Reformed STEM Education and Its Effects on Student Learning Outcomes and Plagiarism Rates: A Look at a Higher Education Institution in the Northeastern Democratic Republic of Congo

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Abstract
Research on higher education in the Democratic Republic of Congo (DRC) is virtually absent (Zavale & Schneijderberg, 2020). Science, Technology, Engineering and Math (STEM) programs are being encouraged by the global community without assessments of the learning outcomes of the students enrolled (Blom, Lan & Adil, 2015). This project compared two STEM programs within the same university in the North Kivu province of the DRC. One program institutes non-semesterized, intensive courses with little resource availability and no homework assignments (pre-reformed program). In contrast, the reformed version of the same program follows a semesterized course calendar and uses inquiry-based pedagogy in line with current models of internationalized education. This study assessed differences in science literacy, science reasoning, rates of plagiarism and general numeracy between the two groups. It was found that students in the reformed program had improved numeracy scores after one year in the program while pre-reformed students' levels of numeracy were as low as incoming high school students. In addition, students in the reformed program had higher levels of science literacy than their peers in the pre-reformed program. Science reasoning was more in line with first-year students across other internationalized HEI's in the reformed program than it was in the less developed science reasoning test outcomes of the pre-reformed students. Lastly, it was discovered that plagiarism in the pre-reformed program was prolific while students in the pre-reformed program exhibited fewer examples of plagiarism. This research presents data that is currently absent within the field of higher education in the DRC.

Keywords: The Democratic Republic of the Congo, Higher Education, STEM, Student Learning Outcomes, Reformed Teaching, Inquiry-Based Learning

Introduction

The Democratic Republic of Congo (DRC) is 12th on the list of least developed countries in the world (Human Development Report, 2020). Despite this fact, the nation has incredible wealth and provides more of the world's electronic-dependent element, cobalt, than any other nation (Scheele, De Haan & Kiezebrink, 2016). The juxtaposition of natural resource wealth with human poverty can be traced back to the horrific colonial rule of Belgium's King Leopold, who is held responsible - by some estimates - for the death of 10 million Congolese people from 1885 to 1908 while claiming ivory and rubber for personal gain (Moore, 2001). Today ivory and rubber have been replaced by mineral extraction, but the inequitable distribution of wealth remains a dire issue. The labour force extracting these minerals and gaining high salaries is largely foreign, with only the lowest paying and most dangerous jobs going to local people (Rubbers, 2020). Science, Technology, Engineering and Math (STEM) educated individuals may gain access to this booming industry, but education in the DRC is ineffective, both at an institutional and governmental level (De Herdt & Titeca, 2016). With a ministry of education that is nearly bankrupt, offering high-quality education is difficult for primary and secondary schools in the DRC in which teacher training programs are being supported by international development institutions (Lund, 2020). The quality of higher education in the DRC is virtually unknown and unresearched, aside from a few broad, cross-regional studies (Zavale & Schneijderberg, 2022).

Although STEM education remains an important means of getting locals into the lucrative economies of the region, STEM programs are also the most costly discipline for a higher education institution (HEI) to offer, averaging almost four times as much per student than a humanities major (Hemelt, Stange, Furquim, Simon & Sawyer, 2018). Furthermore, without knowledge of the quality of such programs in the DRC, it is impossible to know whether graduates are qualified enough to fill high-paying positions in their local economies.

This study took place at an HEI in the northeastern region of the DRC which is currently in the midst of reforming an established STEM program. This allowed for a comparison between a normative, pre-reformed STEM program and a reformed, inquiry-based program striving for a more internationalized level of education. This study assessed the achievement of learning outcomes and plagiarism rates by students in the new program with those in the original program. It aimed to determine if the curriculum's inquiry-based learning approach is successful through assessment tools and quantitative analysis.

Study site, programs of study, and participants

Université Chrétienne Bilingue du Congo (UCBC) is a small, private university located in the town of Beni in northeast DRC. It has a student body of approximately three hundred students living within the UCBC campus region. It was established in 2006 by a team of educators including Dr. David Kasali who spent a career as a postsecondary educator and as the president of Africa International University in Nairobi, Kenya. Dr. Kasali recruited a team of qualified administrators and professors to found UCBC, feeling the need for a high-quality HEI in his hometown of Beni, DRC. Tuition is approximately $2,200USD/year; students are required to pay $400 of this with the rest being matched through outside, international donors. The coordination of this comes from UCBC's non-profit governing body: Congo Initiative (CI). CI is a registered not-for-profit headquartered in Indiana, USA and hosts several other organizations within Beni.

After recruiting a qualified Ph.D. holder trained in physics in the U.S., the university planned to reform its current applied science program to a higher quality, internationalized program, beginning in 2020. The reformed applied science program requires that students sit for an entrance math exam - a new assessment not required by the pre-reformed applied science program and representing one of its most impactful changes. Requirements like entrance exams can be difficult for HEIs to make as the government must grant approval for entrance requirements (Majaliwa, 2020).

Assessing for numeracy

The UCBC entrance exams were an important addition to ensure student success in the rigorous, reformed STEM program, especially since delineated grades are not listed by subject on secondary school transcripts. Instead, grades are given as a blended average of all courses taken under the umbrella of broader categories like “math”, making it hard to assess a student’s strengths and weaknesses per subject (Talwanga, 2015). Although incoming students to UCBC’s newly reformed STEM program have mixed abilities in literacy and computer skills, they are expected to have a minimum level of numeracy to enter this newly reformed program.

Because this mathematical ability is being assessed by the institution, capturing its change over time in the reformed program was possible. It was also possible to administer the same test to students currently in the pre-reformed program to gauge the difference in student ability as a whole.

Assessing for Science literacy

Aside from foundational mathematical abilities, a more general cognitive function was assessed in students in both programs. Measuring the effectiveness of the new reformed program by looking at students’ “scientific thinking” or “science inquiry” skill development, was achieved through the medium of their written assignments. Research shows that the development of scientific knowledge (a collection of isolated facts) is separate from the skill of scientific thinking, which is defined as a combination of theoretical knowledge, curiosity, an understanding that theories must be falsifiable, respect and understanding of evidence, and an understanding that evidence is distinct from the theory (Kuhn, 2011). This developing science thinking can be observed in a student’s level of science literacy.

Gormally, Brickman and Lutz (2012) used large international and governmental education research bodies (AAAS, National Academy of Science, OECD) to construct a comprehensive list of science literacy skills, shown in Table 1. These skills are the foundation for a widely used science literacy assessment tool called the Test of Scientific Literacy Skills, filling important research needs that focus on being able to measure the learning outcomes of students in STEM programs and track their progress (ibid.).

Table 1. *A List of Scientific Literacy Skills. The 9 science literacy skills and examples of each are divided into two groups. (*adapted from Gormally, Brickman & Lutz, 2012)

Skills for Understanding Methods of Inquiry that Lead to Scientific Knowledge	**Skills to Organize, Analyze, and Interpret Quantitative Data and Scientific Information**
1. Identify a valid scientific argument	**5.** Create graphical representations of data
2. Evaluate the validity of sources	**6.** Read and interpret graphical representations of data
3. Evaluate the use and misuse of scientific information	**7.** Solve problems using quantitative skills, including probability and statistics
4. Understand elements of research design and how they impact scientific findings/conclusions	**8.** Understand and interpret basic statistics
	9. Justify inferences, predictions, and conclusions based on quantitative data

A rubric based on these nine traits was designed for this study to analyze student artifacts (see Table 2). For the pre-reformed students, final-year thesis documents were assessed and for the reformed program, physic lab reports were used.

Table 2. *Science Literacy Rubric. The rubric used to analyze scientific literacy skills in student documents. If the answer to questions is "yes", then the student receives a point. There are 18 possible points. Half points are offered for partial inclusions of components. (ie. the data tables have some labels but not all)*

Introduction	Hypothesis listed anywhere?	Hypothesis in Intro?	Hypothesis match experiment?	Hypothesis explicit (insert text)	Hypothesis appropriately presented?	Does the student relate the experiment and question back to a "real life" event or need?
Methods and Procedures	Is there an exhaustive materials list?	Is there a written procedure?	Are there diagrams or photos of the procedures?			
Results	Are there data tables?	Are the data tables labelled properly (labels and units)?	Are there graphs?	Are the graphs appropriately labelled?	Is the data described in the text?	
Conclusion	Is there a conclusion based on gathered evidence?	Does the student differentiate between probability and proof?	Does the student accept or reject the hypothesis?	Is the report coherently ordered?		

Assessing for science reasoning

Science reasoning (one aspect of science literacy) has a correspondingly large body of research offering well-tested tools and assessment methods for STEM students. This cognitive function can be described as the ability to overcome embedded alternative conceptions about the natural world incompatible with current scientific theories (Lawson & Thompson, 1988). This journey a student makes from reasoning with alternate conceptions to reasoning with non-intuitive scientific theories after formalized education can be captured through various tools, including the Lawson Classroom Test of Scientific Reasoning (LCSTR) (Lawson & Thomson, 1988). The validity of this tool has been long established and it continues to be used as a means to gather evidence of learning outcomes achieved by students from middle school to early tertiary education in STEM programs (Bao et al. 2009; Hrouzkova & Richterek, 2021; Zhou et al. 2021).

An example of a typical distribution of first-year university STEM students' scores on the LCTSR can be viewed in Figure 1 (Hrouzkova & Richterek, 2021). In this study, 446 first-year science majors took the LCTSR, prior to beginning their first year of study. The score achieved on the test is connected with the stage of scientific reasoning that an individual falls into. They found that most students entering their first year of a science degree exhibited transitional reasoning (having some ability to engage with formal operational reasoning), with approximately a quarter falling into both the concrete operational and formal operational categories.

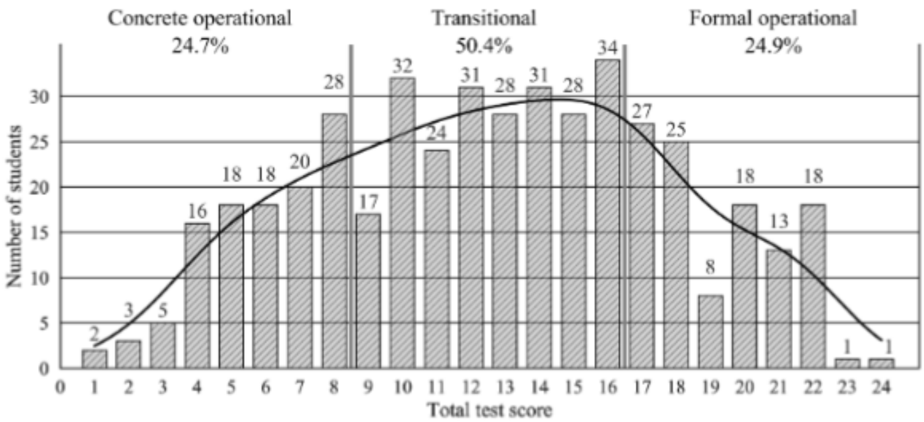

Figure 1. *Lawson's Classroom Test of Scientific Reasoning Distribution and Reasoning Categories. Of 446 first-year chemistry and physics students in the Czech Republic (published results) for comparison.*
Note: Reprinted from Hrouzkova, T. and Richterek, T. (2021)

Having a list of skills defining science literacy as outlined in Table 1 and tests like the LCTSR allow educators to map student outcomes and institutional patterns of success or failure. However, in order for these tools to be effective, student work needs to be original and mirror their thinking. This leads to the perennial problem of plagiarism.

Plagiarism in higher education as a barrier to assessment

Plagiarism is a universal problem, and there are many studies providing data on its prevalence in HEIs, even in well-resourced settings (Pupovac & Fanelli, 2015). Plagiarism takes different forms and has a plethora of definitions in the existing literature. For these reasons, it is hard to quantify how problematic plagiarism is in any given institution. A few examples that highlight the spectrum of plagiarism are the extreme instances of “paper-mills" being used, in which students purchase entire essays. Additionally, “patchworking” occurs when students take chunks of another’s work and then change around words and structure or academic dishonesty can occur through citing work improperly, which can be either intentional or innocent. Each of these types of plagiarism can cloud the ability of instructors to assess student learning outcomes properly.

There is evidence that suggests a combination of these forms of plagiarism is more rampant in low-income countries (Ana, Koehlmoos, Smith & Yan, 2013), but a paucity of research does not allow for conclusive statements to be made on patterns, causes, or implications. McCabe (2005) points out a potential reason for this observed increase in plagiarism gleaned from his research in the US: institutions that do not have systems in place to quell plagiarism and, in any way allow it, find honest students frustrated that those who are dishonest may have an unfair advantage. This leads to an apparent increase in overall academic dishonesty so as to level the playing field. In other words, institutional complacency encourages academic dishonesty. McCabe (2005) points out that a lax institutional culture is more common in programs with large enrollment numbers and lower resources to check for plagiarism.

Although it is difficult to gain access to places like the DRC to determine student plagiarism rates, it is known that many of these institutions often have high enrollment and low resources (De Herdt & Titeca, 2016). Institutions in least-developed nations, like the DRC, often lack the capacity and resources to implement robust investigations, punishments, and prevention measures which are also known factors that suppress plagiarism rates (Ana, Koehlmoos, Smith & Yan, 2013).

Research design

This study used quantitative methods to measure the outcomes of the reformed program and the parallel pre-reformed STEM program. All data collection occurred in partnership with the applied science program staff and faculty at the chosen HEI in the DRC. This study was conducted in compliance with the Point Loma Nazarene University (USA) Institutional Review Board policies and procedures and informed consent was collected from each student involved. Participation in activities for this project took place during class time.

Table 3 outlines the differences between the reformed and pre-reformed programs. Currently, the degree is four years in length for both the reformed and pre-reformed applied science programs. The reformed program is systematically replacing the pre-reformed, and during the time of this study, the first and second-year students (L0 and L1 respectively) represent the reformed program. The third and fourth-year degree students represent those in the pre-reformed program (L2 and L3).

Table 3. *Differences in Student Groups. A breakdown of the differences between the student groups in the reformed and pre-reformed programs.*

Program Feature	**Reformed program** (L0 and L1 students)	**Pre-reformed program** (L2 and L3 students)
Professors	Consistent faculty	Visiting faculty
Class schedule	Courses spread over 7 weeks	Intensive courses 1-2 weeks long
Regular homework and feedback to students on their learning	Yes	No
Textbooks	Provided by faculty	No
Required reading and writing assignments	Yes	No
Course schedule	Planned prior to academic year	Planned week by week, based on professor availability

The length of the program has fluctuated in the recent past from three years to four (a remnant of Belgium's three-year degree system during colonial rule). The first year of the reformed program acts as a bridging year for making the program unofficially four years in length so as to act as a buffer against governmental requirements that may pressure the HEI to shorten the program to three years. It is also imperative to help incoming students reach a level of numeracy and academic competency to succeed in the more internationalized STEM program.

Results

Mathematical ability starting point and improvement

The combined mean scores of all prospective students who sat for the program entrance exam (including those who were not accepted into the program) from 2021 and 2022 (M= 55.48, SD=18.47) were statistically significantly higher than the combined averages of all the pre-reformed students of L2 and L3 (M=45.82, SD=15.9, t(144)= 3.2 p=<0.001). The scores of the successful applicants invited into the program in 2021 were retested after one year in the program, and their average scores were compared through a paired t-test as shown in Figures 2 and 3. The scores are shown as box and whiskers plots displaying the variation and means of each group. The highest mean score achieved came from applicants in 2021 and the lowest mean score achieved was from a student in the L2 class. Only 6 of the 55 students in the pre-reformed program achieved a score high enough to be considered eligible for the reformed program.

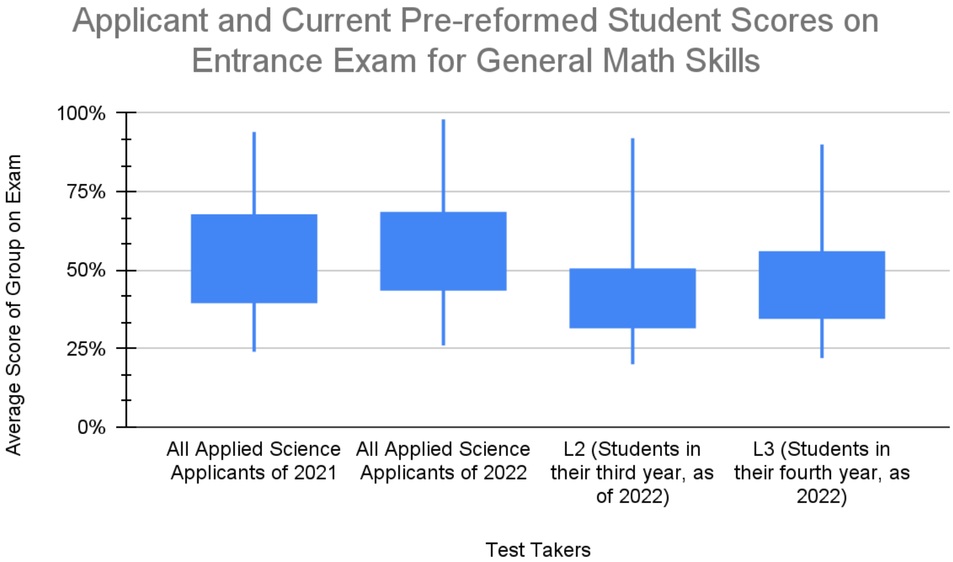

Figure 2. *Average Scores of Applicants and Pre-reformed Program Students on the Entrance Exam. Scores for the reformed program's mandatory entrance exam across four groups: all applicants for the new program from 2021 and 2022 as well as the third and fourth-year students in the pre-reformed program. For 2022 n = 46, for 2021 n = 45 for L2 n = 37 and for L3 n = 18.*

On average, students in L1 achieved a higher score on the entrance exam (M = 85, SD = 9.6) than they did the year prior, before beginning the program (M = 78, SD = 11.9) (see Figure 3). This mean difference of 7% was statistically significant ($t(18)=2.1$, $p = 0.004$).

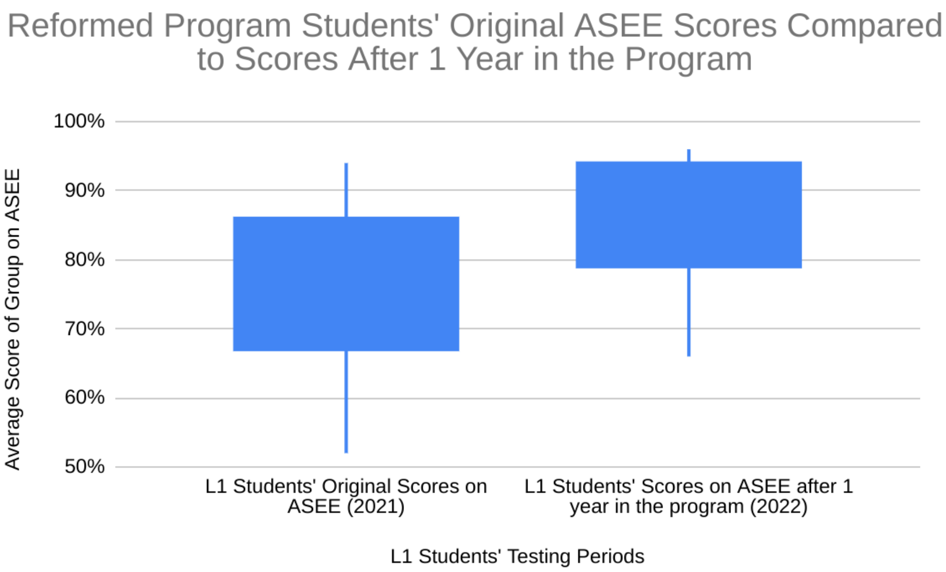

Figure 3. *Average Scores of L1 Students at Time of Application and After One Year on the Entrance Exam. This was a comparison over time, with the same individuals in each group (n=19). The 2022 entrance exam was built from questions of similar difficulty and style, but they were not the same.*

Lawson Classroom Test of Scientific Reasoning results

Similar to Hrouzkova and Richterek's (2021) findings shown in Figure 1, 58.2% of the UCBC reformed-program students scored within the "transitional" reasoning stage (Figure 4). Differing from their findings is the proportion of students in the present study classified in the "formal operational" range, in which only two achieved - both L0 students. L2 and L3 students (N = 41) fall mainly within the concrete operational stage (73.17%). Only 1 student scored higher than the transitional threshold (an L2 student).

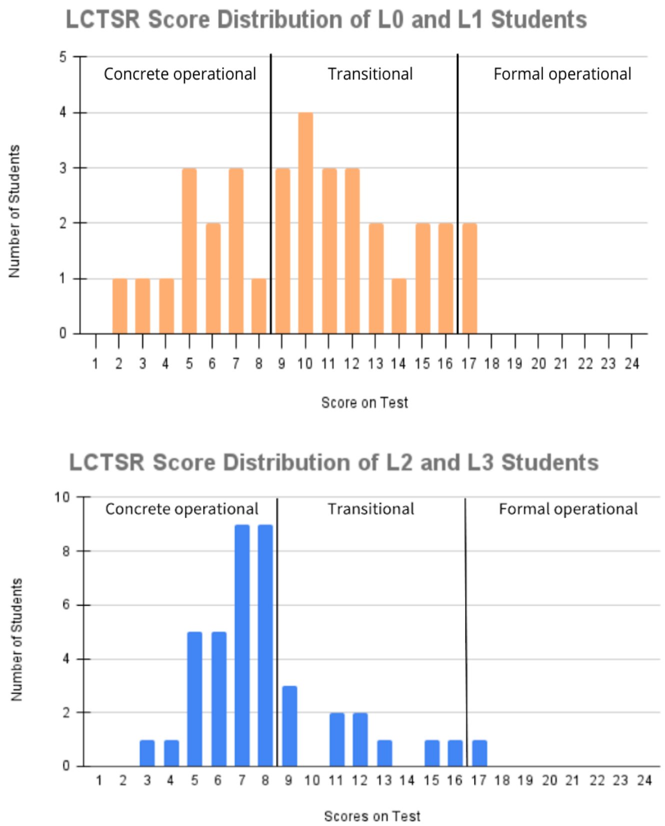

Figure 4. *The Distribution of Student Test Scores on the LCTSR. L0/L1 (top) and L2/L3 (bottom) in relation to the Piagetian stages of cognitive development.*

The makeup of the reformed program student scores is more closely related to that of typical first-year STEM students shown in other studies (Bao et al. 2009; Hrouzkova & Richterek, 2021; Zhou et al. 2021). The pre-reformed student distribution is heavily skewed into the concrete operational end of the curve where reasoning is based on naive reasoning.

Science literacy in written student work

Figure 5 shows the proportion of points awarded for the combined reformed and pre-reformed student artifacts for each section of the rubric. All student documents for the reformed program were found to have a hypothesis listed in their document. The lowest scoring components for the L1 student lab reports were for an appropriately presented hypothesis and for appropriately labelled graphs. The pre-reformed student documents had no examples of graphs and very few offered data sets or clear conclusions in regard to their hypotheses. Not correctly and coherently testing their hypotheses was the most obvious sign of low levels of science literacy within their documents.

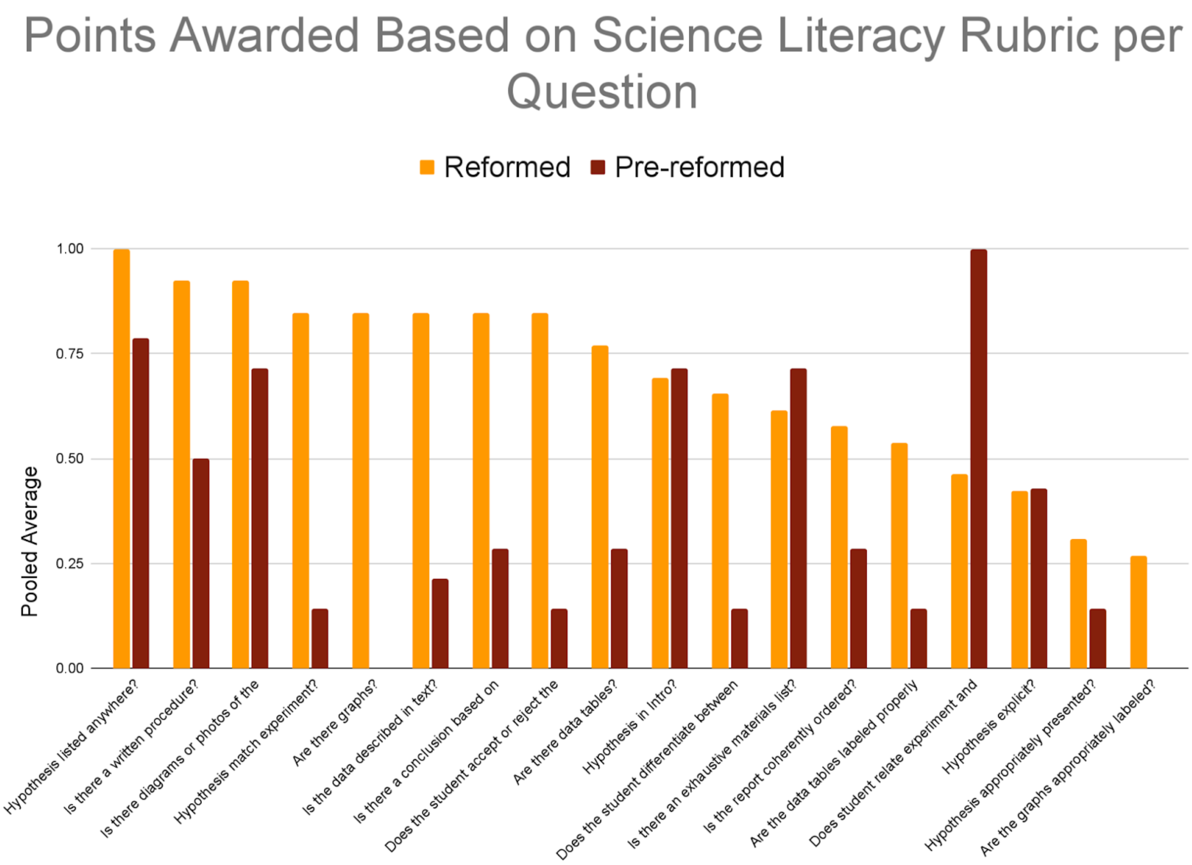

Figure 5. *A Breakdown of the Proportion of Points Achieved per Question on Science Literacy Rubric. The histogram is organized by highest to lowest combined scores/questions for the L1 student documents.*

Plagiarism in student written work

Table 4 shows the percentage of plagiarism present in student works assessed for the science literacy skill rubric. One student in the reformed program plagiarised more than 25% and another over 5% of the artifact. The rest of the reformed student participants had less than 5% plagiarism with over half of the students having no examples of plagiarism. Meanwhile, there are only two examples of students in the pre-reformed program with less than 5% of their documents (theses) plagiarised; both of these students were under the supervision of the founder of the reformed program and were confronted for handing in early drafts of plagiarised work. The plagiarism protocol for the students not under the supervision of the founder of the reformed program is unknown.

Table 4. *Rates of Plagiarism in Reformed and Pre-reformed artifacts.* Plagiarism rates for L1 students as assessed from lab reports (n = 36) and from thesis documents of graduated pre-reformed students (n=7).

	Number of Students with 0% plagiarism	**Number of Students with >0% - 5% plagiarism**	**Number of Students with >5% - 10% plagiarism**	**Number of Students with >10% - 25% plagiarism**	**Number of Students with >25% plagiarism**
L1	27 (75%)	6 (16.7%)	2 (5.7%)	0	1 (2.8%)
Graduated Pre-reformed student	0	2 (28.6%)*	0	2 (28.6%)	3 (42.9%)

*These students had the founder of the reformed program as their supervisor, who required students to re-do plagiarised work.

Conclusions

Students in the reformed program showed significant improvement in their mathematical abilities over the course of one year while the pre-reformed students scored below the average in mathematical ability compared to the applicants from the past two years. Their abilities in math remain lower than what is expected of a high school student.

Students in both the reformed and pre-reformed programs had fewer students fall into the formal operational category of reasoning than first-year university students from other studies (Hrouzkova & Richterek, 2021). All students in the UCBC program scored below the average of a sample of similarly aged students from Hrouzkova and Reichterek's (2021) study, but more students from the reformed science program sit within the transitional reasoning stage.

Students in the pre-reformed program exhibit more examples of science literacy, based on the nine key science literacy skills from Table 1 (Gormally, Brickman & Lutz, 2012) than students in the pre-reformed program. The selected written artifacts from the students in the pre-reformed program were completely lacking graphs and had very few examples of statistical analysis of their empirical research.

Students in the reformed program resort to plagiarism less frequently and less extensively than those in the pre-reformed program. Results show that 3 out of 7 (43%) of students in the pre-reformed program had examples of content that were more than 25% plagiarised, while most of the students in the reformed program either had no examples at all or minor incidents of plagiarism with the exception of two students.

This research project asked whether a newly reformed applied science program was different from a pre-reformed applied science program at the same small HEI in northeastern DRC. The study asked if the achievement of the learning outcomes by the students was different in three areas: mathematical ability, science literacy and reasoning, and rates of plagiarism. The findings from this study show that students in the reformed program have higher mathematical abilities than those in the pre-reformed program and that their abilities improved after a year in the reformed program. Furthermore, students in the reformed program have higher levels of science literacy evident in the written reports of their scientific method-structured assignments and corresponding results and achieved higher scores on the

Lawson's Classroom Test of Scientific Reasoning. Lastly, lower rates of plagiarism were found in the reformed students' written works.

In Beni, DRC, being a member of the national education community and the international education community are often mutually exclusive. The government demands that certain courses be offered in a degree program whether the institution can provide them effectively or not. To be considered a state-recognized institution these demands must be met and some years ago, this HEI's accreditation was revoked for choosing more evidence-based approaches to instructing and structuring certain programs. To function at an international standard with the resources at hand, substantial deviations from these national requirements had to be taken to create the reformed program, including the introduction of an entrance exam for incoming applied science students (forbidden by the government). By exempting itself from national rules to achieve greater international standards, the institution runs the risk of losing all legitimacy. A recent graduate informally interviewed during this research project was rejected for admission to an institution in the United Kingdom for not having an undergraduate diploma from a government-recognized university. As De Herdt and Titeca (2016) put it, although the government of the DRC itself lacks legitimacy, it is still required to lend legitimacy to educational institutions.

This leaves the question of which rules are more important for a university in the DRC to follow if the outcome means exclusion from the international academic community either way. If international standards are only achievable through the aid and intervention of staff and faculty trained in the ways of the international education community (such as the founder of the HEI, who spent his career at an internationalized university in Nairobi, Kenya) then the university will always be in a precarious state, since these members are apt to use their access to mobility to leave during times of instability. Indeed, since it was founded in 2008, the international staff has ebbed and flowed, and at the time of this research, only one full-time, on-the-ground, international instructor was present.

The reformed program is not widely accepted or welcomed by every member of the Applied Science staff and faculty at UCBC. Tabulawa (1997, 2003, 2013) points out in his expansive research on the matter, that instructors must be treated in the same manner that students are when expected to adopt new pedagogical methods: as thinking and belief-holding individuals that must construct knowledge before adhering to new models. Instructors of the pre-reformed program struggle to implement new methods of teaching, but the most adamant supporters of the new program are the teaching assistants (former pre-reformed students) who have observed the positive impact of the program and been allowed time to construct new ideas about teacher-student relationships and classroom management.

Although the reformed program was granted permission to institute an admissions test for mathematical abilities, a literacy test for English and French was not included. Since the literacy levels of students at UCBC in both the reformed and pre-reformed program, as well as all students in the DRC as a whole, are not assessed, it is likely that many students struggle with fundamental levels of literacy due to a lack of resources and trained teachers in primary and secondary schools. An added level of difficulty for students at UCBC with respect to the development of their fundamental literacy is that UCBC is a bilingual institution; students are expected to be fluent on an academic level in both French and English by the end of their degree. Ongoing debates continue among the faculty about whether this is causing more harm than good, especially as many of the English-speaking instructors have fled Beni due to the recent periods of unrest, as well as the ebola and Covid-19 crisis. Those remaining are nonnative English-speaking faculty, stretched thinly across the disciplines. As evidence suggests that general literacy is a key factor in science literacy, this should be considered when reviewing the data (Shaffer, Ferguson and Denaro, 2019). Namely, some of the student artifacts that were analyzed for this study were completed in English and some in French, but the literacy level of the students in either of these languages is unknown.

In conclusion, this study has found that students of the reformed program at this HEI are exhibiting improved achievement of learning outcomes. Although the sustainability of the program is not known, the unique history of this HEI and its willingness to explore empirically-driven pedagogical methods makes it an ideal subject for continued research.

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References

Ana, J., Koehlmoos, T., Smith, R., & Yan, L. L. (2013). Research misconduct in low-and middle-income countries. PLoS medicine, 10(3), e1001315.

Bao, L., Fang, K., Cai, T., Wang, J., Yang, L., Cui, L., ... & Luo, Y. (2009). Learning of content knowledge and development of scientific reasoning ability: A cross-culture comparison. American Journal of Physics, 77(12), 1118-1123.

Blom, A., Lan, G., & Adil, M. (2015). Sub-Saharan African science, technology, engineering, and mathematics research: A decade of development. World Bank Publications.

De Herdt, T., & Titeca, K. (2016). Governance with empty pockets: The education sector in the Democratic Republic of Congo. Development and Change, 47(3), 472-494.

Gormally, C., Brickman, P., & Lutz, M. (2012). Developing a test of scientific literacy skills (TOSLS): Measuring undergraduates' evaluation of scientific information and arguments. CBE—Life Sciences Education, 11(4), 364-377.

Hemelt, S. W., Stange, K. M., Furquim, F., Simon, A., & Sawyer, J. E. (2018). Why is math cheaper than English? Understanding cost differences in higher education (Working Paper 25314). Cambridge, MA: National Bureau of Economic Research. Retrieved from www.nber.org/papers/w25314

Hrouzková, T., & Richterek, L. (2021). Lawson classroom test of scientific reasoning at entrance university level. In. V. Lamanauskas (Ed.),Science and technology education: Developing a global perspective. Proceedings of the 4th International Baltic Symposium on Science and Technology Education (BalticSTE2021) (pp. 74-85). Scientia Socialis Press. https://doi.org/10.33225/BalticSTE/2021.74

Human Development Report. (2020). The Next Frontier: Human Development and the Anthropocene (PDF). United Nations Development Programme. 15 December 2020. pp. 343–346. ISBN 978-92-1-126442-5. Retrieved 16 December 2020.

Kuhn, D. (2011). What is scientific thinking and how does it develop? In U. Goswami (Ed.), The Wiley-Blackwell Handbook of Childhood Cognitive Development (pp. 497–523). Wiley-Blackwell.

Lawson, A. E., & Thompson, L. D. (1988). Formal reasoning ability and misconceptions concerning genetics and natural selection. Journal of Research in Science Teaching, 25(9), 733-746.

Lund, J. A. (2020). Continuous Teacher Learning Circles in Learner-Centered Pedagogy: A Case Study in the Democratic Republic of the Congo [Doctoral dissertation, Indiana University].

Majaliwah, J. G. M. (2020). Strengthening higher education and science, technology and innovation in DRC. African Journal of Rural Development, 5 (3), 143-168.

McCabe, D. Levels of Cheating and Plagiarism Remain High. Center for Academic Integrity, Duke University, 2005. Website: http://academicintegrity.org

Moore, D. (2001). From King Leopold to King Kabila in the Congo: The continuities and contradictions of the long road from warlordism to democracy in the heart of Africa. Review of African Political Economy, 28(87), 130–135.

Pupovac, V., & Fanelli, D. (2015). Scientists admitting to plagiarism: Ameta-analysis of surveys. Science and Engineering Ethics, 21(5), 1331-1352.

Rubbers, B. (2020). Mining boom, labour market segmentation and social inequality in the Congolese Copperbelt. Development and Change, 51(6), 1555-1578.

Shaffer, J. F., Ferguson, J., & Denaro, K. (2019). Use of the test of scientific literacy skills reveals that fundamental literacy is an important contributor to scientific literacy. CBE—Life Sciences Education, 18(3), ar31.

Scheele, F., De Haan, E., & Kiezebrink, V. (2016). Cobalt blues: environmental pollution and human rights violations in katanga's copper and cobalt mines. SOMO Cent. Res. Multinatl. Corp., Amsterdam, Netherlands.

Tabulawa, R. (1997). Pedagogical classroom practice and the social context: The case of Botswana. International Journal of Educational Development, 17(2), 189-204.

Tabulawa, R. (2003). International aid agencies, learner-centred pedagogy and political democratisation: A critique. Comparative education, 39(1), 7-26.

Tabulawa, R. (2013). Teaching and learning in context: Why pedagogical reforms fail in Sub-Saharan Africa. African Books Collective.

Talwanga, M. (2015). A close look at the matric examinations in the Democratic Republic of Congo (DRC). Journal of Educational and Social Research, 5(1), 45.

Zavale, N. C., & Schneijderberg, C. (2020). Mapping the field of research on African higher education: a review of 6483 publications from 1980 to 2019. Higher Education, 1-35.

Zhou, S. N., Liu, Q. Y., Koenig, K., Xiao, Q. Y. L. Y., & Bao, L. (2021). Analysis of two-tier question scoring methods: A case study on the Lawson's Classroom Test of Scientific Reasoning. Journal of Baltic Science Education, 20(1), 146-159.