Digital Technology in STEM Education: Coding and Programming as a Base-line

Abstrak

Teachers use varieties digital resources to assist learners explore and learn Science, Technology, Engineering, and Mathematics (STEM) particularly now that tremendous progress has been made in the field of computing where information technology provides communication between people and ensures that the transmission of information is not restricted. In view of this development, this paper considered learning STEM through the use of computer technology in the form of coding. In the paper, children of today are regarded as digital natives and generation Z during digital technology of the 21st century who required to be taught the STEM disciplines using digital technology. Also how coding works in STEM Education and some resources that can be used to teach children programming with some guidance were discussed by the paper in addition to the benefits of integrating digital technology in STEM education.

Keywords: STEM education, Coding, Digital technology, Computing, etc..

Corrienna Abdul Talib[1*], Faruku Aliyu[2] & Ramlawati[3]

[1]Faculty of Social Sceinces and Humanities, Universiti Teknologi Malaysia,

[2]Depertement of Science Education, Sokoto State University, Sokoto Nigeria

[3]Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Negeri Makssar, Indonesia

[*]corrienna@utm.my

Introduction

In today's world, tremendous progress has been made in the field of computing. Information technology provides communication between people and ensures that the transmission of information is not restricted. The Internet, wireless Internet networks, and mobile devices have entered social life, accelerating the progress of science and technology. Digital cameras, smartphones, tablets, and other mobile devices have become influential participants in the rapidly changing global world (Uçak, 2019). STEM is regarded as an educational course that emphases on science, engineering, ,technology and math. In conventional education, the subjects are divided into separate courses. But through STEM, students learn them from an interdisciplinary system designed to train the workforce. STEM learning activities helps connect the dots between subjects. STEM learning is more than just learning how to integrate course subjects. Bringing STEM approach into the classroom provides numerous opportunities for creativity and innovation projects. STEM is an educational philosophy that teaches these topics in project-based courses, such as the challenges students face in real life outside of the classroom. In the real world, few challenges only require a set of skills. Without practical application, it is difficult to understand how various skills are related to each other (Victoria, 2018). For example, programmers use science, mathematics, design, technology, and art to create their final product. If you do not understand all STEM concepts, you will not be able to design new applications, video games, or computer programs. One of the most common misconceptions about STEM education is that students need the latest technology and equipment to stay ahead. Curvilinear. Although technology is constantly changing and evolving, STEM doesn't necessarily have the most expensive equipment. STEM should focus on solving problems so that young people can live a life based on technology. It must prepare them to continually learn new advancements throughout their lives and lay the foundation for their expectations of new tools and procedures to be developed in the future. Students learn creativity and innovation as they complete the project from start to finish. As students learn through STEM projects, they are developing the skills of determination and perseverance through difficult task.

The children of today are regarded as digital native generation Z during digital technology of the 21st century. They grow up with marvelous advancements in technology resulting from the power of artificial intelligence and programming. STEM education emphasizes creating and developing soft skills such as creativity, critical thinking, metacognitive skills, and the necessary skills required of

them in solving real-life problems with the help of assorted logic, science, and technology (Ninjas, 2020). Through coding, teaching students how to integrate technology into various disciplines would be made easy. The students learn how to code and develop a solution and solve an existing problem through computational thinking which is very vital and critical in problem-solving skills among students. Teaching students the strategies of breaking down concepts and problems into simpler ones that are manageable in byte size. The coding guides their visualization of abstract concepts to enhance their talent in dealing with their failure and improving their success.

Coding in STEM education plays the role of linking theoretical science with practical technology. It must be understood that it has become an almost universal requirement and applies to all areas of work. Machine literacy and technology awareness begins at an early age. Emphasize coding through virtual aids and hand toys (STEM kits) to ensure students have fun while learning to deal with the world of programming.

How Coding work in STEM Education

Technology is regarded as an integral part of any STEM activities. It contributes to the design and implementation of STEM activities in a variety of ways. When analyzing the use of technology in STEM education some issues are considered; direct embedding of technology in STEM approach; using technology as a tool or facilitator to enrich STEM (Capraro, Capraro, & James, 2013). Hence, technology is incorporated into engineering, science, and mathematics. In this method, students use digital technology to find problem-solving methods in inventive and difficult ways. In this way, the use of digital technology inspires students to innovate and develop thinking skills while working on projectsSTEM education always bundles technology with natural science and formal science so that children can learn to code by understanding the functions that different parts of the code can perform. Here are some resources/software that can be used to teach children programming/coding with some guidance.

1. **Scratch:** Applications like Scratch and ScratchJr are used to teach coding as part of STEM. These platforms allow learners to bring their imagination to the world in the form of stories, games, or simple animations. Scratch is a coding technique that involves sounds, graphics, and other programs. The first version of this game-based project was developed in 2003 by Brian Silverman and Paula Bonta. Scratch platform has been used in teaching and learning process to enhance reasoning skills (Talib, Aliyu, Malik, & Siang, 2019) and computational skills as

shown in Figure 1 based on the Scratchtopia Challenge Project (Loganathan et al, 2019). It allows engineering and technical teachers to design and create conceptual and visual courses to guide the learning of abstract concepts and develop students' reasoning skills.

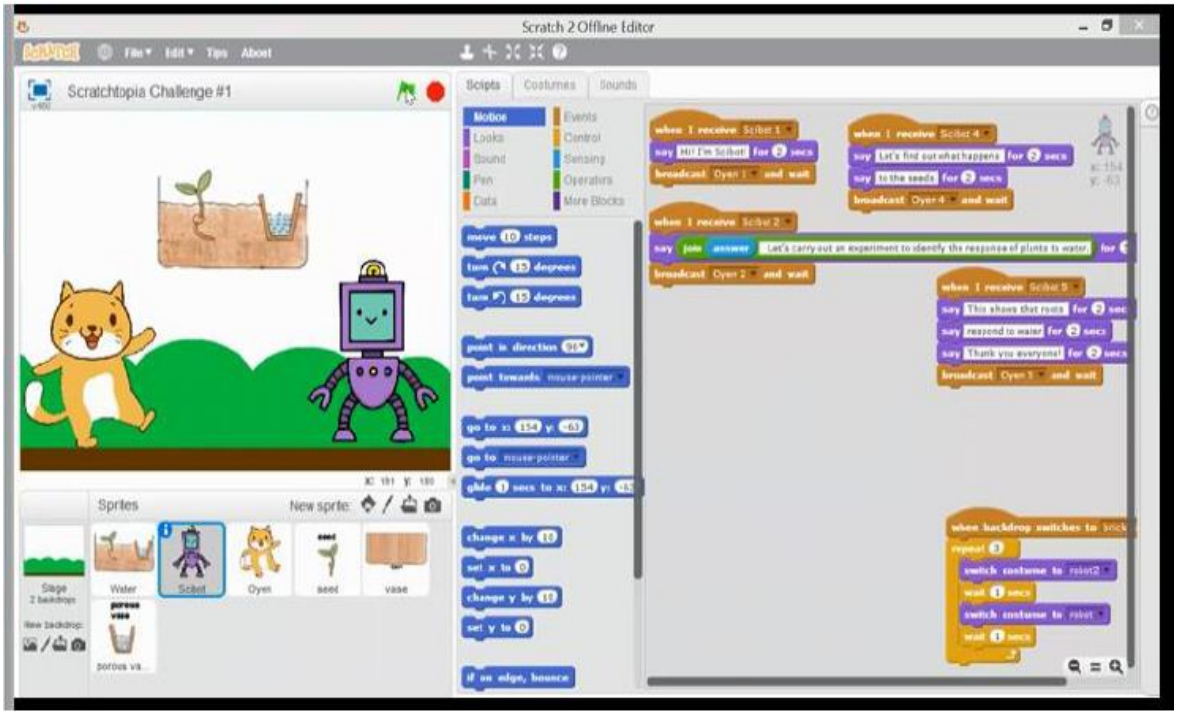
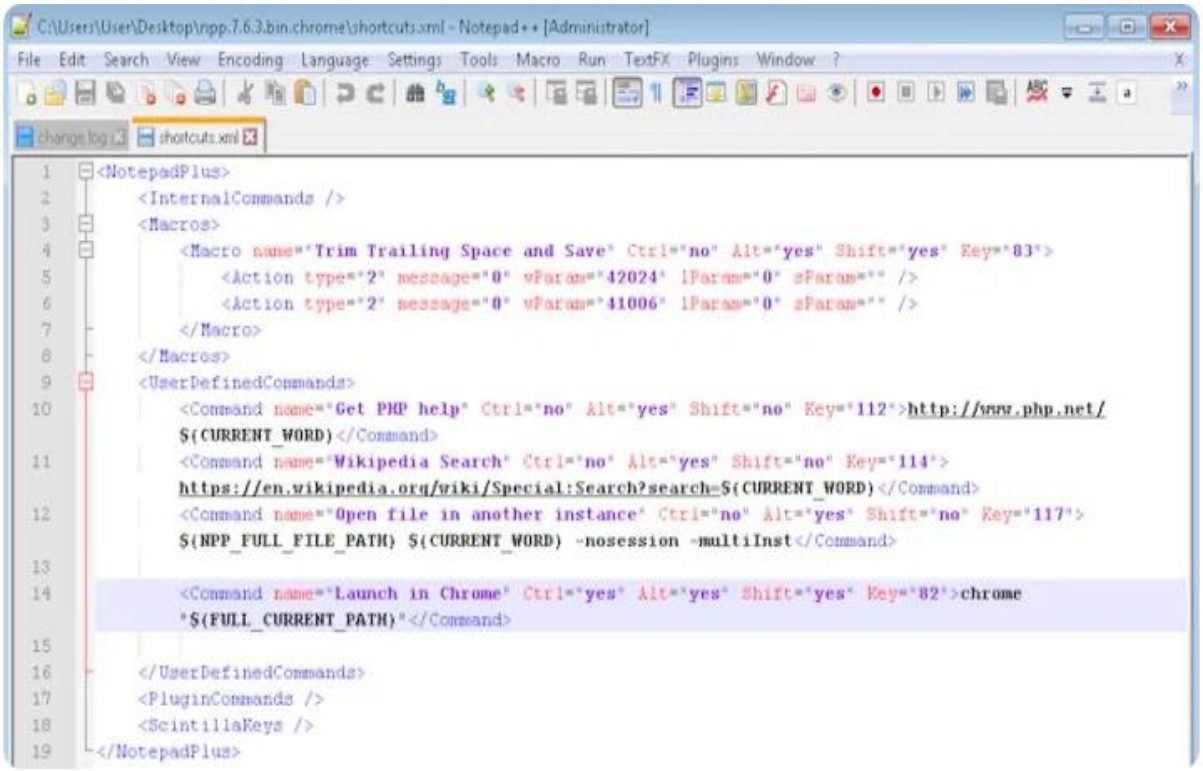


Figure 1 Example of coding with visual programming language based

Oluk and Korknaz (2016) conducted a study comparing the computational thinking of students who used Scratch and those who did not, and found that there is a highly significant relationship between students' computational thinking skills and their programming. Skills from scratch. It was found that students' reasoning ability improved when playing temporary projects (Brown, 2017; Kalelioglu & Gulbahar, 2015; Vaca-Cardenas et al., 2015). Integrating coding like games into teaching and learning STEM can improve students' reasoning ability in computer engineering and other engineering technology fields**.**

2. Notepad++: This is more than just an editor but rather a replacement for Notepad that supports many different programming languages. It is written in C++ and uses Win32 to ensure a smaller program size and very faster execution speed (RankRed, 2021). It is an excellent companion for coding projects in STEM learning. It is characterized by its multi-tab editing function,

which can process multiple documents at the same time. The editor can easily check the files of each stage of the embedded software project, from HEX source code to C++ source code.



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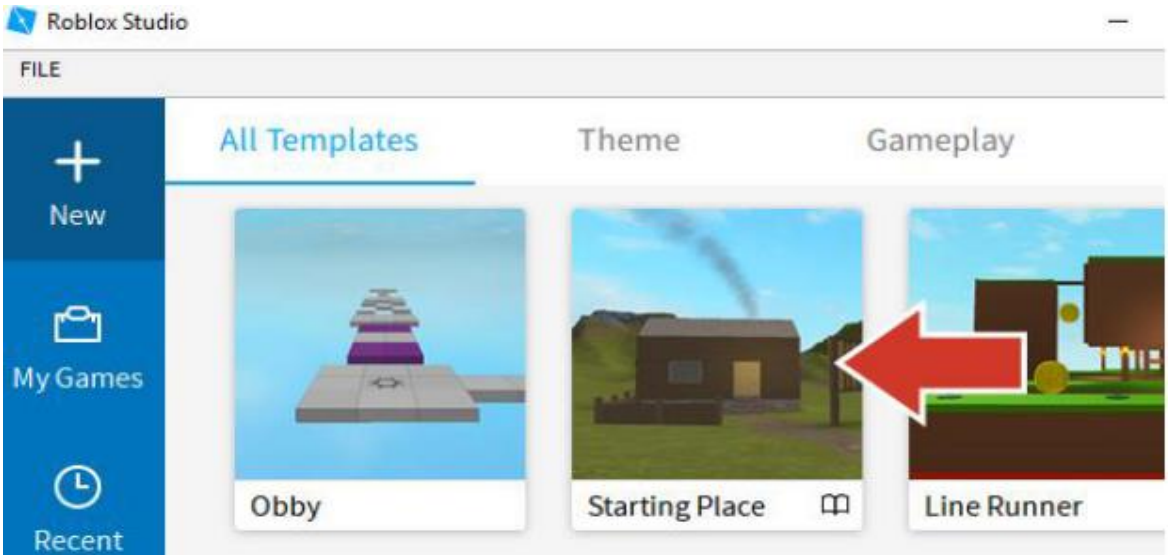
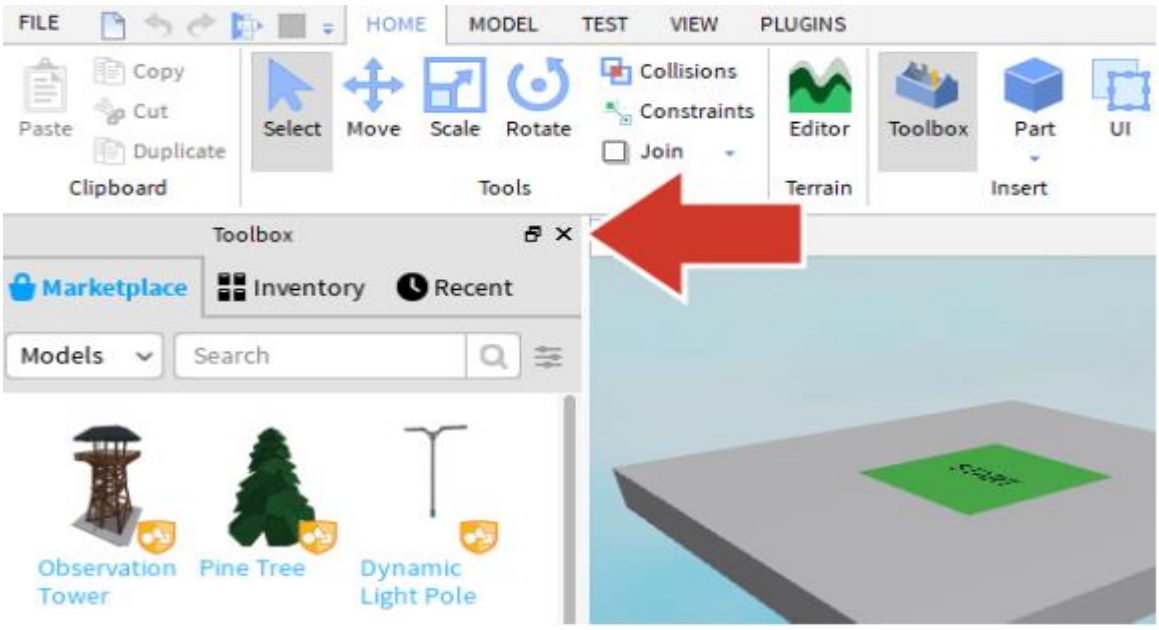
Some of the advantages of Notepad++ include easy to read and write files, supports more than 60 programming/scripting languages, and can automatically save files and also find and replace multiple files at once even though it sometimes hangs when processing large amounts of data.

3. **Roblox:** Another favorite platform for kids is Roblox, where they can design, build and create their 3D worlds and games. Roblox is not just an entertainment platform, it is also an educational tool. provides free software and courses to teach students of all ages computer science, digital literacy, entrepreneurship, and satisfy STEAM (science, technology, engineering, art, and mathematics) learning Outcome). Students can build 3D worlds, write game scripts, and publish works online without subscription fees or licenses (Roblox, 2019). According to Long (2020), Roblox as an educational game provides various opportunities to

learn unlimited creativity from STEM, coding, innovation, and educational games. As students learn the basic principles and structures of languages in regular classrooms, and with the advancement of technology, another language has emerged. With the rise of video games and online games, students are unknowingly exposed to the language of computer science, innovation, and scripting. Video game enthusiasts can understand its essence because they have the first-hand experience of the world of video games. For example, when students design a Minecraft skin through Minecraft, they already know how the character should be different from the default skin (Steve).





The layout of Roblox Studio (Roblox, 2019)

Players who have played Roblox will have the advantage of creating games or virtual worlds because of their experience. How the example character (avatar) behaves in the actual configuration of the game, including the operation of design (for example, construction). Although this is not limited to understanding the basic commands of the keyboard keys. Playing the game itself requires familiarity. To perform tasks, you need to master keystrokes and commands. Therefore, teachers must fully demonstrate these skills at the beginning. Set aside time for students to learn basic skills. The game must also have a clear goal. Students should be able to complete this work without expecting them to spend money. For educators who can use the Roblox platform to create games, the game must be intentional. Any learning can be applied, such as setting obstacles for spelling (obby), students can enter the next level by correctly spelling words. Roblox has hundreds of games or virtual worlds to explore, which can be used as learning opportunities. Educators can use back-end functions to create or present learning, which is also a playable level (can be tested). Both the design platform and the creation of the initial account are free (Long, 2020). Teachers and students do not need to use real names to create accounts. The account also allows them to access different games. The game must be connected to the Internet to use it. Students should be reminded of the importance of safety, cyberbullying, fingerprints, and chatting with people they don't know. Therefore, the

private server needs full control and the owner can choose which players to invite. On the other hand, Roblox has features such as a reporting system, chat filters, and customizable parental controls to ensure the safety of each player.

4. **Python**: is a high-level, general-purpose programming language since the code is automatically compiled into bytecode and runs, Python is suitable for use as a scripting language, web application implementation language, and so on. Because Python can be extended into C and C ++, Python can even provide the speed required for computationally intensive tasks. Its powerful structure (nested code blocks, functions, classes, modules, and packages) and the constant use of object-oriented and object-oriented programming, Python allows both learners and teachers to write clear and logical applications for small and large tasks (Kuhlman, 2013). The Python language is becoming more and more popular as a scientific computing language, mainly due to its concise syntax, high-level standard libraries, and various scientific packages. However, compared to the same algorithm written in a statically compiled language (such as C), the cost of running a scientific application written in Python is high, due to the many dynamic search and interpretation costs inherent in high-level languages (Guelton et al., 2015).

```
def dot(l0, l1):
    return sum(x*y for x,y in zip(l0,l1))
```

and in C++:

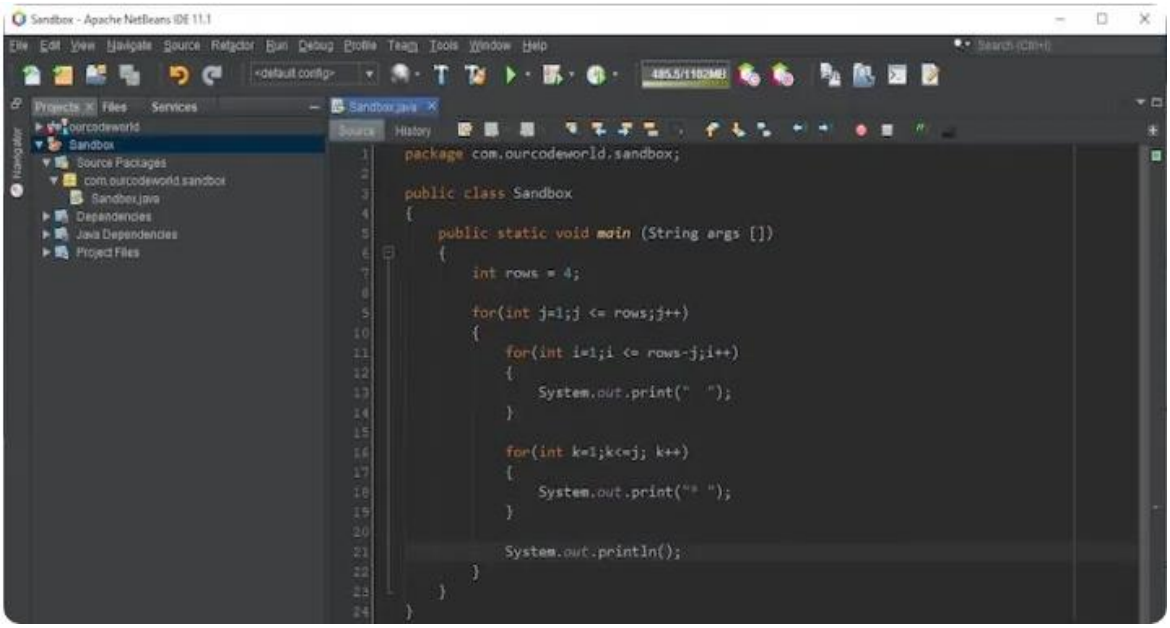
```
template<class T0, class T1>
    auto dot(T0&& l0, T1&& l1)
    -> decltype(/* skipped */)
    {
        return pythonic::sum(
            pythonic::map(
                operator_::multiply(),
                    pythonic::zip(
                        std::forward<T0>(l0),
                        std::forward<T1>(l1))
            )
        );
    }
```

Sample of Python Programming Language (Guelton et al., 2015)

In addition, the Python compiler does not optimize bytecode, and scientific applications are first-class candidates for many of them. Python is an interpreted high-level general-purpose programming language. Its design philosophy emphasizes the readability of the code by using significant indentation (Kuhlman, 2013). Its language structure and object-oriented approach are designed to help programmers write clear and logical code for small and large projects. Python is dynamically written and garbage is collected. It supports multiple programming paradigms, including structured (especially procedural), object-oriented, and functional programming.

5. NetBeans: This is an open-source that allows you to quickly develop Web, desktop, and mobile applications using Java, C/C++, PHP, etc. Applications are developed from a set of modular software components called modules. This tool does not require any license and is easy to use (RankRed, 2021). One can indent code effortlessly-just define code indentation rules for each language, and the system will follow those rules accordingly. Also one compares code in different files to see the differences between code from different developers (Ganfield et al.,

2014; Ide, n.d.; Infographics, 2018). NetBeans integrates seamlessly with various web application servers such as GlassFish and Tomcat. It also applies to version control tools.



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NetBeans is easy to use and very efficient in code development, it supports multiple programming languages and includes static analysis tools and batch code analyzers that are very suitable for creating test scripts for automated testing though it consumes more RAM compared to others and sometimes it becomes slow to compile and run programs.

Benefits of Integrating Coding and Programming as Digital Technology in STEM Education

Technology can contribute to the design and implementation of STEM activities in many ways. The use of digital technology inspires students to invent and develop skills when working on projects (Dogan & Robin, 2015). The technology of programming and coding is also a good tool to promote the effective learning of STEM subjects. Teaching strategies based on digital technology can be described as ethical practices that promote student learning and improve their skills, productivity, and performance (Imforgraphics, 2018). It has also inspired positive changes in teaching methods internationally. Imforgraphics (2018) outlined advantages of integration of technology in the field of STEM education as; facilitating teaching with audiovisual presentations; projection and computer

presentations to make teaching becomes easy; helps to track student progress and allow teachers to track student performance; increase student participation using a laptop or iPad to study can increase their participation and interest; make collaboration effective online tools and applications provide to a unique environment for students to participate in projects; make information accessible to students and teachers.

Teachers use various digital technologies to assist students learn, support classroom collaboration, and conduct formative assessments. They also make of use the internet and websites to guide students learn and strengthen their understanding of specific content. There is no doubt that technology is a tool used by teachers when preparing lessons and sharing experiences with other students. This means that technology has changed teaching and learning methods (Byers, 2016).

Birzina & Pigozne (2020) determined the role of technology in the process of STEM learning. With the help of electronic platform QuestionPro, a survey was conducted 128 STEM teachers and 257 students in schools in Latvia. The data obtained show that both students and teachers have some similar and different views on the use of technology. They both use technology primarily in regenerative ways as regulars of information rather than productive developers of knowledge. There are issues with specific STEM technologies: sensor data logging and processing system, computer tuning microscope, and lab simulation for virtual experiments. By implication the impact of digital technologies in STEM approach is of significant role.

Generating content with the support of technology, such as designing and programming robots, supporting active learning and deeper understanding. By creating content, students reorganize and reshape their knowledge, thereby deepening their learning and fostering creativity. Students went from learning to program to using specific concepts (eg, conditional statements, repeated blocks) to programming robots (Yang & Baldwin, 2020). Students demonstrate collaborative thinking in design, construction, and problem-solving. The use of robotics allows students to engage in trial and error and explore the relationship between different mathematical concepts (such as measuring the circumference, measuring length) collaboratively. Using technology to design, iterate, and create products (for example, designing and programming robots) can help alleviate some of the challenges associated with integrating STEM learning environments. Robot assembly and programming helps explain to students how ideas from different disciplines are connected (eg, programming and math

concepts) (Yang & Baldwin, 2020). Robots help students demonstrate relevant scientific and mathematical concepts and provide a way to effectively connect subject knowledge in a comprehensive environment.

Conclusion and Suggestion for Further Studies

Generating content with the support of digital technology, such as designing and programming robots, supports active learning with deeper understanding. Students reorganize and reshape their knowledge, deepening their learning and foster their creativity. They demonstrate collaborative thinking in design, construction, and problem-solving. The use of technology allows students to engage and explore the coding on different mathematical concepts (such as measuring the circumference, measuring length) collaboratively. Hence, they can design, and create products (for example, designing and programming robots) that could help alleviate some of the challenges associated with STEM education. The paper is conceptual, it, therefore, suggested further research on the empirical aspect with hands-on activities regarding coding in STEM education.

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