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Interdisciplinary STEM Education: Evaluating Education Models, Tools, Thought Processes and Software

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ABSTRACT

In this paper, we examine several different articles in the field of education, specifically mathematical and STEM education, and how different innovations can affect the job of teaching. Critical thinking and problem-based learning are methods that can help strengthen the minds of students, and ADDIE is a thought process that teachers and educators can use to create worksheets that benefit their students better. LaTeX is a typesetting system that can be used to create printable PDF worksheets quicker, and template math problem generators can be used to create unique worksheets for each student. In this paper, we evaluate the impact that each innovation has, or possibly could have, and we look forward to what future research and innovation needs to be done to help teachers give better lessons, and help each student learn better.

Introduction: Multidisciplinary Approaches to STEM Education (Computer Science, Mathematics, and Education)

In recent scientific advancement, in the twenty-first century, it is prominent to witness that problem-solving is a multidisciplinary challenge that is deeply-rooted in the interdisciplinary frameworks. Thus, it is essential to consider that natural sciences, mathematics and computer science education all rely upon the frameworks of problem-solving, as seen in the propositions built in this technical literature review paper. In order to construct computational thinking, it is necessary for scholars to consider an epistemological framework that supports problem-solving through different modules of scientific processes and methods that can be delivered for mathematical, computational, engineering, technological, and scientific thinking. (Priemer et al., 2019) In all computer science and mathematics subjects, it is important to ensure that problem-solving processes are uncovered through an empirical form of collecting data through both hypothetico-inductive and observational-inductive methods that are empirically-based. (Priemer et al., 2019)

Analysis of Problem-Based Learning in Bolstering Mathematical Skills

Problem-based learning has been witnessed to have significant applications in ensuring that students are able to develop their argumentation and CT (critical thinking) through both modules of high-intensity problem-based learning as well as low-intensity problem-based learning. Researchers have underlined the importance of components within comprehensive science education that stresses the role of critical thinking skills, contribution of science, and better scientific literacy in the form of both individual and collaborative processes. Discussing, debating, and arguing about SSIs help students develop CT skills (Jafari & Meisert, 2021). In the SSI context, Yacoubian and Khishfe (2018) highlighted the alliance between argumentation and CT. Argumentation is a necessary component of CT when dealing with SSIs and is required Students engaging in M-PBL biology learnings can have higher levels of argumentation and better for informed decision making. For the formulated conclusion, developing a rationale for one's claims and

supporting those claims with evidence in a way that is consistent with a scientist's work are critical steps in the scientific process. Two critical processes are required for the creation of knowledge. The first is research, which generates knowledge claims. The second is criticisms and arguments from members of the scientific community and the public, which allow those claims to be scrutinized and questioned. Learners can improve their scientific argumentation by engaging in this analytical process. They can also learn to filter information from various sources and determine the credibility or reasonability of the information. To be successful, learners must be able to construct and communicate persuasive scientific arguments.

Applications of Computational Models (Dynamic Geometry Software and Computer Algebra Systems) in Educational Interventions

The use of dynamic geometry computer software (DGCS) is important in the educational environment, and it is more advantageous for learning mathematics comprehensively. This study examined the importance of dynamic geometry computer software on learners' performance in geometry. (Adelabu et al., 2019) A quasi experimental, non-equivalent control group was used. The instrument used in this study was the geometry achievement mathematics test (GMAT) that comprised 15 multiple choice items. The GMAT was administered to 87 grade nine learners in two secondary schools in Tshwane south district, Gauteng Province South Africa. One school was used as an experimental group and the second school was used as the control group. Data analysis employed the use of the statistical t-test independent sample. The result of the study shows that using DGCS is important in geometry, which improves the performance of learners. In addition, the results show that the software affects the female learners' mathematics performances more positively than the male learners. Hence, the results of this study showed that there is great potential in using the DGCS (GeoGebra) to teach secondary schools mathematics. The study recommends that the use of technology in teaching and learning of mathematics should be a priority in the schools, further highlighting how the implementation of critical thinking skills can be diversified across various educational sectors. (Adelabu et al., 2019)

Thought Processes Used by Teachers to Make Mathematical Assignments (Cognitive Science)

Researchers in recent scientific advancements found a pattern that separated the decisions used by new teachers to make problems, and those used by more advanced teachers (Murtafiah et al., 2020). They learned that while less experienced teachers employed problems from textbooks, those who have been teaching for longer designed their own new problems, and adjusted those problems to be relatable to students. For instance, the researchers noted that an experienced teacher wrote a problem about a class with twenty-two students, which was relatable to all of the students in that class. According to these same researchers, novice teachers trust textbook publishers to give them the best problems, and will use them for classwork, as a "one size fits all" approach (Murtafiah et al., 2020). Meanwhile, more experienced teachers, who have the knowledge of how their students react to different problems, will have written their own problems that are specific to their class. The specificity of these problems can make them more interesting, and thus make a student more likely to solve a problem that is more relatable, than one that is more generic.

In order to create their worksheets, teachers can use a school of thought known as Analysis, Design, Development, Implementation, and Evaluation, or ADDIE (Supriyanto, 2020). Analysis refers to analyzing what students in a specific class need in order to learn, Design refers to planning out how the worksheet will be formed, Development is when the problems in the worksheet are created, Implementation is when these problems in the worksheets are distributed to students, and Evaluation refers to the feedback of the students on the worksheets, which is needed to make those worksheets better. This process was used to make a math assignment catered to students at an Indonesian school, and was well received (Supriyanto, 2020). However, ADDIE, which is reminiscent of the Scientific Method

and Engineering Process, could impose too much work for teachers, who must grade assignments and manage their time effectively. Thus, in the future years of research, whilst ADDIE does exemplify great growth, it could be implemented in mathematical software to improve its versatility.

Evaluation of Software That Can Be Used to Make Different Mathematical Problems

One software that can help teachers make problems easier is LaTeX, a typesetting software with a multitude of different commands to create PDFs of math equations, and thus make math worksheets. LaTeX has many functions that are accessible by using the backslash, such as using square brackets to make multi-line equations (Grätzer, 2013). Unfortunately, due to the fact that this typesetting system is text-based, it comes with a complicated learning curve that can be difficult for teachers to climb, especially if they have to spend most of their time grading classwork. For instance, it can take some time to learn how to bold, italicize, underline, add single-line and multi-line equations, and style LaTeX-generated pages to look good. Nevertheless, once one is familiar with a text-based language such as LaTeX, it will become easier to write in it, than it would be to perform the same action in a traditional word processor.

A math teacher from California State University created a math worksheet generator in order to teach students in middle school. In order to do this, he used Google Sites, and created a site that parses templates in order to create problems that can use random numbers, and thus differ across different students (Garcia, 2017). This is a very nice way to make homework less repetitive, since it can make everyone's worksheet unique, meaning that every student will have to actually try on each problem, instead of acquiring answers from their peers. Unfortunately, the site for this generator does not exist anymore, but the teacher provided a very meticulous guide on how he made the generator, which could be used for making a new worksheet generator in the future (Garcia, 2017).

Discussion (Ethics & Limitations)

In terms of ethical limitations, it is important to note that some of the findings cannot be diversified to other incoming research studies, as the results were obtained from earlier years. For instance, some of the results obtained from early 2018-2019 cannot be diversified to the current period, as AI and scientific advancements within technology have become much more progressive over the past few years. Another aspect to note is in regards to the ethics of job and career opportunities. For instance, this concern is in regards to the employment and job loss that could happen for instructors, as a result of significant advancements in AI and technology, which could take away jobs for millions of individuals. At the same time, mathematical technology could also make the jobs of teachers easier, if it is not fully used to replace teachers, thus meaning that they can focus on other things, such as the needs of individual students to learn on their own. This means that although Artificial Intelligence is hazardous to the teaching job market, in moderation, it could help make schooling better, and help each individual child learn better, with less students being left behind in their education, as well as an optimization in students' productivity and learning processes.

Conclusion

In conclusion, through scientific advancement made possible through various implementations of mathematical tools that provide academic solutions in STEM learning, researchers have been able to witness the prominence of applying problem-based learning and critical thinking (CT) through formulating proper scientific argumentation. In addition to this, specific tools like dynamic geometry computer software (DGCS) have been utilized in various educational groups to help learners dabbling with mathematical understanding, that have promising efficacy in various educational sectors across interdisciplinary areas. When making assignments, it is important to always keep the individual student

and their needs in mind, and the ADDIE model can be utilized to help create schoolwork with this principle in mind. Typesetting programs and template math worksheet generators are tools that teachers can use in order to make worksheets easier, which gives them more free time to experiment with their worksheets, and use thought processes such as ADDIE to improve the education of their students. Further research and innovation is required to make more interventions that expand on those previously mentioned.

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