paper is focusing on the role of knowledge management and its implementation through the process of accreditation.

2 Literature review

2.1 Institutional accreditation

Institutional accreditation is a voluntary quality assurance process for schools and colleges (Blanco Ramírez, 2014). It involves the evaluation of an institution's effectiveness based on a set of criteria by an external commission consisting of representatives. The process recognizes the importance of student learning and development as a central focus in the evaluation criteria. Accreditation provides recognition to institutions that meet minimum quality standards and encourages them to maintain and improve their resources, programs, services, and impact on students and stakeholders. Institutions need to response to the criticism or suggestions and work towards resolving identified issues to maintain their accreditation. Institutional accreditation offers opportunities for institutional improvement and accountability.

2.2 Business Graduates Association accreditation in China

In the United States, accreditation in business education initially developed through the expansion of the American Assembly of Business Schools (Cret, 2010). In Europe, however, its significance is relatively recent. The Business Graduates Association (BGA) is a global accrediting body that focuses on business education (BGA, n.d.). It assesses various aspects of business programs, including curriculum, faculty qualifications, and the learning environment. BGA is highly regarded internationally and evaluates business schools based on global standards and best practices in business education. In China, 65 universities have received accreditation from BGA. BGA accreditation provides these schools with advantages such as enhanced credibility, reputation, and recognition both domestically and internationally (BGA, n.d.). When selecting a business school, prospective students often take into account its accreditation status as an indicator of quality and assurance that the educational institution meets certain standards.

2.3 Knowledge management process

From an organizational point of view, knowledge management (KM) is defined as the systematic process for organizations to create, capturing, organizing, storing, and distributing knowledge to enhance its effectiveness and performance (Alavi & Leidner, 2001). It involves the creation, sharing, and application of knowledge to facilitate decision-making, problem-solving, innovation, and learning (Dalkir, 2017).

Knowledge acquisition refers to the process of getting through various means, such as conducting research, gathering information from external sources, capturing expertise from experienced employees, or conducting internal surveys and interviews (Dalkir, 2017). The goal is to collect relevant and valuable knowledge that can be used to meet the identified needs. In the context of business school accreditation, knowledge acquisition refers to the process of gathering the necessary information and data about the business school to assess its qualifications and meet the accreditation requirements. It involves collecting and documenting evidence to demonstrate that the school meets specific standards set by accrediting bodies.

Knowledge sharing is a critical aspect of the knowledge management process. It involves facilitating the transfer of knowledge among individuals or teams within the organization (Dalkir, 2017). Knowledge sharing and collaboration plays an important role in business school accreditation, as they contribute to the continuous improvement and development of the school's educational programs, faculty expertise, and overall quality. Overall, knowledge sharing and collaboration in business school accreditation facilitate the exchange of ideas, best practices, and research findings within and outside the institution.

Knowledge application involves using the captured and shared knowledge to address challenges, develop innovative solutions, improve processes, and enhance organizational learning (Dalkir, 2017). Knowledge application in business school accreditation refers to the utilization of acquired knowledge, best practices, and insights to improve the quality of education, enhance institutional effectiveness, and meet accreditation standards. By applying acquired knowledge in these various areas, business schools demonstrate their commitment to continuous improvement, relevance, and the fulfillment of accreditation standards. The effective application of knowledge enhances the quality of education, strengthens institutional effectiveness, and contributes to the overall success of the business school.

Overall, the knowledge management process is an ongoing cycle that requires a systematic approach to capturing, organizing, storing, sharing, and applying knowledge to drive organizational success and competitiveness. It involves a combination of people, processes, technology, and organizational culture to create an environment where knowledge is valued, accessible, and effectively utilized.

2.4 Knowledge management enablers

Knowledge management enablers are the operational or service settings in an organization that is accountable for the success of a KM initiative. These enablers are considered as mechanisms or factors that facilitate the creation, sharing, and application of knowledge within the organization. (Yasir & Majid, 2017). Choo and Neto (2010) identified four distinct categories of facilitators that enable the effective implementation of knowledge processes, they are social dimension, relational dimension, technological dimension, and cognitive dimension.

In the context of BGA accreditation, technological dimension of knowledge enabler develops into information technology usage. In this paper, the term "social dimension" refers to the aspect of organizational culture, specifically referring to the shared understanding and significance that individuals within a network derive from their affiliation with the group. A shared culture within an organization enhances cooperation and creates opportunities for knowledge sharing. It is important to have a mutual understanding between accreditors and accreditees to facilitate knowledge transfer. Therefore, the social dimension encompasses the organizational culture among stakeholders (Hall & Ellis, 2022). The relational dimension of a knowledge enabler is characterized by the development of trust, which is built upon the belief in the integrity and competence of others (Hall & Ellis, 2022). Trust is a multifaceted concept that encompasses the anticipation of cooperation and integrity among individuals, nurturing a sense of mutual confidence. It is based on factors such as benevolence (concern for the well-being of others) and competence. In order to facilitate the transfer of explicit and tacit knowledge between different organizations, the utilization of electronic systems that rely on information technology is crucial (Anvari, 2011). These systems allow for the creation of networks that bridge the gap of time and space, providing effective channels for knowledge transfer. The research mentioned here focused on examining the knowledge exchanges that occur through the utilization of information technology among members involved in the accreditation process. According to Andreeva & Kianto (2011), motivation plays a crucial role in enhancing knowledge sharing, with inter-organizational trust acting as a mediating factor. Moreover, when members of organizations have both external and internal incentives, it strengthens their willingness to engage in knowledge sharing activities. Therefore, the cognitive dimension pertains to the motivations that have been shown in the study to positively influence the quality and quantity of knowledge sharing.

2.5 Hypothesis model and research questions

This study examines the connections between knowledge enablers and organizational performance by emphasizing the importance of knowledge processes as the foundation for organizational advantage. The impact of knowledge management enablers on organizational performance is mediated through knowledge processes (Hall & Ellis, 2022). This implies that knowledge enablers influence organizational outcomes through the facilitation of knowledge processes. The knowledge-chain model proposed by Tseng (2010) is used to explain this relationship. According to the model, culture, trust, information technology, and motivations create conditions that enable the achievement of organizational outcomes through knowledge management activities such as acquisition, sharing, and application. By incorporating these elements, it can be confirmed that enablers ultimately generate business value. In summary, this paper formulated five hypotheses as presented in the model shown in Figure 1.

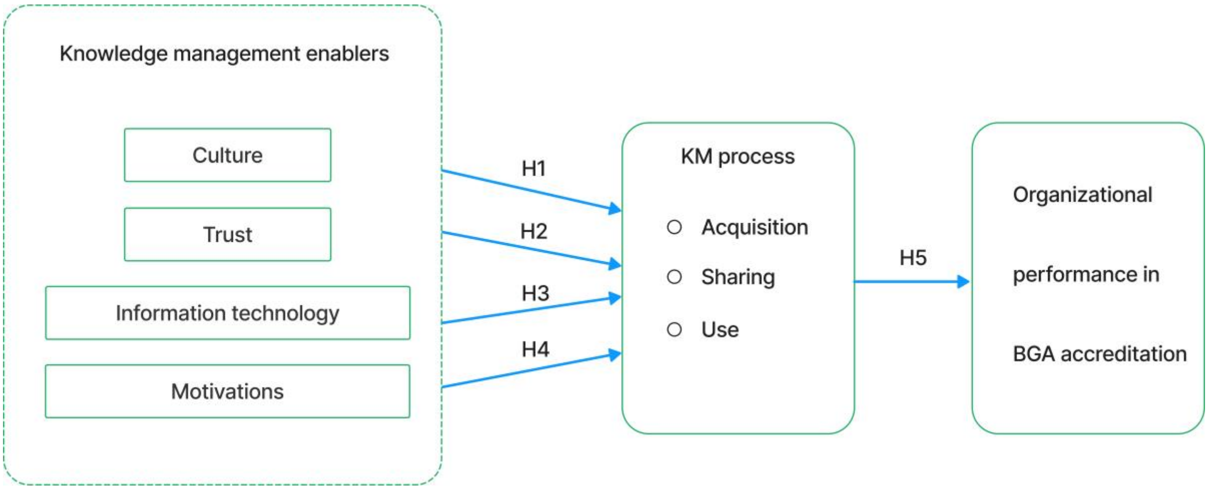

Figure 1: Research model

Based on the above literature and research model, the research therefore investigated the relationship between KM enablers, KM processes and organizational performance in the following hypothesis:

H1: KM process is positively affected by the culture of institutional accreditation.

H2: KM process is positively affected by the trust in institutional accreditation.

H3: KM process is positively affected by the information technology in institutional accreditation.

H4: KM process is positively affected by the motivations in institutional accreditation.

H5: The organizational performance in institutional accreditation is positively affected by KM process.

3 Research methodology

3.1 Participants

Participants are randomly selected from 8 BGA accredited universities in China, 1 in Liaoning province, 2 in Guangdong province, 2 in Shandong province and 2 in Jiangsu province. 350 participants received an invitation by email and consented to take part in this research survey. They are BGA stakeholder including administrative leadership, deans, chairs of department, faculty, and staff. 20 invalid questionnaires were deleted for missing answers. The demographic of 330 participants is presented in Table 1.

Table 1: Demographic profile

Items	Categories	Frequency	Percentage
Gender	Male	175	42.9%
	Female	233	57.1%
Age	under 30	20	4.9%
	31-40	151	37.0%
	41-50	196	48.0%
	51-60	41	10.0%
Degree	Master’s degree	172	42.2%
	PhD	236	57.8%
Working position	Leadership of university	21	5.1%
	Deans of schools	61	15.0%
	Chairs of departments	89	21.8%
	Faculty of university	184	45.1%
	Staff of university	53	13.0%

3.2 Questionnaire design

The questionnaire item is designed to collect the data regarding each knowledge enabling factor with a series of 5-point Likert items from 1= totally disagree to 5= totally agree (Table 2).

Table 2: Questionnaire items

Factor	**Items**	**Content**
Culture	CUL1	Sharing of successful experience in accreditation is encouraged in my university.
	CUL2	My university advocates for empowerment and encourages active participation in accreditation work.
	CUL3	Collaboration and group work are encouraged in my university to support BGA accreditation stakeholders in exchanging their expertise.
	CUL4	Knowledge sharing among BGA accreditation stakeholders in my university does not pose a threat to their positions.
	CUL5	In this university, we have a culture of openness and trust that facilitates the acquisition and sharing of knowledge in BGA accreditation.
Trust	TRU1	Other members of this network help me when I have a problem concerning BGA accreditation.
	TRU2	I can rely on the other members of our team to support me in BGA accreditation.
	TRU3	I can count on the other members of our team to do what they say.
	TRU4	I have faith in the skills of the other members in my team.
Information technology	IFT1	I am open to new technology utilization in BGA accreditation work.
	IFT2	I like to use information technology in my BGA accreditation work,
	IFT3	I am willing to support technology-based change in BGA accreditation system in my university.

	IFT4	I am highly enthusiastic about information assistance-driven changes in the BGA accreditation system.
Motivation	MOT1	Knowledge sharing in BGA accreditation should be rewarded with higher salary or bonus.
	MOT2	Knowledge sharing in BGA accreditation should be rewarded career development opportunities
	MOT3	Knowledge sharing in BGA accreditation should be rewarded with more exchanges opportunities with external partners.
	MOT4	Faculty and staff should be encouraged to continue with further study.
Knowledge acquisition	KNA1	Knowledge in BGA accreditation can be acquired from shared culture.
	KNA2	Knowledge in BGA accreditation can be acquired from my peers.
	KNA3	Knowledge in BGA accreditation can be acquired from faculty and staff.
	KNA4	My university supports the exchange of knowledge among individuals and groups.
	KNA5	My university employs competent staff to promote the sharing of ideas.
Knowledge sharing	KNS1	Knowledge can be shared with BGA accreditation external stakeholders in my university.
	KNS2	Knowledge can be shared with BGA accreditation working staff.
	KNS3	Knowledge in BGA accreditation can be shared across different departments.
	KNS4	ICT are developed to share BGA accreditation knowledge.
	KNS5	Tasks and efficiency in BGA accreditation are improved by database utilization.
Knowledge application	KNU1	Knowledge can be utilized in BGA accreditation in form of databases and information technology which helps store knowledge for easy access by others.
	KNU2	Different sources of knowledge in BGA accreditation are effective transferred.
	KNU3	There is perfect system in internal knowledge exchange in BGA accreditation.
	KNU4	Experienced know-how can be clear and assessable in BGA accreditation.
	KNU5	Databases and information technology in BGA accreditation are easily accessible.
	KNU6	Knowledge in BGA accreditation is put in practice.
Organizational performance in accreditation	In the last 5 years, my university…	
	OPA1	has more contribution to economic growth and development.
	OPA2	has more contribution to achieving United Nations Sustainable Development Goals.
	OPA3	has better institutional sustainability and integrity.
	OPA4	has generating more value by building tangible connections with other academic institutions.
	OPA5	is more impactful and innovative.
	OPA6	is more devoted to the principles of equality and diversity.
	OPA7	has higher graduate employment rate and corporate relations.

4 Results and discussion

Structural equation modelling (SEM) was utilized to examine the five hypotheses using SPSS and AMOS 26.0 software for data analysis. Confirmatory factor analysis (CFA) was conducted as an initial step to establish convergent and discriminant validity. Both the CFI and NFI values exceed 0.9, thus they are considered acceptable. All measurement model fit indices yield satisfactory values, indicating good fit (Hair et al., 2019). Detailed information on the fit indices is presented in Table 3.

Table 3: Fit indices values

DF	P-value	CMIN/DF	GFI	AGFI	PNFI	PGFI	NFI	IFI	TLI	CFI	RMSEA
-	>0.05	<3	>0.9	>0.9	>0.5	>0.5	>0.9	>0.9	>0.9	>0.9	<0.1
712	0.213	1.042	0.921	0.909	0.842	0.8	0.922	0.997	0.996	0.997	0.01

A threshold of 0.5 or higher demonstrates acceptable convergent validity (Hair et al., 2019). As Table 4 shows, all average variance extracted (AVE) values indicate that at least 50% of the variance in the indicators is captured by the constructs. The composite reliability (CR) values in Table 5 all exceed 0.7, which is considered acceptable and indicates good construct reliability (Hair et al., 2019).

Table 4: AVE and CR values in measurement model

Factor	CR	AVE
Culture	0.888	0.613
Trust	0.868	0.621
Information technology	0.858	0.601
Motivation	0.842	0.572
Acquisition	0.884	0.603
Distribution	0.889	0.617
Application	0.899	0.597
Organizational performance	0.896	0.553

Regarding the path analysis results in Figure 2 and Table 5, most of the paths demonstrate statistically significant relationships. However, it is important to note that the relationships between culture and KM processes do not reach statistical significance. The analysis results in Table 5 indicate a non-significant effect (p>0.05) of organizational culture on KM processes. Consequently, H2 are rejected.

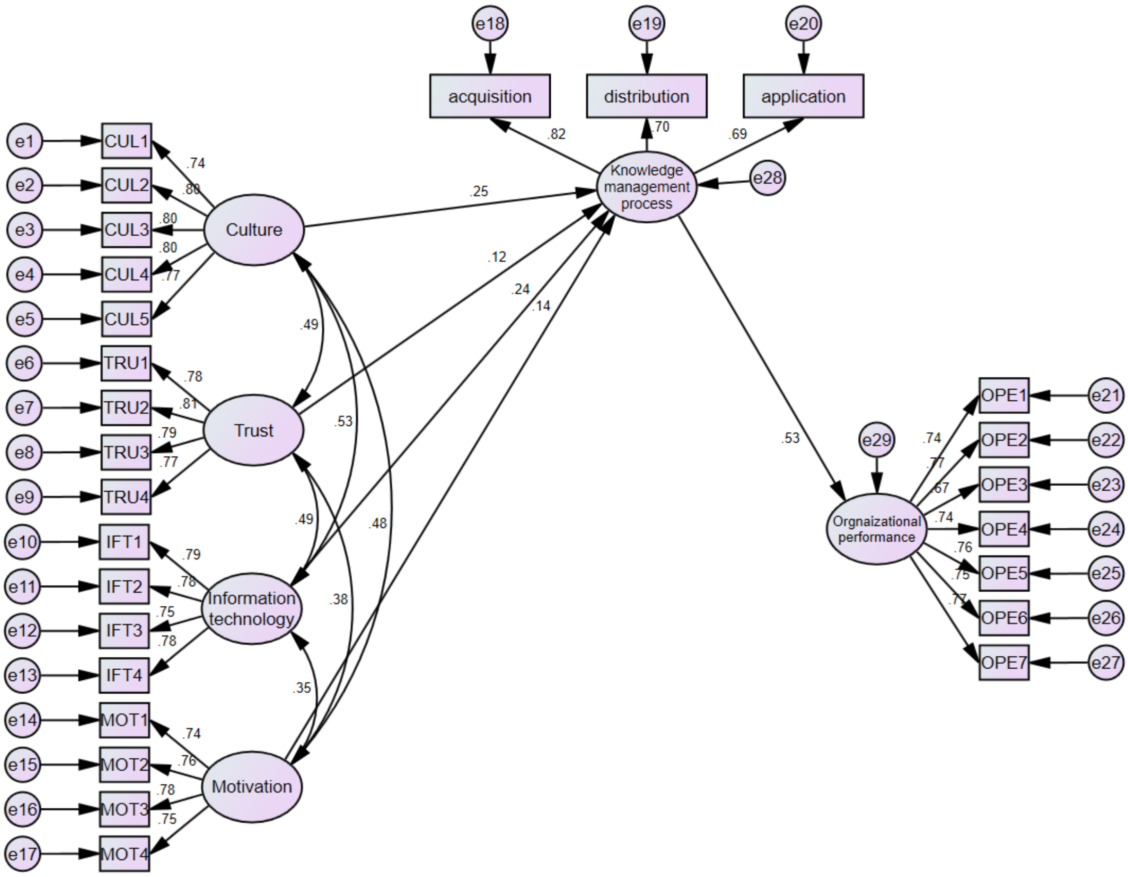

Figure 2: Structural equation model with path analysis

However, there is a significantly positive relationship between knowledge management processes and culture ($p<0.05$) as well as information technology and motivations ($p<0.05$). Hence, H1, H3 and H4 are accepted. Moreover, there is a significantly positive relationship between KM processes and organizational performance in the institutional accreditation context. Thus, H5 is supported.

Table 5: Results of testing proposed hypotheses

Relationship			S.D.	Estimate	S.E.	C.R.	P
Knowledge management process	<---	Culture	0.246	0.225	0.065	3.476	***
Knowledge management process	<---	Trust	0.123	0.104	0.056	1.868	0.062
Knowledge management process	<---	Information technology	0.244	0.203	0.057	3.575	***
Knowledge management process	<---	Motivation	0.144	0.14	0.061	2.287	0.022
Organizational performance	<---	Knowledge management process	0.533	0.594	0.068	8.718	***

5 Discussion

This research contributed to the field of knowledge management and institutional literature in the context of Chinese higher education institutes. The study establishes a model to investigate how the organizational enablers contribute to the facilitation of knowledge flow in institutional accreditation within Chinese universities. The study recognizes the importance of these enablers in enhancing organizational performance in accreditation.

5.1 Significant enablers in institutional accreditation

The results of this study highlight the significance of organizational culture, information technology, and motivations in fostering KM processes in institutional accreditation. These factors were found to have positive and significant relationships with institutional accreditation performance and KM processes. Notably, organizational culture emerged as the strongest influencer of KM processes, aligning with previous research conducted, such as the study conducted by Schein (2016), which also found organizational culture to be a crucial determinant of KM processes in accreditation settings.

The value of knowledge management created by culture was perceived very differently depending on the organizations. Culture plays a crucial role in the knowledge management process within an organization. The organizational culture encompasses the shared values, beliefs, norms, and behaviors that influence how knowledge is perceived, created, shared, and utilized. The results indicate that communication patterns and information flow within an organization are influenced by its culture. A culture that promotes open communication, knowledge sharing platforms, and transparent information flow enhances the effectiveness of knowledge management initiatives. By integrating knowledge management practices into interactions with external stakeholders, institutions can foster collaboration culture, and enhance their ability to meet accreditation requirements and stakeholder expectations. These practices promote efficient knowledge sharing, evidence-based decision-making, and a culture of learning and improvement.

Also, the findings of this study contribute important empirical insights on the support of information technology. Information technology offer various benefits and capabilities to streamline and enhance accreditation activities. Knowledge management in accreditation process involves capturing and organizing relevant information, documentation, and evidence to support the institution’s interactions with external stakeholders. This includes maintaining records, reports, and data that demonstrate compliance with accreditation standards, student outcomes, institutional effectiveness, and other relevant information requested by accrediting agencies or external stakeholders. Accreditation agencies often require institutions to submit comprehensive data related to student outcomes, faculty qualifications, curriculum, financial information, and more. The technology-based management system and its databases allows efficient data collection, validation, reporting, ensuring accuracy and timeliness. Information technology also enables effective collaboration and communication among stakeholders involved in the accreditation process. Online collaboration platforms, video conferencing tools, and project management software support remote collaboration and facilitate real-time communication between institutions, accreditation agencies, peer reviewers, and external stakeholders. These tools streamline coordination, enhance information sharing, and promote efficient feedback exchange.

These empirical findings also echo the valuable insights into the association between stakeholders' motivations and KM processes (Nguyen et al., 2019). Intrinsic motivation refers to the internal desire and satisfaction individuals derive from engaging in knowledge management activities. When individuals find value in sharing their knowledge, contributing to the collective knowledge pool with each other, they are more likely to participate actively in knowledge management process. Intrinsic motivation can be fostered by creating a supportive culture that recognizes and rewards knowledge sharing and promotes a sense of purpose and mastery. When faculty and staff have greater confidence in their knowledge and expertise, they are more motivated to transfer knowledge with their peers and external stakeholders, leading to improved institutional performance in institutional accreditation. Extrinsic motivation involves rewards, recognition, and incentives that encourage individuals to engage in knowledge management. Recognizing and rewarding individuals for their knowledge-sharing efforts can serve as an extrinsic motivator, encouraging them to contribute their expertise and actively participate in knowledge management activities. This can be done through incentives, performance evaluations, promotions, or other forms of recognition that acknowledge and appreciate their contributions.

In summary, the diverse perspectives on the value of knowledge management in institutional accreditation organizations highlight the need for tailored approaches and strategies. Effective communication of benefits, superior rewards and open culture are essential for successful knowledge management initiatives in this HE institutional accreditation.

5.2 Insignificant enablers in institutional accreditation

Interestingly, the results of this study reveal that trust do not have a significant impact on KM processes. This unexpected finding may be attributed to considering source of knowledge power and may be less willing to share their knowledge. When individuals feel uncomfortable sharing their knowledge and ideas with fear of judgment or reprisal, it creates an environment obstructive to knowledge sharing and collaboration. This find is also echoed with Covey and Merrill's research (2008). When trust is low, there may be a lack of recognition and appreciation for knowledge-sharing efforts. Individuals may feel that their contributions are not acknowledged or valued, leading to a decreased motivation to share their knowledge. Without the perception that their efforts will be recognized and appreciated, individuals may be less willing to invest their time and energy in knowledge sharing.

This study emphasizes the positive and significant relationship between KM processes and organizational performance in institutional accreditation. Successful implementation of organizational culture, information technology and motivations lead to continuously improvement in educational offerings, faculty expertise, and programs quality align with industry needs and global standards, which aligns with the findings of previous research conducted by Rios-Ballesteros and Fuerst (2021). These results highlight the importance of prioritizing and optimizing KM processes to enhance organizational performance in the institutional accreditation context.

6 Recommendations and limitations

This study offers practical recommendations for Chinese universities aiming to enhance their knowledge management practices in institutional accreditation. Considering the crucial function of organizational culture, information technology, and motivations in promoting knowledge sharing, several strategies can be adopted to foster a knowledge-friendly environment within the organization.

The findings underline the significant impact of KM on institutional accreditation. Chinese universities should prioritize and devote more resources to institutional accreditation, which involve promoting knowledge sharing, utilizing effective knowledge repositories, and leveraging diverse knowledge sources. By focusing on these aspects, universities can enhance their organizational performance and excel in quality assurance practices. Overall, this study provides empirical evidence on the relationships among organizational culture, information technology, motivations, and KM processes. It offers practical implications for organizations in effectively managing knowledge resources to drive institutional performance.

This study acknowledges several limitations. This research was conducted solely within the Chinese context, the interpretation of the results may be influenced by national culture. Future studies should consider cross-cultural investigations involving emerging countries to validate and extend the findings across different cultural contexts. By addressing these limitations and incorporating a broader range of KM enablers, expanding the sample size and diversity, and conducting cross-cultural studies, future research can enhance the generalizability, depth, and robustness of our understanding of KM processes in the HE context and institutional domain.

In summary, institutional accreditation ensures educational quality and accountability at an institutional level, while knowledge management focuses on effectively managing and utilizing institutional knowledge assets. Both are important for educational institutions to operate effectively, improve educational outcomes, and demonstrate their commitment to excellence.

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Contact email: s2120425@jaist.ac.jp

Supporting Equity in Education for Underrepresented Learners

Imani Akin, American College of Education, United States
Gail Claybrooks, American College of Education, United States

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Abstract
Educational institutions lead in the construction and dissemination of knowledge. The responsibility of supporting underrepresented learners in their pursuit of knowledge includes proactive and collaborative action. Higher education was once considered a tool for social mobility but now reinforces the social and economic divide. Earning an education was a promise to level the playing field and help learners realize their potential and increase their opportunities for success. For some, gaining an education is their measure of success in social advancement. For underrepresented learners, access to higher education is a challenge. For those who gain acceptance to educational institutions, there are challenges to navigating the environment to access resources and maximize their academic achievement. Cultural competence is a necessary skill for enhancing the educational experience of the underrepresented learner. Cultural competence as a requirement for higher education faculty and staff can reduce the effects of marginalizing learners. Marginality occurs as populations are pushed outside of the margins of support structures. Marginalized and underrepresented populations need support in learning to navigate through some educational systems. Collaborative strategies are needed to reimagine educational success for underrepresented learners striving for success in higher education. Greenberg recommends actions for educational institutions to support underrepresented learners that include incorporating equity priorities in the institutional culture. This research was conducted to explore the barriers and challenges underrepresented learners may experience in higher learning. Strategies for overcoming the barriers and challenges include cultural competence for faculty and staff.

Keywords: Equity in Education, Higher Education, Marginalization, Underrepresented Learner

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Introduction

Educational institutions lead in the construction and dissemination of knowledge (Altback, 2003). Native American, Latino and Black students are among the racial and ethnic groups that have been historically marginalized and underrepresented as learners in higher education (Ellsworth et al., 2022). First generation and non-white learners are underrepresented student populations that continues to expand in higher education (Banerjee, 2020). The responsibility of supporting underrepresented learners in their pursuit of knowledge includes proactive and collaborative action. By 2045, it is predicted that the multicultural populations in the United States will become the majority and the multicultural groups will represent around 64% of the population in the United States by 2060 (Frey, 2018). Working towards equity in education for underrepresented learners is a matter of social justice (Turner, 2016). In the year 2017, even though 44% of adults aged 25 years old or older had attained a degree, significant disparities in educational in equity still exist (American Council on Education, n.d.). College completion rates remain significantly low for historically underrepresented students in higher education (Ellsworth et al., 2022).

Earning an education can aid in leveling the playing field and help learners realize their potential and increase their opportunity for success. For some, gaining an education is their measure of success for social advancement. Miller (2019) draws upon the work of Paul Tough and how higher education was once considered a tool for social mobility but now reinforces social and economic divide. The reality is that education as a tool was not intended for use by all. Admissions processes, financial aid models, hiring practices, and testing are some of factors that reinforce the inequities impacting students.

The Problem of Equity in Access to Higher Education

For underrepresented learners, access and success in higher education is a challenge (NCES, 2019). For those who gain acceptance to educational institutions, there are challenges to navigating the environment to access resources and maximize their academic achievement. challenges are magnified for members of underrepresented populations. Marginality occurs as populations are pushed outside of the margins of support structures (Akin & Neumann, 2013). Some marginalized groups learn to work within the margin and devise alternative methods of navigating throughout systems. Cultural competence is a necessary skill for enhancing the educational experience of the underrepresented learner (Whitman & Jayakumar, 2023).

Collaborative strategies are needed to reimagine educational success for underrepresented learners striving for success in higher education. Postsecondary institutions have a direct responsibility to support learners in pursuit of knowledge. Greenberg (2022) recommended actions for educational institutions to support underrepresented learners that includes incorporating equity priorities in the institutional culture. Cultural competence as a requirement for higher education faculty and staff can reduce the effects of marginalizing learners.

This paper will explore the barriers and challenges underrepresented learners may experience in higher learning. Strategies for overcoming the barriers and challenges include cultural competence for faculty and staff. Theories supporting the strategies will be explained.

Significance of the Study

Addressing the needs of learners in higher education is important to the construction of our global society and their impact in that society. To support learners, we need to understand their issues with access, their experience in belonging, and their teaching and learning experiences. Cuellar and Gándara (2021), revealed that administrator perception of promoting equity, accessibility of information, and consistency were key factors in ensuring efforts to address inequities in high education are successful. The perceptions of the faculty who serve underrepresented learners are critical to the learners' psychological safety and academic outcomes.

Theories of Equity and Student Integration

Two theories were researched to explore equity and learner support. The equity theory developed by Stacy Adams addresses and supports motivation of learners. Tinto's theory of student integration is a paradigm that depicts the basic requirements necessary for students to perceive a degree of fit, or sense of belonging, which leads to persistence. Conversely, it illuminates how student attrition becomes inevitable when student needs are unmet.

Adams' Equity Theory

The equity theory of motivation was founded by Stacey Adams in 1963 in response to the cognitive dissonance theory (Fowler & Brown, 2018). Stacey was a workplace and behavior psychologist. The original focus was on employee behavior and motivation. The theory has evolved to a model of motivation. Inputs and outputs contribute to the sense of equity. Learners want to be rewarded for their academic efforts at school. The equity theory addresses dissonance that one may encounter due to perceived lack of reciprocity by faculty towards the efforts of underrepresented learners (Hoffman-Miller, 2022).

Mental Health

Underrepresented learners may have some academic gaps that contribute to challenges while they are in higher education. Equity theory is useful in conceptualizing some of the invisible barriers that impact learning outcomes for underrepresented learners. Instructors, faculty, and staff actions may affect the cognitive, emotional, and social process for learners and the outcomes result in their levels of success as well as their emotional capital or self-esteem (Fowler & Brown, 2018). In higher education consideration of the impact of the people and processes within the educational institution is necessary to build collaborative institutional interventions for the success of underrepresented learners.

Tinto's Theory of Student Integration

Tinto's (1973) seminal work on student retention revealed three primary indicators of student withdrawal: academic ability, degree of fit, and institutional commitment. First-time students require additional support, and institutions have responded with strategies targeting engagement in the first year. The matriculation experience beyond the first year tends to be more challenging. Tinto's student integration theory emanated from Durkheim's 1951 theory of suicide, which proposed that suicidal ideation and behavior originated from perceived alienation and inability to integrate with society socially and intellectually (Claybrooks & Taylor, 2016). Tinto likened withdrawal from school to the withdrawal from family or society observed in individuals exhibiting suicidal behavior (Tinto & Cullen, 1973). The argument held that students must experience a certain degree of social and academic integration with their campus to commit to the institution and persist to graduation. Tinto conceived that successful first-year students entered colleges with basic traits such as family background, motivation, individual characteristics, and ability. Further, the interaction between these inherent characteristics and the collegiate environment influenced student achievement; consequently, there is a symbiotic relationship between integration and achievement. As students acclimate to campus culture, their commitment to the institution is positively influenced, and their likelihood of persistence and academic success increased. Conversely, unsuccessful integration culminates in reduced goal and institutional commitment, and increased chances of withdrawal (Tinto, 1975, 1987, 1993).

Freeman et al. (2007) furthered Tinto's degree of fit or sense of belonging hypothesis through identification of five significant influences on student withdrawal: (a) lack of diversity on the campus, (b) lack of satisfaction with social life, (c) lack of emotional preparation for college, (d) lack of academic preparation for college, and (e) lack of satisfaction with experiences in college. These findings supported Tinto's 1975, 1987, and 1993 works on student integration by concluding that student satisfaction and preparedness for the college experience were the greatest deterrents to withdrawal. Tinto's paradigm is tried and true and remains the gold standard 50 years later. National data from 2022 reveal decreased degree completion (provide data), which could signal inequity for underrepresented learners. Gallup-Lumina Foundation (2023) noted in its 2022 report on mental health in higher education, 41% of students enrolled in a postsecondary education program considered stopping out in the six months prior to being surveyed, and 55% of respondents cited emotional stress as a reason.

The combination of equity theory and theory of student integration provides a thorough framework of intersectionality through which institutions can identify, better acknowledge, and advocate for inclusive environments conducive to grounding disparities for underrepresented learners. Collaborative strategies to support underrepresented learners are paramount to student persistence.

Barriers and Challenges to Student Learning

Tinto (1975, 1993) defined academic integration as students' academic performance, level of intellectual development, and perception of having a positive experience in academic settings, while social integration was defined by involvement in extracurricular activities and the presence of positive relationships with peers. Academic leaders, administrators, and faculty play a key role in students' academic and social integration through the choices they make pertaining to course offerings, program content and outcomes, teaching, learning, and assessment strategies. Academic and social integration not only rely on the appropriateness of these factors but also on a strategy that demonstrates awareness and advocacy for all students' needs.

Cultural Competence

The level of readiness for faculty to work with diverse populations has been an issue not often addressed in education. Faculty cannot give what they do not comprehend or understand underrepresented learners' needs. Educator belief systems may contribute to perceptions of a lack of intellectual abilities for culturally or linguistically diverse learners (Fowler & Brown, 2018).

Psychological Safety

Conley (2015) insisted that a developmental trajectory is necessary for learners in higher education to foster academic success in student performance and retention. Lawless (2018) addressed the necessity of emotional labor for faculty and staff serving in higher education as higher education has shifted to the service industry. Emotional labor is effective work which includes making a student feel that they are competent. Communication and cultural competencies and emotional intelligence are skills needed for this working with underrepresented learners.

Adult learners may be experiencing unrecognizable trauma symptomology that appears invisible. Each learner must balance the pursuit of aspirational goals with daily responsibilities creating an invisible juxtaposition that is sometimes insurmountable. A student experience devoid of concern for individual student needs intensifies the learners' difficulties. Gallup-Lumina Foundation (2023, Feb) survey respondents characterized themselves as misunderstood and unsupported in their descriptions of disparate impact and treatment in postsecondary education. One in three students expressed feeling unsafe, psychologically and/or physically. Discrimination was noted to be prevalent in less diverse academic environments, namely private, for-profit schools, and short-term credential programs. Gallup respondents cited feeling ostracized by classroom practices devoid of Black scholarship or worldviews and argued that institutions did not appear to value nor practice inclusion. Contemplations of stop-out were further exacerbated by a lack of confidence that there would be a favorable response from the administration if they alleged discrimination by peers or faculty.

Sense of Belonging

Institutions rely heavily on first-year orientation and retention-focused programming to improve retention. Orientation agendas for first-year aim to build community for the entire campus population and acclimate students to the campus, but specific inclusion strategies for underserved and marginalized students are not a focal point. Campuses may tout inclusive philosophies by catering to some subsets of the populations such as LGBTQIA+ students but a universal dedication to all populations is not present. After the first-term drive to campus acclimation, students do not have specially selected instructors or established class schedules developed to promote student success; they are expected to fend for themselves using the tools introduced in the first-year courses. This eye-opening experience results in a myriad of reactions from learners, ranging from poor academic performance to withdrawal.

National student college completion data for 2022 reveals Black students had a 44% 6-year graduation rate, the lowest of all racial and ethnic groups due to financial and institutional barriers (Causey et al., 2022). A key finding illuminated decreased degree completion among Black students. Qualitative evidence revealed two phenomena fueling Black students' withdrawal: balancing external responsibilities and racial discrimination (Gallup-Lumina Foundation, 2023). The challenge of maintaining a work-life balance while undergoing an educational pursuit lessens the likelihood of degree completion for Black learners. Twenty-two percent of Black students serve as caregivers (15% for adults and 11% parenting children under 18 years of age), and 20% are employed full-time (Lumina Foundation & Gallup, Inc., 2023, Feb).

Technological Literacy

Technology related access and competence correlate to student academic success (Banerjee, 2020). Technological literacy and access to technology are other barriers to success that often go unnoticed. Educators in higher education must consider the gaps in technology access and skills for learners who may be marginalized or underrepresented within their institutions (Banerjee, 2020).

Addressing Academic and Social Needs for Underrepresented Learners

One's ability to connect with the learner and support them academically and socially calls for a repertoire of resources and strategies. Some faculty and staff in higher education are not prepared for this reality and are not meeting the needs of underrepresented learners. Institutional strategic planning fueled informed by student data can be the catalyst for new academic programs for adults, equip the campuses to receive adult learners, and create an inclusive student experience in which marginalized learners can thrive (Tuset, 2022).

Institutional Interventions

Institutional strategy should envision a culture of continuous improvement that permeates all facets of the campus environment. Theoretical organizational mission should become action on display as a dynamic array of resources, skills, and strategies in three areas of focus: advocacy, multiculturalism, and social justice. *Advocacy* could promote a mindfulness to social and financial needs that may place learners at risk. Embodiment of *multiculturalism* would permit a swift response to threats/reports of disparate treatment. Commitment to s*ocial justice* would engrain a spirit of diversity and inclusion in mission, hiring, and curricula.

Bai and Pan (2009) denoted despite there being evidence that special interventions are necessary at the beginning of a student's experiences with higher education, strategies beyond the first year are scant. They suggested that higher education institutions implement audience-specific intervention programs in lieu of general orientation programs for the entire cohort. Conducting smaller sessions during orientation sessions could establish the foundation for inclusion and prompt proactive identification of underrepresented student needs previously unknown or unaddressed.

Faculty Support Strategies

Institutions can create standards that focus on faculty disposition and faculty readiness to work with and support diverse populations in teaching and mentoring roles (Halpern & Aydin, 2020). However, individual contributions from faculty are paramount to student persistence. Faculty, as the front line, must intentionally tailor teaching methods and classroom management practices to engage and support underrepresented learners. Adopting a philosophy of *communication* and mentorship should translate into practice, which can be observed through *modeling* and *mentoring*. Developing students' critical thinking and problem-solving skills will inherently *promote a mindset of growth, individuality, and collaboration* among students. Faculty should model the behaviors desired in students by creating safe spaces that allow students to exhibit individuality and share concerns without fear of reprisal. Providing clear, consistent statements of expectations, grading criteria, and feedback improves students' perceptions of equity.

Educators in higher education must consider the gaps in technology access and skills for learners who may be marginalized or underrepresented within their institutions (Banerjee, 2020).

Conclusion

Successful postsecondary matriculation requires a navigation roadmap of the collegiate environment and a supportive village driven by a genuine desire for continuous improvement aimed at addressing academic and social needs for all learners. Celebrating multiculturalism fosters an environment where students feel free, accepted, and respected. Equity in the educational experience inherently involves awareness, acknowledgment, and celebration of multiculturalism. Mere acceptance is not enough. A heightened awareness of the specific needs of underrepresented learners must be followed with a systemic concerted effort.

Higher education institutions can make a social impact in society through their support of underrepresented learners. The equity theory and Tinto's theory of student integration support the research by highlighting the factors that impact students. Reimaging educational success for underrepresented learners calls for collaboration and partnership in support structures. The layers of collaboration include faculty development to support a diverse population and institutional interventions.

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Contact email: imani.akin@hotmail.com

Tackling the STEM Recruitment & Retention Challenges at a Flagship, Research Institution With an Evidence-Driven, Innovative Hybrid Course

Sheila Tabanli, Rutgers University-New Brunswick, United States

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Abstract
The challenges of recruitment and retention in STEM did not start with the COVID-19 pandemic; however, these challenges still affect the workforce needs of our world. Historically marginalized students in STEM fields are disproportionally affected by these ongoing challenges that further causes diversity & inclusion issues in the workforce. An innovative hybrid course grounded on research from cognitive science and social emotional learning was designed to address these educational challenges at a flagship, large research university in New Jersey, USA. This interdisciplinary course framework is aimed to address (1) the research-to-practice gap between cognitive science research and classroom practices, (2) the perception gap between the instructors and students (expert-to-novice perception gap), (3) the conceptual and procedural gaps in students' learning and studying. Furthermore, authentically designed instructional resources and assessments address students' math mindsets and anxieties by fostering students' sense of belonging in a discipline that disproportionally affects marginalized groups. We hope our work will serve as a driving force to promote interdisciplinary discourse and improved awareness in an area that needs multifaceted approaches to a core issue of our time, namely the ongoing STEM recruitment and retention challenges.

Keywords: STEM Education, Recruitment and Retention, Interdisciplinary Curriculum Design, Cognitive Science, Social Emotional Learning

Introduction

The discipline of Mathematics is considered a gateway to STEM majors, however, due to several factors negatively contributing to students' perceptions, studying, and performances in introductory undergraduate math courses it is becoming a gatekeeper to STEM. This outcome negatively impacts the needs of our technology-driven society in the forms of STEM recruitment, retention, and workforce challenges. In the context of our paper, we define research to practice (R2P) gap as the research on human learning not being integrated into the math classrooms. In an era where students are digital natives and due to the dual nature of our complex attention system which makes us capable of focusing but open to distractions (Lang, 2020) classrooms with the traditional, teacher-centered instructional practices are not meeting the needs of these highly interactive learners. The curse of knowledge (Newton, 1990) states that experts do not tend to see the challenges within their discipline from the novice's perspective. In other words, once a novice levels up to an expert status this tends to contaminate the ability of the expert to see the same facts from the novice's less informed perspective. In some literature, this is referred to as the hindsight bias (Bernstein et al., 2004), the curse of expertise (Hinds, 1999), or the knew-it-all-along effect (Fischhoff, 1977). The instructors' expert attitudes may introduce an additional barrier to students' math learning in the form of expert-to-novice perspective gap. Furthermore, the widely accepted negative social norms such as the myth of a math brain combined with a recently acquired pandemic learning gap adds more gaps to the existing math achievement gap in the form of conceptual and procedural gaps. The discipline of mathematics demands conceptual mastery and procedural fluency for effective math learning. Redmond-Sanogo et al. (2016) suggests that obstacles keeping students from achieving STEM degrees may include uninspiring introductory courses, lack of adequate preparation in the content of mathematics, and academically or culturally uninviting environment to underrepresented populations.

Packer (2022) asserted that several professional organizations such as MAA, NSF, NCTM have repeatedly called for fundamental changes for students' mathematical experiences. These changes are aimed to offer students deep engagement with mathematical ideas and productive struggle in solving novel problems, learning goals and trajectories informed by mathematics education research and not simply a reproduction of instructors' experiences as students, and a focus on coherence across lessons and units (and courses) so students see how key "big ideas" extend across topics. Our interpretation of the second point in this assertion is, an instructor such as the author of this paper who attended undergraduate studies in a different country in a different decade needs to be mindful of the current, relevant mathematics education research to improve students' learning experiences. The alternative to this approach is to rely on the way the content was taught in her native country in the late 1900s.

Covid-19 pandemic brought additional challenges to everyday life including the education field. (Sparks, 2022) stated that, after the pandemic, math achievement fell across every percentile, even for the highest performers, the latest graduating class of 2022 had historically low scores on college placement tests. One robust way to combat these challenges is to bring evidence-based teaching practices to our classrooms. Cognitive science research provides many insights into potential ways to improve teaching and learning in schools, but those insights infrequently make their way into classrooms (The National Academies of Sciences, Engineering, and Medicine, 2018). Students who know about the different kinds of strategies for learning, thinking, and problem solving will be more likely to use them (Pintrich, 2002).

In this paper, we describe an innovative curriculum with particular emphasis on the cognitive science principles and social emotional learning techniques that facilitate students' math learning. The course design itself is grounded on Fink's Taxonomy of Significant Learning (Fink, 2003) that incorporates cognitive and affective domains of learning. The curriculum is intentionally designed in a way to include a wide range of evidence-based practices and frequent no- to low-stakes assessments to further address widely accepted negative social norms and misconceptions about math in general. This innovative course development sought to (1) cultivate a stimulating first-year student experience and classroom culture grounded on the empirical and theoretical knowledge from the science of learning, (2) offer an inviting learning environment with frequent assessments nurturing the sense of belonging through social emotional learning principles.

Development of Pilot Course

The initial course development was started by the author during the earlier stages of the pandemic after observing ineffective study techniques in her Introductory Calculus course. Historically, the introductory undergraduate calculus courses have high DFW rates at several higher ed institutions. After meetings with the university leadership at the school and department level, the course was initially offered as a pilot program in fully synchronous 2-credit virtual format during Winter 2022 semester over a three-week period. The projected outcome of our curriculum design efforts is to improve first-year student learning experiences such as students' sense of belonging and math learning outcomes.

The curriculum has three modules designed in Canvas Learning Management System as seen in Figure 1 below. The first module is aimed to improve the cognitive domain, the second module is targeted as an "intervention" for the affective domain. The third module is a combination of both cognitive and the affective domains by reflecting and implementing the strategies learned in the previous two domains.

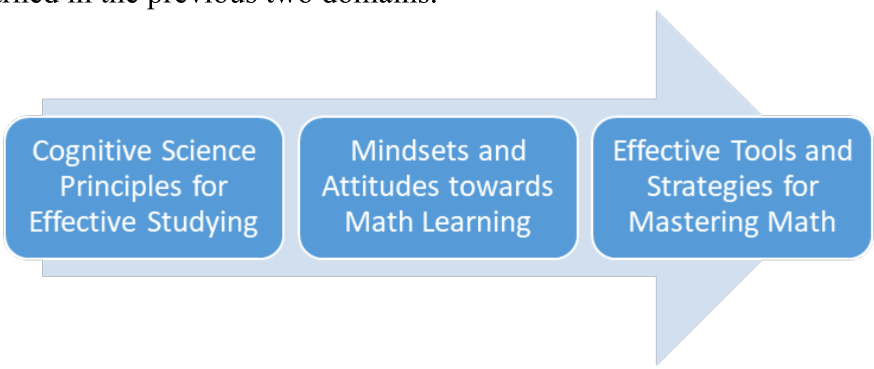

Figure 1: The Pilot Course Curriculum

Intentionally Addressing the Gaps in Students' Math Learning and Performance by using Engaging, Student-Relevant Assignments

In the pilot course curriculum, every module has a core assignment that offers some creativity and flexibility for students. For example, the first module's core assignment is for students to critically read (Dunlosky et al., 2013) and learn about the low, moderate, and high utility learning techniques as demonstrated by several experiments and research articles. Students are invited to use metacognition to reflect on their current learning strategies, then refer to the article to find out which of their current strategies are considered low utility, which means low impactful. (Dunlosky et al., 2013) explains each of the learning technique by describing the content and the rationale behind why it is classified as a low/moderate/high utility strategy, providing empirical evidence for different student characteristics, and the issues in implementation for educational setting concluded with an overall assessment of the technique. The students are tasked to become familiar with all techniques, however, they are given flexibility to pick only one technique to teach it via a video recording. The instructor provides a template explaining the distributed practice technique for students to see the expected outcome for this core assignment. Table 1 below includes the description of the learning techniques as reprinted from (Dunlosky et al., 2013).

Table 1. Learning Techniques

Technique	Description
1. Elaborative interrogation	Generating an explanation for why an explicitly stated fact or concept is true
2. Self-explanation	Explaining how new information is related to known information, or explaining steps taken during problem solving
3. Summarization	Writing summaries (of various lengths) of to-be-learned texts
4. Highlighting/underlining	Marking potentially important portions of to-be-learned materials while reading
5. Keyword mnemonic	Using keywords and mental imagery to associate verbal materials
6. Imagery for text	Attempting to form mental images of text materials while reading or listening
7. Rereading	Restudying text material again after an initial reading
8. Practice testing	Self-testing or taking practice tests over to-be-learned material
9. Distributed practice	Implementing a schedule of practice that spreads out study activities over time
10. Interleaved practice	Implementing a schedule of practice that mixes different kinds of problems, or a schedule of study that mixes different kinds of material, within a single study session

Note. Reprinted from “Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology” by Dunlosky et al., 2013, *Psychol Sci Public Interest. Jan;14(1):*4-58.

Students are invited to use the evidence-based learning strategy, generation effect, to create knowledge based on their readings. (Kelley et al., 2019) demonstrated that the generation effect, which occurs when individuals remember materials, they have generated better than materials by others, along with retrieval practice improved student exam performance. For this core assignment, students are tasked to create a short video teaching their chosen technique over a document (such as a Microsoft PowerPoint file) they also create in order to teach it to an audience. Students can either choose a moderate or high utility learning technique based on the reading. In addition to teaching this evidence-based technique, students are expected to include an attainable weekly study schedule and how they plan to incorporate this one technique in their studies. The authentically created videos by students also improve students’ presentation and technology skills. Students are given opportunities to implement the two moderate-utility techniques, elaborative interrogation and the self-explanation, in their assignment submissions. Students are expected to critically respond to the why and how questions of elaborative interrogation and explain the technique in their own words.

To understand students’ attitudes towards the discipline of mathematics, the core assignment of the second module is a case study of the research demonstrated in (Code et al., 2006). In order to support mathematical novices’ transition to more expert-like perceptions of mathematics we need to first characterize students’ perceptions of mathematics, then help students to develop a productive disposition for mathematics. (Code et al., 2006) proposed to address this need by the meticulous creation and verification of the MAPS (The Mathematics Attitudes and Perceptions Survey). In this core assignment, students are tasked to take this survey then rate themselves based on the provided rubric (Code et al., 2006). The outcome of the survey reveals how likely the students' attitudes to experts' attitudes in the field of mathematics are. For example: a student who scores low on the growth mindset sub-category of MAPS will benefit from taking the mindset intervention (Dweck, 2008) later in the module. A follow-up discussion board was created in CANVAS by mapping each of the sub-categories of the MAPS to students where students utilized the generation effect to create a video of their further analysis of the sub-scale. In order to empower students and improve their sense of belonging, students are also tasked to relate this sub-category to their life experiences in math classes. For example, after going through growth mindset induction exercise (Dweck, 2008) in this course, they share how would they react to the previous experience differently. This assignment enables students to implement compare-contrast methodology for fixed and growth mindset personalities. The action verbs of compare-contrast are considered a moderate-high level of thinking (Blooms, 1956). By addressing students' (mis)perceptions of their math abilities and clarifying the myth of a math brain through assignments we aim to improve students' sense of belonging and address their social-emotional learning needs in a safe learning environment.

The third module combines both affective domain and the cognitive domain principles that are learned in the first two modules. The core assignment for this module is to take a math test by using evidence-based strategies, then to receive grading feedback from the instructor and to use metacognitive skills to re-attempt the problems in order to fix the previous mistakes. The expected outcome of this assignment is for students are threefold: (1) to study by using the moderate-high utility cognitive-science based learning techniques (Dunlosky et al., 2013), (2) to approach math problems with a growth mindset and a better perception towards their math abilities (Dweck, 2008; Code et al., 2006), (3) to incorporate the principles of metacognitive thinking into mathematical practices. The overall benefit of this threefold implementation cycle is to reduce the conceptual and procedural gaps in students' learning and studying.

Future Directions and Conclusion

Students are encouraged to use evidence-based strategies such as generation effect in completing the assignments. Creating a repository of student products would help the future students to view sample assignments to guide them in the process. This is a feasible task for the author since as a part of the end-of-semester celebratory event students are asked if they give permission for their names and work to be shared with other students for educational purposes. The author can easily select the sample work for the students who give such permissions.

Although the core assignment for the first module requires students to identify the effective study techniques, a follow up assignment would enable distributed practice and retrieval practice opportunities for students to combat their forgetting curve. A viable alternative is to have students pick a different moderate-high utility learning technique to implement in the following weeks of the semester based on the already submitted study schedule. This could be facilitated as a discussion board activity. This way students are encouraged to share their best practices and what worked or did not work for them to make their experiences more relatable to their peers, in order to foster a community of learners. Furthermore, this will improve individual accountability.

Case-based learning has a strong history of effective application in medical, law, and business schools, and is increasingly used within undergraduate education (Herreid, 1994).

Williams (2005) describes the several advantages of case-based learning such as improving student motivation to learn, encouraging self-reflection, fostering scientific inquiry, and integrating knowledge and practice. In addition to the MAPS survey result discussion and students representing themselves as a character in a case study, due to the aforementioned advantages of case-based learning the author plans to construct more case studies for students to discuss in groups to enhance active participation, teamworking, and presentation skills which are skills desired by the employers.

The alternative to incorporating evidence-based strategies to classrooms is not to incorporate these techniques and not to teach them to the students. Although domain experts may have a perceptive of novices knowing how to learn in their domains, many novices (students) may arrive at post-secondary institutions without actually knowing how to learn effectively. This may be due to the fact that students may not have ever learned it before. Our goal in this paper is to provide a curriculum framework, similar to the concept of a co-req, to be paired up with STEM courses for first-year undergraduate classes.

Recommendations

To bridge research to practice; the author completed an extensive literature review, developed an innovative course curriculum to create an authentic Canvas course website with three modules. In this novel course, information and assignments were presented in diverse formats such as videos, PlayPostIt quizzes, discussion boards, peer reviews of presentations, student-generated videos, math problem solving sessions. In a higher educational setting, bringing the research on human learning to the practice of human teaching is a much-needed instructional strategy specifically in the discipline of mathematics where U.S. students underperform their peers on international assessments such as Trends in International Mathematics and Science Study (Mullis et al., 2020). We conclude this instructional paper with key recommendations as follows.

In a discipline where students universally struggle with numerous challenges that creates culturally acceptable social norms such as some people are born with a math brain, boys are better than the girls in math, it is crucial for experts in their respective disciplines of mathematics education, pure math, and applied math to collaborate in order to offer improved learning experiences to students. The author asserts that intentionally creating such a strong collaboration coupled with empathy-filled classrooms to novices' perceptions of math, will create research-driven, student-centered practices for all. By promoting interdisciplinary discourse and innovative curriculum design ideas, we can create multifaceted solutions to an evolving problem, namely STEM recruitment and retention. This proposed initiative has the potential to address the persistent STEM recruitment and retention challenges, as well as the factors that disproportionally affect marginalized groups in STEM.

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The Survey on Online Learning for Secondary School Students During the COVID-19 Pandemic

Qi Zhu, University of Houston–Victoria, United States
Joyce Zhu, Awty International School, United States

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Abstract
COVID-19 has forced nearly all students including K-12 into online education during pandemic time. This study explores how students at the secondary school reacted to the full-time online learning during the COVID-19 pandemic. A survey has been carried out in Fort Bend and nearby counties, Texas to compare students' online learning conditions, experiences, and expectations. Some implications were made to advise the related policy makers and schools on improving for the future online learning into the secondary school students.

Keywords: Online Learning, Secondary School, COVID-19 Pandemic

Introduction

Online instructional education has grown rapidly in the past decade with the advantages to learn anytime and anywhere (Norman, 2016). However, there has been a long-time debate on whether online learning is a good format for K-12 students (Zheng, Lin, and Kwon 2020). Because of COVID-19 Pandemic, online learning was adopted by all stages of education to provide students with continuous education (Hong, et. al. 2021). This survey study explores how students in secondary school reacted to the mandatory full-time online learning during the COVID-19 pandemic in Fort Bend and nearby counties, Texas.

Literature Review

Online learning has the benefit of various forms of multimedia such as texts, audios, and videos (Clark 2015), more flexible self-responsible learning pace, and lower costs (Sun and Chen, 2016). Of all students enrolled in higher education before 2020, 33.5% enrolled in some form of distance education/online learning courses (Education Data, 2021).

In US, K-12 schools' curriculum entirely online are usually Charter schools offering alternative formats for students (Anthony, 2019; Barbour, 2019), and before COVID-19 the online education in the US was mainly asynchronous in nature or hybrid, with a combination of online and face to face format (Molnar et al., 2021). Fully online or synchronous education for K-12 students is low participation in Charter schools and advanced courses offered in public schools (Arnesen et al, 2019). However, enrollment in US online schools is growing, 30.6% of Charter schools offers an entire course online, versus 28.5% of traditional public schools (NCES data, 2021).

Compared to online learning, numerous studies (Major, 2014) show that traditional face to face learning provides real and meaningful interactions among students and teachers. There are concerns and complaints on online instruction including: poor course content, little collaborative learning, inconsistent instruction, no access to teachers, poor instructor preparation, and technical or network problems (Kumari, Hemalatha, and Ali 2020; Raheim, 2020).

Starting from March 2020, almost all students in the United States are forced to transit from face-to-face classes to online learning because of the coronavirus disease (COVID-19) pandemic. However, some challenges are faced by the students. Hong et al. (2021) and Salzano et al. (2021) stated that online learning is ineffective because of unsuitable internet facilities, teachers' inability to implement online learning, and the lack of cooperation given by parents. Basar et al. (2021) found that online learning outcomes cannot be met since of high cost to purchase suitable tools. Studies by Muhammad and Kainat (2020) and De Leon (2022) found that internet access problems, a lack of interaction between teachers and students, and a lack of technological facilities have the important effect on the efficacy of online learning.

In this paper, we conducted a survey focused on secondary school students to explore their reaction to full-time online learning during this pandemic time.

Survey Design

The demand for online learning has kept on rising because of its flexible forms, lower costs, easily accessibility, and self-adjustable pace (Sun and Chen, 2016). While online learning can be a highly effective education method, it is less effective or efficient for secondary school students (Jung and Lee, 2018).

In (Agung et. al 2020, Yan et. al. 2021), some issues are identified for online learning during Pandemic COVID-19, including internet connection, IT equipment, limited collaborative learning opportunities, reduced learning motivation and increased learning burdens. Most of the papers are focused on higher education, we hope to conduct a survey mainly focusing on the secondary school students to find out their reactions to full-time online learning. The survey results may help educational authorities and institutions to better understand students' difficulties and potentially improve their online learning in the future.

The survey is carried out and most of feedback is collected in Fort Bend ISD, a school district system in Texas based in the city of Sugar Land. The district received an accountability rating of B for 2021-2022 school year, and the district ethnic distribution is 27.5% African American, 27.3% Asian, 26.4% Hispanic, 14.8% White and 4% Others. Like most schools in US, Fort Bend has implemented the online learning program starting from Mar. 2020, then started to offer both face-to-face and online instructional delivery to the students from Oct 2020, and finally discontinued the online program in Dec 2021. Students should have between 7 months to 18 months experience of mandatory online learning depending on the learning method they select.

The survey and this study aimed to examine online learning for feedback from the secondary school students and provide some potential actions to improve the future online education. Formally, there are three research questions for students during online learning compared to face-to-face education:

1. What learning conditions were experienced by students?
2. What benefits and obstacles were received by the students?
3. What expectations do students have for future online learning education?

Survey Results

The survey was conducted from September 2022 to December 2022, targeting at the secondary school students, grade 9 to grade 12. A total of 180 students completed the survey, the number of students and percentage in different school grades are shown in Figure 1.

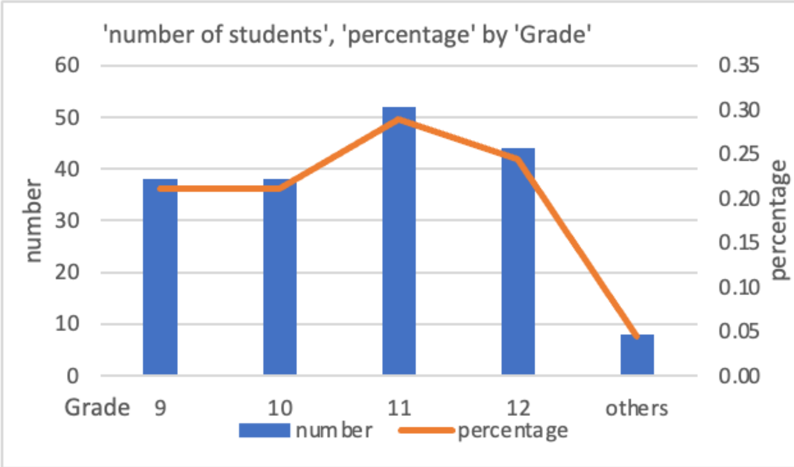

Figure 1: The number of students in each grade

Among them, about 74 are female (41.1%), 102 are male (56.7%), and 4 (2.2%) declined to answer this question.

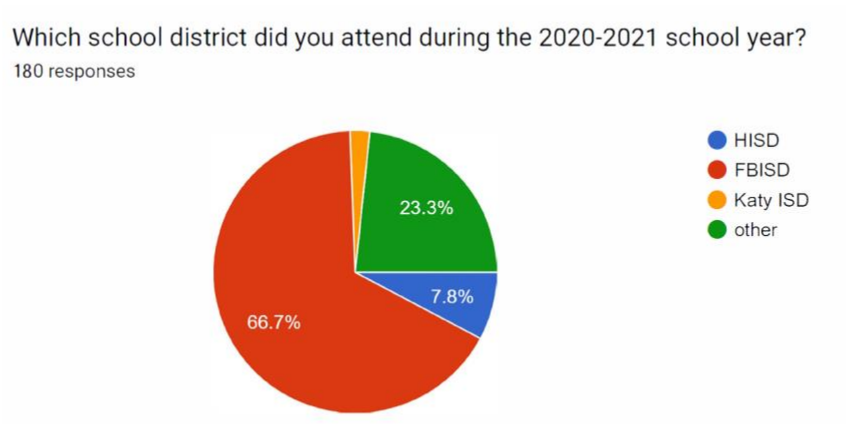

Figure 2: The percentage of students in school district

Also, we asked which school district did the student attend during the academic year 2020-2021? The response is in Figure 2, 66.7% students are in Fort Bend ISD, 7.8% from Houston ISD, 2.2% from Katy ISD, and the rest is from other ISD.

Learning Methodology and Tools

In this subsection, we first show the survey results from the teachers' teaching methods, teachers' teaching tools, and students' learning platform. The responder could select one or more answers from each question.

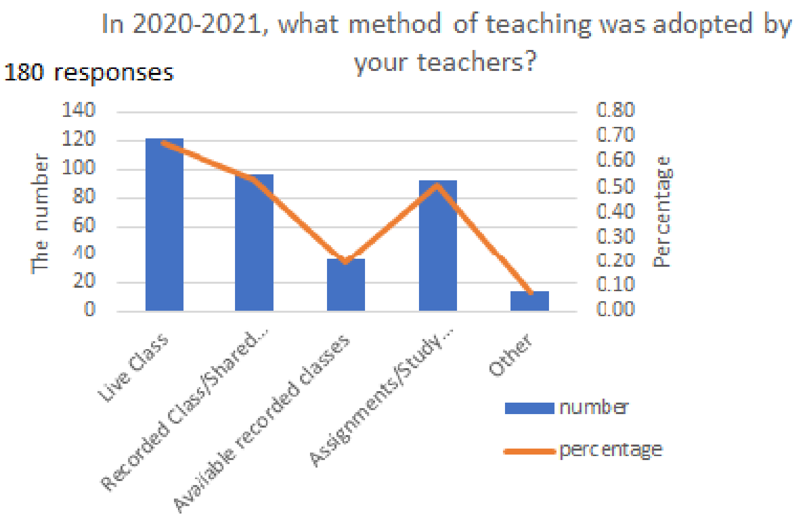

Figure 3: The teaching method

In the digital age, the use of information and communications technology during online learning allows students to learn and apply the skills that they need (Ratheeswari, 2018). In Figure 3, when moving classes from face-to-face to online, around 68% teachers selected live/synchronous classes, which provided students in a similar way to face-to-face learning. Also, synchronous classes would enhance direct interaction for online learning, "students don't get to see the professor or classmates face to face" gives negative experiences for online students (Johnson, 2022). In addition, more than half of the teachers also used recorded class/shared video and asynchronous assignments/study materials as well.

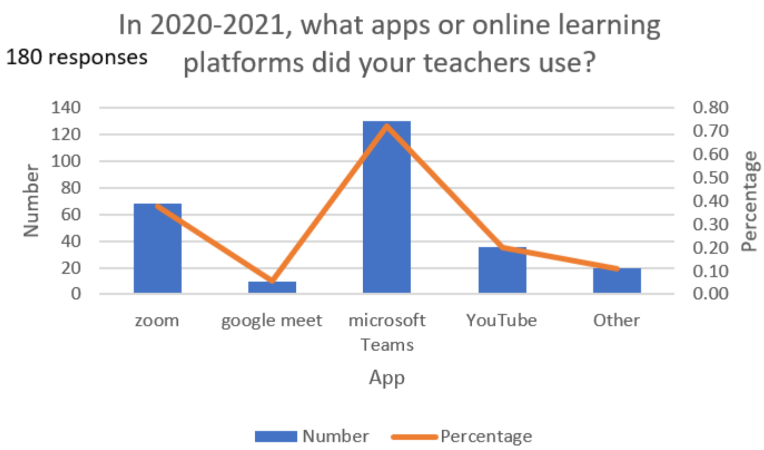

Figure 4: The teaching platform

In Figure 4, it showed that about 72% of teachers use Microsoft Teams and 38% use zoom, mostly teachers use Microsoft Teams for synchronized class, but using Zoom for office hours or teacher-parent conference, administrated by the ISD IT department. YouTube is also used for teaching, evidence showed that the young generation possess the greatest interests in games and videos for their online education (Basar, 2021).

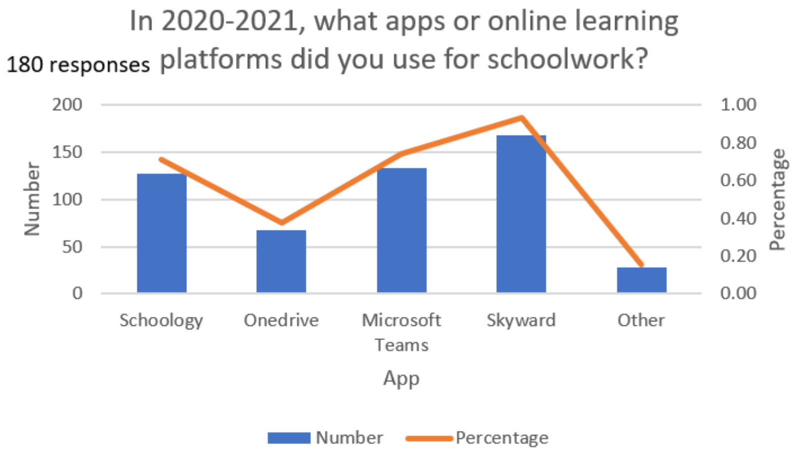

Figure 5: The learning platform

Finally in Figure 5, the applications that students used for online learning are surveyed: Schoology is used for instructional delivery, communication, and progress monitoring; Onedrive is used for cloud document access; skyward is used for class scheduling, gradebook, and the attendance record; and Microsoft Teams is used for synchronous classes.

Learning Environment

According to Wildana et al. (2020), the availability of the internet, the cost of machine or network, and the new modern technologies are the top reasons to affect the mass-adoption of online learning. In the 180 responses of our survey, 81.1% of respondents said they use devices they have already owned, 6.7% purchased new devices, and 12.2% borrowed devices from school.

In figure 6, the top three factors are network connectivity, hardware devices, and electricity. Also, around 31% have no problem during their learning.

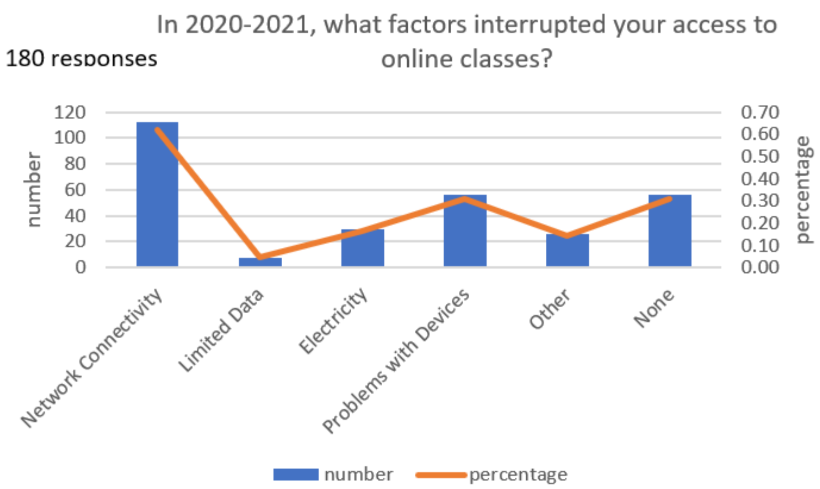

Figure 6: The factors interrupted online classes.

Parental engagement has been shown to be correlated with student performance in traditional face-to-face courses. As a result, parental help has the potential to increase student performance in online courses. However, since our responders are mainly secondary school students, age 14 to 18, 43.3% of respondents said that parents have only a little involvement in online learning, then 26.7%, 14.4%, 13.3%, and 2.2% increasing to heavy involvement.

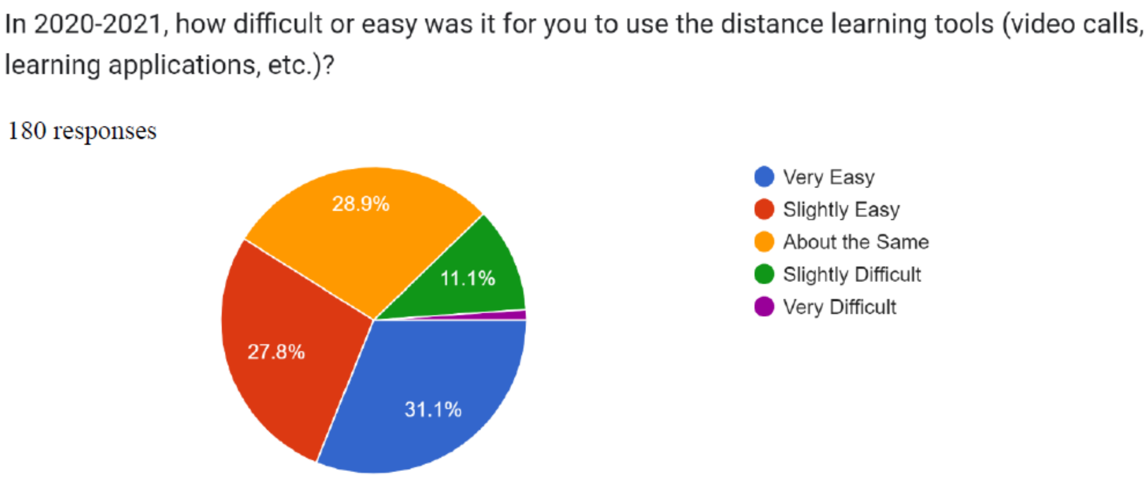

Figure 7: The learning tool difficulty

During pandemic, when school moved the students' learning from face-to-face to online environment, in our survey results in Figure 7, only 1.1% thought it is very difficult for the new modern technologies, and only 11.1% thought it is a slightly difficulty, 28.9% thought it is the same as face-to-face environment. 27.8% and 31.1% thought it is slightly easy and very easy. So at least in our survey, new technologies and tools are not a factor to affect online learning for high-school students.

Learning Benefits and Obstacles

Even though online learning is the only suitable method of learning in pandemic, we wonder that compared to conventional classroom learning, what percentage of students felt they benefitted from online learning environment, and what they really enjoy or dislike. In 2020-2021 online learning, the questions we asked are following:

1. Do you think it was easier to obtain teaching materials delivered by the teacher?
2. Do you spend more time and effort learning online when compared to face-to-face classes?
3. Do you think the material presented by the teacher in class is easier when studying online compared to face-to-face classes?
4. Could you communicate smoothly with the teacher/lecturer during online learning when compared to face-to-face classes?
5. Were you more eager to participate in class compared to face-to-face classes?
6. Did you always get a quick response from the teacher when compared to face-to-face classes?
7. Did you feel that you had the necessary support and resources needed to study effectively from home?
8. Did you have a better bond with your friends and classmates online compared to face-to-face learning?
9. Did you feel more comfortable taking online exams or tests compared to face to face?
10. Compared to face-to-face, the workload was heavier throughout the school year?

QUESTIONS	STROGNLY AGREE	AGREE	ABOUT THE SAME	DISAGREE	STRONGLY DISAGREE
Q1	11.1%	24.4%	28.9%	27.8%	7.8%
Q2	6.7%	17.8%	24.4%	36.7%	14.4%
Q3	6.7%	12.2%	23.3%	38.9%	18.9%
Q4	2.2%	5.6%	21.3%	51.7%	19.1%
Q5	1.1%	6.7%	18%	41.6%	32.6%
Q6	1.1%	6.8%	46.6%	34.1%	11.4%
Q7	5.7%	31.8%	36.4%	19.3%	6.8%
Q8	1.1%	4.5%	5.7%	36.4%	52.3%
Q9	13.6%	22.7%	45.5%	15.9%	2.3%
Q10	2.3%	3.4%	46.6%	40.9%	6.8%

Table 1: Survey Results for Online vs. Face-to-Face

All survey results are given in Table 1. In Q1, almost the same percentage 35.6% students thought it is harder vs. 35.5% thought it is easier to get the online teaching materials. From Q2, 75.5% of students didn't think they spent more time learning on-line. Also 73.9% thought that they have enough support or resources to study for online environment (Q7). In addition, more students 36.3% of students like online exams compared to 18.2% who dislikes in Q9. Finally, in Q10, only 5.7% thought the workload in online learning was heavier than face-to-face learning.

However, around 57.8% of students thought online learning was harder in Q3, also, around 70.8% of students thought it was harder to communicate with teacher (Q4), and 45.5% of students didn't get a quick response from the teachers (Q6). In addition, 88.7% missed face-to-face classmate interaction or bonding in Q8, and 74.2% of students preferred face-to-face mode in learning in Q5.

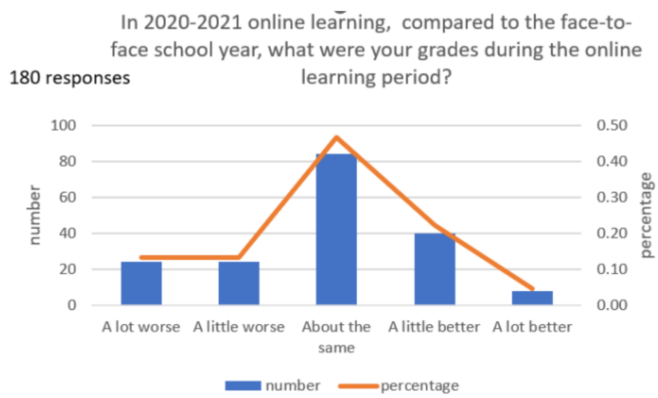

Figure 8: The grade for online vs. face-to-face

We also asked what students' grades for online learning were compared to face-to-face classes in Figure 8, about 26% students thought it is worse than face-to-face, at the same time, 26% students thought it is better than face-to-face, the remaining 48% thought it is the same.

At last, we have two open questions without answer:

1. Which course or subject did you think was the most difficult to learn in an online environment in 2020-2021?
2. In 2020-2021, what did you miss the most about physically attending classes?

The top 3 answers for Q1 are Math (38), Science (34), and English or ELA (28). It is harder to learn Math and ELA online since it can be hard to learn complex topics without a teacher to explain things directly and hear questions other students ask. Science is selected since it is an experimental class by operating hands-on labs, which turns out very hard to do labs online. For Q2, almost 95% of 176 responses mentioned friends/classmates/teacher/peers, which has been identified as the biggest challenge for online education (Johnson, 2022). Also, there are a few answers such as school, classroom, organization, etc. Increased isolation impacted the mental health of children as it did adults, experts said. Negative emotions such as frustration, anxiety, depression, and boredom are companied with the students (Naff, 2022, Browne, et. al, 2021). In early 2021, emergency department visits for suspected suicide attempts were 51% higher for adolescent girls nationwide compared to the same period in early 2019, according to (Yard et al., 2021).

Suggestions for Future Online Learning

In conclusion, when we talk about the online learning benefits and obstacles, most students recognized that online learning is more convenient, learning anytime and anywhere, most of them do not have difficulty in using tool, finding materials, and taking exam. However, the main obstacle in online learning is lacking communication with classmates and slow or absent responses from teachers (Yates et. al. 2020), also, most students thought online learning is harder. Thus, high-school students need further guidance to help them better direct their learning efforts.

As shown from the survey results, improving the delivery of online learning not only requires the efforts of students, but also depends on the actions of policy makers, teachers, and parents.

- Educational authorities and schools should always provide a thorough guide and technical support for students who have technical issues in online learning.
- Group learning and peer interaction are important for secondary school students. The delivery of online learning should be carefully designed to provide more communication with each other and engage in collaboration learning.
- Special options should be supplied to school students, providing them with paper-based materials such as exam papers, so they prefer to take paper-based examinations.
- Administrators and educational leaders should also provide licensed mental health professionals for the students to handle mental issues for long-time online learning.

The above findings are limited to the survey we have done for online learning during the COVID-19 pandemic. The population may not be representative as participants are all from a single city. Also, the quality of online learning platforms, teaching contents, and pedagogy could be unique or special from others.

Conclusions

Online instruction is increasing very fast recently, in 2020, COVID-19 has forced nearly all global students, including the secondary students to online instruction during pandemic time for more than one year. However, we must recognize that the objective of online learning during COVID-19 was not to reconstruct an environment that provided a stable or better education, but an environment that provided immediate virtual access to most students during the crisis.

In this paper, a survey has been carried out in Fort Bend and nearby counties, Texas to compare students' online learning conditions, experiences, and expectations with the traditional face-to-face learning. Some implications were made to advise the related policy makers and schools on improving for the future online learning for the secondary school students.

Finally, there are many negative impacts of online learning during pandemic time, especially mental health issues. Administrators and educational leaders need to make decisions about how to best offer support for online education in the future.

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Naka Ward, Nagoya, Aichi
Japan 460-0008
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