Surviving Distance Learning Calculus: Students' Perspective, Practices, Experience and Performance on a Modular Instruction Class

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Abstract
The absence of in-person classes due to COVID-19 compelled the teacher-researcher to deviate from the traditional face-to face class and lecture instruction delivery. This cycle 2 of an action research study using the Plan-Do-Study-Act (PDSA) model determined the students' perspective, practices, and performance on a fully modular calculus class. Survey questionnaires, reflective journals, and focus group discussion were used for the qualitative part while pretest and posttest scores were used to assess calculus performance using a two-tailed paired t-test at $\alpha=0.05$. Descriptive and thematic analyses revealed that students viewed modules as printed materials which cover everything and modular instruction as entailing a lot of reading and self-study. Students' practices to survive the modular instruction included reading of the modules several times a week, engaging in group studies, watching You Tube videos, and asking questions to the teacher. Using Jamovi 2.3.13, results revealed that the participants' calculus performance increased significantly $(p < 0.001, d=1.89)$ which is largely attributed to the use of the self-learning modules. Modular instruction appears to be a viable mode for calculus agency during remote learning.

Keywords: Distance Learning, Modular Instruction, Self-Learning Modules, Calculus Agency, Surviving Calculus

Introduction

Physical learning disruption caused by the global health pandemic due to COVID 19 posed formidable challenges to educators. The predicament is more stimulating to teachers of domains requiring knowledge of both declarative-propositional (knowledge) and procedural (skill) like mathematics. It is expected to be even more demanding for teachers and learners of calculus, because concepts are abstract and complicated (Zachariades et al., 2007).

The choice of calculus instruction delivery amidst the pandemic considering inadequate online learning gadgets and internet connectivity issues in a state university serves as the subject of this paper. How does one provide an effective calculus instruction during remote learning with the aforementioned considerations? A completely modular form of instruction seems to be a viable option for the teacher-researcher and through action research the students' perspective, practices, experiences and performance were determined.

Why Action Research. Elliot (1991) as cited by Young et al. (2010) defined actions research (AR) as a process in which teachers collaborate with peers to jointly evaluate their practice; raise awareness of their personal theory; express a shared conception of values; honing new strategies so that practice and educational values they espouse are consistent; ensure recording of their work in a manner which can be understood by their peers and make them readily available; and thus develop a shared theory of teaching by research practice. AR enables researchers to develop a systematic, inquiring approach toward their own practices orienting towards effecting positive change in this practice (Hine, 2013; Holter & Frabutt, 2012). The belief that one can know through doing, exemplified by pragmatists, reinforces these practices of action researchers (Brydon-Miller et al., 2003).

The adoption of an action research design to explore the perspective, practices, experiences and performance of students in a fully modular instruction calculus class finds underpinnings in the aforementioned.

On Distance Learning. Students may be separated geographically from their campus, teachers, and institution services through distance learning (Lentel, 2012). Many researchers have applied distance education and distance learning interchangeably to a variety of programs, audience, and media (Sherry, 1995). It can take different forms and be supported by various systems and applications (Zarzycka et al., 2021) with the common feature of delivery being remote (Means et al., 2010). Distance education describes education delivered to distant or remote locations via print, audio, video (live or pre-recorded) and/or computer technologies, including both synchronous and asynchronous instruction (Cain, et al. 2007 as cited by Owens, et al. 2009).

Modular Instruction. As early as 1972, Goldschmid & Goldschmid have explained that a modular instruction is one which either partly or entirely uses a module which is a self-contained, independent unit of a planned series of learning activities designed to help the students accomplish certain well-defined objectives. The main objective of the modules is to provide resources to instructors that will allow them to transform their classrooms into active, student-centered learning environment (Sadiq & Zamir, 2014). Rakova et al. (2018) considered a module to be a set of learning opportunities which are organized around a well-defined topic which contains elements of instruction, specific objectives, learning activities and self-assessment and evaluation using criteria-referenced measurement. To have control over their learning while accepting greater responsibility for learning as well (Dejene &

Chen, 2019) has been greatly encouraged by the modular approach which is an alternative instructional design that uses developed instructional materials which are based on the needs of the students (Nardo, 2017).

Calculus Agency. Calculus has a critical role and varied goals across different contexts (Biza et al., 2022) Calculus courses are considered to be a vital gate keeper in various academic and professional paths (Bressoud et al., Thompson & Harel, 2021) and calculus is widely known as a critical stage in many transition processes including transition from secondary mathematics to tertiary mathematics, transition within and across university courses, or more importantly the transition from university to the workplace (Hocmuth et al., 2021). Though the importance of calculus is widely accepted, ample evidence shows that students around the world struggle in their calculus courses and the rates of failure in these courses are relatively high (Artigue et al., 2007; Faulkner et al., 2019). As many components of calculus depend on reasoning with visual representation (Sorby et al., 2013) it would really be a tremendous challenge to teach calculus in the absence of a face-to-face class and trying to provide calculus instruction in online distance learning via a fully modular instruction mode while taking into consideration mobile learning gadget limitations, signal and internet connectivity problems.

Methodology

The study involving 40 BSCS students, employed an action research design and adopted the Plan-Do-Study-Act (PDSA) model. What is presented hereon is the result of Cycle 2 of the PDSA.

Design and Development of Modules. With the aid of available offline and online resources and aptly guided by an approved Math 2 (Calculus) syllabus, 15 self-learning modules (SLM) for differential calculus were developed. The SLM provided lessons on limits, continuity, the derivatives, rules on differentiation, implicit differentiation, higher-order derivatives, and problem solving involving the derivatives including related rates, finding extrema, and optimization. Each module contains an introduction of the topic lesson and a brief discussion of requisite concepts, objectives, instruction to users/learners, pretest (and answer to pretest), lesson proper, activity, posttest (and answer to posttest), and self-assessment (Fig 1). The alpha version was given to selected sections of education and computer engineering students for student validation and for cycle 1 of the action research study. Errors such as typographical ones were reported by students and were corrected accordingly; text boxes with brief explanations in the vernacular (Tagalog) were also included. These measures were undertaken to allay confusion among learners, make the SLM more learners' friendly and hopefully address their reading literacy problems.

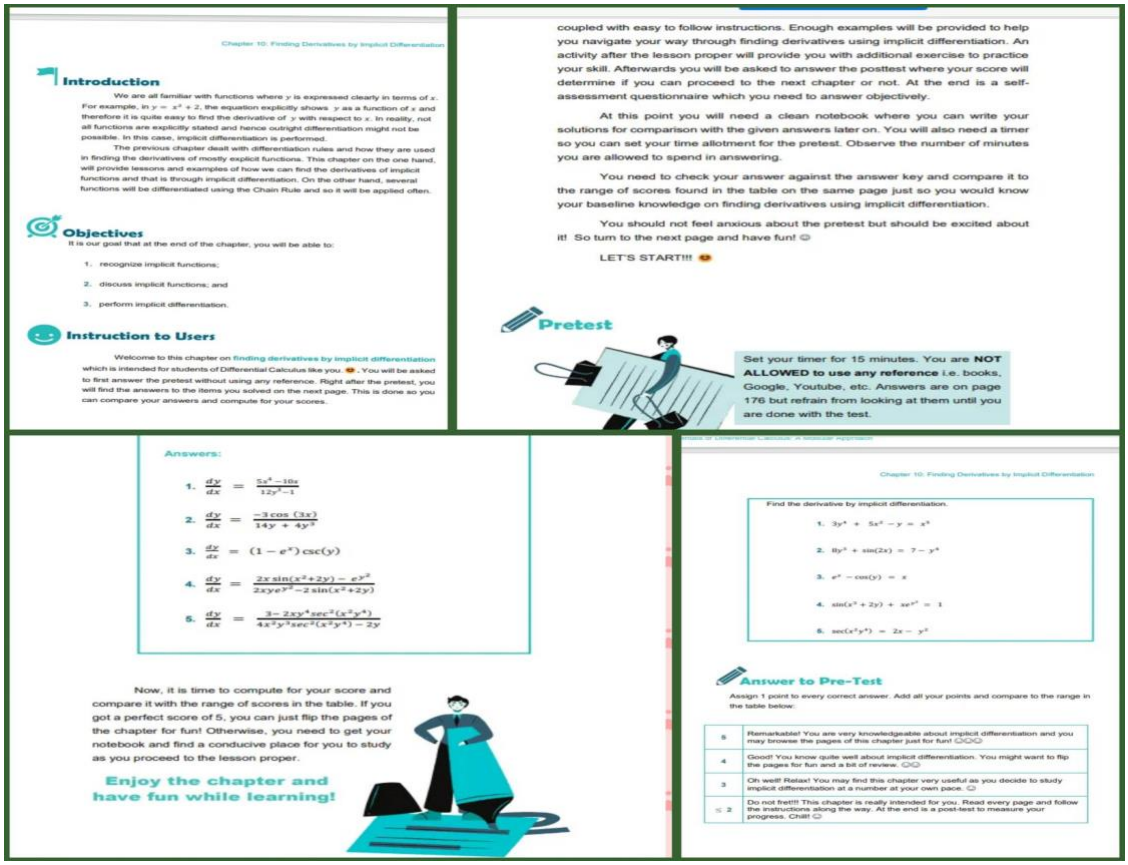

Figure 1. Different parts of the topic module

Implementation of the Modules. The self-learning modules were uploaded in the Google Classroom at the start of the semester. The students were instructed to read the SLM during asynchronous class and have a group meet whenever necessary. During synchronous class, students were allowed to raise questions, concerns, and problems about the topic module; this was done to clarify lessons and discuss solutions to problems encountered. When students have no question, the teacher-researcher then will be the one to ask questions about concepts and applications of that particular topic module. As a requirement, the students have to submit weekly outputs of pretest, activity, posttest, reflection, and self-assessment.

Exploring Students' Views, Practices and Experiences on a Modular Instruction Class.

To determine the students' views, practices, and experiences on a fully modular instruction calculus class, reflective journals, survey questionnaire, and focus group discussion were utilized.

Reflective journals. The potential of reflective practices to engender lasting and effective changes in students' lives is widely recognized (Denton, 2018). It is common practice to encourage higher education students to engage in reflective practices as a preparation for their future professional experiences (Adie and Tangen, 2015). Journaling, along with other writing activities was seen to be an effective supplement to traditional lecture mathematics for it complements the critical and logical identity of mathematics and this blend creates a unique learning culture (Domingo, 2019). This underpins the use of reflective journal as a source of information for students' perspective, practices, and experiences during remote learning under the fully modular form of instruction. At the end of each module, students

were tasked to make a reflection of their learning/understanding of that topic/lesson and to contextualize the lesson.

Survey questionnaire. According to Mathers et al, (2009), survey is a flexible research approach used to investigate a wide range of topics. A self-made questionnaire using a 4-point Likert-scale with 1- never, 2 – sometimes, 3- often, and 4-always was employed to describe the students' experience on MI. It was composed of 17 experience descriptors which were gleaned from the students' written reflections and comments through question and answer during synchronous classes. The descriptors included: have access to the lessons anytime, study calculus remotely, study calculus with flexibility, experience independent-learning, be focused in my learning, be inspired to do my best, understand my own learning (metacognition), experience challenges in reading the lessons, exercise critical thinking while studying, learn without relying on sophisticated gadgets, have difficulty understanding the lessons, have feedback on my progress/performance, be confident in my performance, exercise creativity in my learning, be anxious while studying, communicate for help when the need arises (and extend help when warranted), and appreciate calculus and its use in the real world. A check mark was used to indicate the frequency of experience of the descriptors from never (1) to always (4). At the end of the survey, the students were asked to write their comments/suggestion on the use of modules.

Focus Group Discussion. Before the semester ended, 8 students were randomly selected for a focus group discussion which was done virtually via Google Meet. Each of them, in random order, was asked to answer the prepared questions. They have to answer one at a time until all 8 were able to answer. The questions for FGD included: what is your understanding of a module; what is your understanding of a modular instruction; what are your practices during asynchronous classes, what are the opportunities and challenges encountered during the fully modular form of instruction in the calculus class? The students were allowed to answer in the vernacular (Tagalog).

Pretest and Posttest. Each of the self-learning modules has a pretest and a posttest (Fig. 2). After the introduction, objectives, and instruction to users, the pretest is done where final answers are indicated for self-check. A table of scores is provided so the students have an idea of what to do next. Usually, a student gets very low scores and are directed to continue to the lesson proper where the topic is lengthily discussed and explained. An activity follows the lesson proper and the student has to finish where their solutions and scores are compared to the solution and answers given for the activity. If they get at least 70% correct answer then they are directed to proceed in answering the posttest which is identical to the pretest. In this part, solution to the problems were explained unlike in the pretest where only the final answers were provided. All in all, the students performed 15 pretests and posttest corresponding to the 15 modules.

Paired sample t-test using Jamovi 2.3.13 was utilized to determine if significant difference exists between the mean scores of the pretest and the posttest.

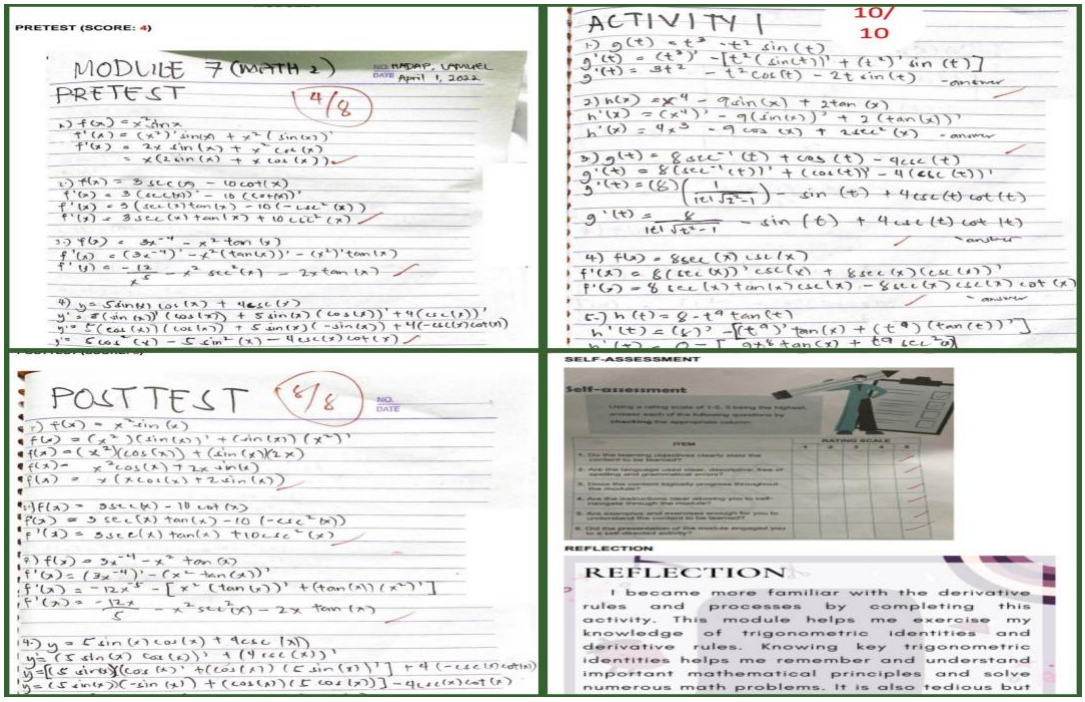

Figure 2. Sample of an answered pretest, activity, and posttest

Findings and Discussion

Students' Perspective, Practices, and Experiences on the Modular Form of Instruction

Using descriptive and thematic analysis, the data collected revealed that students viewed modules as printed materials where everything about the lesson can be found and the modular instruction as something which entails a lot of reading and self-study. This is in consonance with the study of Dejene (2018) which mentioned that modular approach to teaching enables the learner to have control over their learning and accepts greater responsibility for learning. He asserted that modular instruction demands greater maturity on the part of the learners and modules is more appropriate for mature students. This demand led to the development of various practices among the student participants for them to cope. They shared common practices in learning calculus through modular instruction which included: allotting schedule in reading the modules several times a week, engaging in group studies, watching Youtube videos when still confused, and asking the teacher questions if there are still unclear items. Reading (including module reading) is a cognitively complex activity which requires that one fully comprehends the message expressed, interprets between and beyond the lines of text, and constructs personal meaning with the text (Shea & Ceprano, 2017). This leads to the need of modular instruction students to spend time with the modules not just once a week but several times a week. To fully comprehend the calculus lesson, repeated exposure to the modules is imperative. The need for group studies, on the other hand, is supported by Chiriac (2013) who claimed a strong scientific support for the benefits of students learning and working in groups. She posited that when working interactively with others, as common in group studies, students learn to inquire, share ideas, clarify differences, problem-solve, and construct new understandings. The study of Cihangir and Coklar (2021) supports the practice of students in a modular instruction to watch video lessons particularly at Youtube which is considered as a video learning tool with expected benefits due to its popularity and easy access. The availability of self-learning modules and accessible video lessons does not lessen the importance of teacher's presence in virtual classes. Teachers play a crucial role in

synchronous discussions and the quality of interaction in a virtual classroom is determined by the instructor and not by technology (Tyrvainen et al., 2021). In the case of the student participants to the study at hand, they felt the need for confirmation of their own understanding of the lessons as well as learnings from youtube videos; finality and confirmation can be found from the teacher's answers to their questions, thus, the most common practice of asking questions during synchronous classes was observed.

The results revealed that about 97% of the students often or always experienced having access to the module anytime, being able to exercise creativity in learning, communicating for help when needed, and appreciating calculus better. Veletsianos and Houlden in 2019 espoused the flexibility quality of distance education like the modular distance learning as affording anytime, anyplace learning However, because of reading literacy issues, 57% experienced difficulty in understanding some of the lessons. A study on students' reading difficulty in modular learning (Libre III and Decano, 2021) revealed comprehension difficulty as a challenge which results to boredom because they cannot understand what they are reading. Seventy percent said they were often anxious while studying which is supported by the study of Ajmal and Ahmad (2019). They found out the students were anxious during modular distance learning because they are unable to discuss or share problems with their instructors on a daily basis. The result of the accomplished survey was in consonance with the findings of Goldschimd & Goldschimd (1972) that modular learning offers flexibility and cooperation which was manifested with the need for group studies among the learners.

Students' Performance Under the Modular Form of Instruction

Employing Jamovi 2.3.13, the pretest and posttest mean scores were collected and checked for normality using Shapiro-Wilk ($p > 0.05$). Since normality is established, a two-tailed paired-sample t-test was done at $\alpha = 0.05$. The table below shows that a significant difference exists between the mean scores of the pretest and posttest (perfect score of 160). The measured effect size using Cohen's d is 1.83 indicative of mean scores difference of almost two standard deviations away. This reveals that the significant difference is largely attributed to the use of the self-learning modules, in particular, the lesson proper which contained the activity. A study conducted in 2018 (Cramer et al.) suggested that a significant association existed between module receipt and improved performance. Apparently, students are able to have a firm grasp and take responsibility of their own learning and become active participants of their own learning. This was observed among many of the students in calculus under modular form of instruction who often experienced better understanding of their own learning, and thus, better metacognition (Domingo, 2023). One of the more common practices of participants of the fully modular calculus class is to conduct group studies to discuss concerns, questions, queries for a particular topic module. The discussion allowed collaboration among the learners as they shared problems encountered and how these problems were solved and asking other group members for possible solutions if the problems remain unsolved. The group members practiced collaboration which is a philosophy of interaction where individuals are responsible for their actions, including learning and respect the abilities and contributions of their peers (Laal et al., 2012). The modular approach helps to maximize the chances of students' participation to fulfill the given tasks at the spot, so the students feel free to learn in their own style (Sadiq and Zamir, 2014). Despite having to collaborate with peers in their group study, the use of self-learning modules allows learners to work independently and without faculty supervision and is beneficial in self-directed learning (Tohidi et al., 2019).

N = 40	Mean	Standard deviation	Sig (2-tailed, α = 0.05)	Cohen's d	Remark
Pretest	61.4	28.2	$p < 0.001$	1.83	**Significant difference exists** (largely attributed to the use of SLM)
Posttest	128	22.8			

Table 1**.** Students' performance in terms of pretest and posttest scores

Conclusion

Students view modules as printed materials which provides everything about the lessons and the modular instruction as mode of instruction delivery which entails a lot of reading and self-study. This perspective warrants various practices to enable distance learning calculus survival: read the modules several times a week, engage in group studies, watch related Youtube videos and finally ask the teacher for clarity. These practices seem to work well for this led to more calculus engagement resulting to a better understanding of the lessons. The modular form of instruction notwithstanding reading literacy issues provided positive experiences and significantly improve calculus academic performance without trivializing teacher's presence.

References

Adie, L. and Tangen, D. (2015). The use of multimodal technologies to enhance reflective writing in teacher education. Teaching Reflective Learning in Higher Education. https://doi.org/10.1007/978-3-319-09271-3_9

Ajmal, M., and Ahmad, S. (2019). Exploration of anxiety factors among students of distance learning: a case study of Allama Iqbal Open University. *Bulletin of Education and Research*, Vol. 41, No. 2, https://files.eric.ed.gov/fulltext/EJ1229454.pdf

Artigue, M., Batanero, C., & Kent, P. (2007). Mathematics thinking and learning at post-secondary level. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 1011–1049). Information Age Publishers

Biza I, González-Martín AS, Pinto A. Calculus at the intersection of institutions, disciplines and communities: a special issue Guest Editorial. Int. J. Res. Undergrad. Math. Ed. 2022;8(2):217–21. doi: 10.1007/s40753-022-00183-y. Epub 2022 Jun 11. PMCID: PMC9187891

Bressoud, D., Ghedamsi, I., Martinez-Luaces, V., & Törner, G. (2016). *Teaching and Learning of Calculus*. Springer Open. https://doi.org/10.1007/978-3-319-32975-8

Brydon-Miller, M., Greenwood, D., & Maguire, P. (2003). Why Action Research? Action Research, 1(1), 9–28. https://doi.org/10.1177/14767503030011002

Cain, D. L., Marrara, C., Pitre, P. E., & Armour, S. (2007). Support Services That Matter: An Exploration of the Experiences and Needs of Graduate Students in a Distance Learning Environment. *International Journal of E-Learning & Distance Education / Revue Internationale Du E-Learning Et La Formation à Distance*, *18*(1), 42-56. Retrieved from https://www.ijede.ca/index.php/jde/article/view/129

Chiriac, E.H. (2014). Group work as an incentive for learning-students' experiences of group work. Frontiers in Psychology. file:///D:/Downloads/fpsyg-05-00558.pdf

Cihangir, H.H. & Coklar, A.N. (2021). Using youtube as an education environment: examining follower views. International Technology and education Journal. Vol. 5, No.1, https://files.eric.ed.gov/fulltext/EJ1312890.pdf

Cramer, K., Ross, C., Plant, L., Pschibul R. (2018). Efficacy of learning Modules to Enhance Study Skills. Internationl Journal of Technology ang Inclusive Education (IJTIE) Vol 7, Issue 1, https://infonomics-society.org/wp-content/uploads/ijtie/published-papers/volume-7-2018/Efficacy-of-Learning-Modules-to-Enhance-Study-Skills.pdf

Dejene, W., Chen, D. (Reviewing editor) (2019). The practice of modularized curriculum in higher education institution: Active learning and continuous assessment in focus, Cogent Education, 6:1, DOI: 10.1080/2331186X.2019.1611052

Denton, A. W. (2018). The use of a reflective learning journal in an introductory statistics course. Psychology Learning and Teaching. Vol 17, Issue 1. SAGE Publications https://journals.sagepub.com/doi/pdf/10.1177/1475725717728676

Domingo, L. S. (2023). Surviving a calculus class during the pandemic: affordances and constraints of a fully modular instruction class. *Creative Education* Vol 14, No.1 https://doi.org/10.4236/ce.2023.141005

Domingo, LM S. (2019). Writing and mathematics acquisition: can they be allies? Cavite State University Research Journal. Jan-Dec 2019. ISSN-2244-064X

Elliot, J. (1991). Action research for educational change. Open University Press. Brown University, Providence, Rhode Island.

Faulkner B, Earl K, Herman G. (2019). Mathematical maturity for engineering students. *International Journal of Research in Undergraduate Mathematics Education*.5(1):97–128. https://doi.org/10.1007/s40753-019-00083-8.

Goldschmid, B. & Goldschmid, M. (1972). Modular instruction in Higher Education: a review. McGill Univ.. Montreal (Quebec). Center for Learning and Development. https://eric.ed.gov/?id=ED061158

Hochmuth, R., Broley, L., & Nardi, E. (2021). Transition to, across and beyond university. In V. Durand-Guerrier, R. Hochmuth, E. Nardi & C. Winsløw (Eds.), *Research and Development in University Mathematics Education* (pp. 193–215). Routledge. https://doi.org/10.4324/9780429346859

Holter, A. C. & Frabutt, J. M. (2012). Mission driven and data informed leadership. Catholic Education: A Journal of Inquiry and Practice, 15(2), 253-269. http://ejournals.bc.edu/ojs/index.php/catholic/article/view/1935/1753

Laal, M., Laal, M., Kermanshahi, Z. (2012). 21st century learning in collaboration. Procedia-Social and Behavioral Sciences. http://dx.doi.org/10.1016/j.sbspro.2012.06.885

Lentel, H. (2012). Distance learning in British universities: is it possible?, Open Learning: The Journal of Open, Distance and E-learning. Vol 27 No 1, https://doi.og/10.1080/02680513.2012.640782

Libre LL, S. & Decano, R.S. (2021). Experiences and challenges of struggling readers in the framework of modular distance learning. *International Journal of Research and Innovation in Social Science*, Vol V, Issue X, https://www.researchgate.net/publication/356382941_Experiences_and_Challenges_of_Struggling_Readers_in_the_Framework_of_Modular_Distance_Learning

Mathers, N, Fox, N. & Hunn, A. (2009). Surveys and questionnaires. National Institute for Health Research. https://www.rds-yh.nihr.ac.uk/wp-content/uploads/2013/05/12_Surveys_and_Questionnaires_Revision_2009.pdf

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2010).Evaluation of evidence-based practices in online learning: a meta-analysis and review of online learning studies. https://www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf

Nardo, MT. (2017). Modular Instruction Enhances Learner Autonomy. American Journal of Education Research. DOI: 10.12691/education-5-10-3

Owens, J., Hardcastle, L., & Richardson, B. (2009). Learning from a distance: the experience of remote students. *Journal of Distance Education*. Vol 23, No. 3, https://files.eric.ed.gov/fulltext/EJ865347.pdf

Rakova, E., Ibyatova, L., & Oparina, K. (2018). Modular approach to teaching ang learning English grammar in technical universities. Society Integration Education Proceedings of the International Scientific Conference http://dx.doi.org/10.17770/sie2018vol1.3229

Sadiq, S. and Zamir, S. (2014). Effectiveness of Modular Approach in Teaching at University Level. Journal of Education and Practice. Vol 5, No. 17.

Shea, M. and Ceprano, M. (2017). Reading with understanding: a global expectation. *Journal of Inquiry & Action in Education*. Vol. 9, No.1. https://files.eric.ed.gov/fulltext/EJ1158259.pdf

Sherry, L. (1995). Issues in Distance Learning. *International Journal of Educational Telecommunications,* 1(4), 337-365, file:///D:/Downloads/article_8937.pdf

Sorby, S., Casey, B., Veurink, N., & Dulaney, A. (2013). The role of spatial training in improving spatial and calculus performance in engineering students, *Learning and Individual Differences*,Volume 26, https://doi.org/10.1016/j.lindif.2013.03.010

Thompson PW, Harel G. Ideas foundational to calculus learning and their links to students' difficulties. *ZDM – Mathematics Education.* 2021;53(3):507–519. https://doi.og/10.1007/s11858-021-01270-1

Tyrvainen, H., Uotinen, S, and Valkonene, L. (2021). Instructor presence in a virtual classroom. Open Education Studies, Vol 3, No.1. https://www.degruyter.com/document/doi/10.1515/edu-2020-0146/html?lang=en

Tohidi, S., KarimiMoonagi, H., Shayan, A., & Ahmadinia, H. (2019). The effect of self-learning module on nursing students' clinical competency: a pilot study. *Iranian Journal of Nursing and Midwifery Research*. 24(2).

Veletsianos, G. & Houlden, S., (2019). Flexible learning over the last 40 years of distance education. *Distance Education*, 40(4), 454-468. https://doi.org/10.1080/01587919.2019.1681893

Young, M., Rapp, E., & Murphy, J. (2010). Action research: enhancing classroom practice and fulfilling educational responsibilities. Journal of Instructional Pedagogies. https://www.aabri.com/manuscripts/09377.pdf

Zachariades, T., Pamfilos, P., Christou, C., Maleev, R. and Jones, K. (2007), Teaching Introductory Calculus: approaching key ideas with dynamic software. Paper presented at the CETL–MSORConference 2007 on Excellence in the Teaching & Learning of Maths, Stats & OR, University ofBirmingham, 10-11 September 2007. *(2) (PDF) Teaching introductory calculus: approaching key ideas with dynamic software*. https://www.researchgate.net/publication/265634416_Teaching_introductory_calculus_approaching_key_ideas_with_dynamic_software#fullTextFileContent

Zarzycka, E., Krasodomska J., Mazurczak-Mąka, A. & Turek-Radwan, M. Jin, H. (Reviewing editor) (2021) Distance learning during the COVID-19 pandemic: students' communication and collaboration and the role of social media, Cogent Arts & Humanities, 8:1, htpps://doi.org/10.1080/23311983.2021.1953228

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