The International Journal of Science, Mathematics and Technology Learning
ISSN: 2327-0128 (Print), ISSN: 2327-2627 (Online)
Volume 30, Issue 2, 2023
https://www.ijsmtl-cgrn.com

Perspectives on STEAM Education during the COVID-19 Pandemic at an Underprivileged Elementary School in Thailand

Isara Phonnong, Nakhon Ratchasima Rajabhat University, Thailand
Wasana Keeratichamroen, Nakhon Ratchasima Rajabhat University, Thailand

Received: *07/18/2022;* ***Accepted***: *10/10/2022;* ***Published:*** *02/15/2023*

Abstract: The COVID-19 pandemic has had an impact on every aspect of human life. One of the educational challenges has been the transition of teaching from onsite locations to distance learning, as schools with online facility gaps must do the same as well. In this context, STEAM education has widely been accepted as an approach for developing creative thinking and problem-solving abilities. The purpose of this study was to examine teachers' and students' perspectives on STEAM education through distance learning in underprivileged elementary schools during the COVID-19 pandemic. The sample group consisted of 6 teachers and 47 students from an underprivileged primary school in Nakhon Ratchasima province, Thailand. A structured interview was used as the research instrument, and the data were then analyzed by using the content analysis method. The findings revealed that distance learning provided teachers and students with both advantageous and challenging perspectives on the STEAM-centric curriculum. The main benefits were that STEAM education might assist students in achieving mastery in science and mathematics, as well as applying their learning experiences to real-life situations. On the other hand, students faced a hurdle when it came to using digital gadgets, and they also needed to improve their reading and writing skills.

Keywords**:** Underprivileged Elementary School, STEAM-Centric Curriculum, Distance Learning

Introduction

A new coronavirus called COVID-19 emerged and spread across the world since November 2019 that later intensified expeditiously into a health crisis in many countries. The COVID19 pandemic spreading across the planet since 2020 has not only been a global health crisis but has also affected every aspect of human living. Hence, as individuals and societies, we have needed to transform the way we think and act (UNESCO 2020). Furthermore, measures have been taken by most governments around the world to manage this infectious disease, such as the announcement of a general lockdown, social distancing, and transforming faceto-face learning into distance learning. Electronic learning has also been used by teachers to create learning materials for their students to enable the process of learning to continuously progress (Alsoud and Harasis 2021). Additionally, this critical situation has affected the use of e-learning tools that have played a key role in academic institutions worldwide (Giovannella 2021). These tools have played a crucial role in universities and schools, for teachers to have convenient instructional activities during the institutions' closure. These have been in both free and paid versions to maintain continuous learning (Almaiah, AlKhasawneh, and Althunibat 2020). However, the success or failure of any e-learning system is determined by how well users can utilize it. Depending on their prior experience, both learners and teachers have encountered various challenges in using e-

learning platforms at home. Consequently, teachers should be well trained in how to use the various e-learning systems. The shift to e-learning has raised concerns about the quality of traditional education (Alodwan 2021) because children's opportunities in life are strongly influenced by the quality of their education. As such, schools aim at providing children with the necessary knowledge, skills, and interpersonal competencies for working and developing society in the future. Schools can also offer learning experiences that a student may not obtain at home.

Creative thinking is one of the major skills for the twenty-first-century learning of students who are preparing for coping with more complex lives and work (UNESCO 2009). Because of the rapid changes of our present society, we require that problems be handled in a creative manner. The technological advancements and impressive discoveries during the next decades could surpass all the past successes in human history. Consequently, it is difficult to foretell exactly what knowledge and skills could solve the future problems creatively. Moreover, what young students are learning now would also certainly become outdated. Hence, we must continue to gain knowledge throughout our lives, but knowledge alone is no assurance that we could effectively resolve future problems. Only a strong creative ability would be an effective tool for coping with the problems (Mayesky 2002). In addition, STEM (science, technology, engineering, and mathematics) has become a ubiquitous term that is relevant for workers in the century of rapid economic change. There was a belief that students who were educated in STEM subjects tended to exhibit curiosity, creativity, and entrepreneurship (Lindeman 2020). Nevertheless, STEM may not necessarily be sufficient for the future. Consequently, the idea of STEAM education was initiated, which was an evolution from the concept of STEM that included the arts; this inclusion thus provided an interesting representation of what would be a holistic sociocultural development. Therefore, a STEAMcentric curriculum would offer an opportunity to inject creativity into any courses that were traditionally more natural (Khine and Areepattamannil 2019; Zeidler 2016).

In the twenty-first century, technology and learning have become important issues to focus on with regard to educational systems. Additionally, a curriculum's design influences young people's minds and perception; it encourages them to perceive and act in society in specific ways. As a result, every aspect of curriculum reform must be understood and grounded in long waves of societal changes that span the past, present, and future. Thus, a cybernetic type of thought would pervade attempts to both explain and reconstruct the links between the curriculum and society in the digital age, which is a current trend in curriculum development. Because curricular objectives are related to a global concern about the digital era, the future curriculum has become a hot topic of discussion. New technology and digital media, maybe more than any other areas of education, have attracted the interest of a wide range of parties beyond the formal curriculum (Williamson 2013). Moreover, the rapid transition to the digital world during the school closure period has revealed significant disparities in access to digital technology not only between nations, but also between social categories within countries. The sharp digital division has exacerbated and magnified the social divide, as well as increased inequality and had a direct impact on how learning losses are distributed among socioeconomic groups after school closures. As educators and students must familiarize themselves with the new types of technologies in recorded time and deal with uncertainty regarding internet access or connectivity, the sudden shift to online teaching, without careful prior preparation, has had an impact on both learning as

well as teachers' and students' perceptions of online education (Zancajo, Verger, and Bolea 2022).

The United Nations (2020) also reported that many learners in developing countries were not fluent in the language of instruction. In most European countries, children from lower socioeconomic backgrounds were more likely to lack reading opportunities and parental support during school closure. Additionally, Tadesse and Muluye (2020) addressed the issue of how the COVID-19 pandemic was affecting schools, students, teachers, and parents. Furthermore, learning deficits disproportionately impacted students whose parents had a poor level of education and were receiving social assistance (Maldonado and De Witte 2020). Impoverished schools in rural areas also lacked the appropriate digital infrastructure to ensure effective teaching and learning. Therefore, if children were attending a school with inequitable educational policies and practices, it would have negative consequences for the individuals, the economy, and social development at large (OECD 2012).

In general, some teachers in Thailand were not prepared to use online education, and most pupils were unable to access it as well (Fakcharoenphol et al. 2020). Approximately 55 percent of Thailand's underprivileged elementary schools, out of the total number of government schools, faced a shortage of resources, equipment, materials, digital devices, and teachers for implementing a STEAM-centric curriculum (Thailand Development Research Institute 2015). This situation has affected the improvements of the achievements and creative thinking skills of students in underprivileged elementary schools. During the COVID-19 pandemic situation, these schools needed to continuously educate students using STEAM-centric curriculum through distance learning in order to enhance their creative thinking skills and protect them from learning loss, but instruction through distance learning during the COVID-19 crisis was difficult to administer. Although many researchers have separately studied the relationship between STEAM education and distance learning, the effects of offering STEAM education through distance learning during the COVID-19 pandemic have rarely been reported. As a result, the research question of this study was: what were the positive and negative effects of STEAM education via distance learning on teachers and students in underprivileged elementary schools?

To answer the research question, this study aimed to investigate the perspectives toward STEAM education of teachers and students in underprivileged elementary schools in Nakhon Ratchasima province, Thailand, during the COVID-19 situation. The findings required providing equally effective STEAM educational activities through distance learning for supporting the performance of all students in impoverished elementary schools, regardless of whether the activities through distance learning were implemented in a nonstandard stage or not. The results of this study would be useful to the Ministry of Education, which must effectively prepare an educational system that is beneficial for all.

Theoretical Framework

The COVID-19 outbreak impacted schooling rapidly. However, the educational system had to continuously operate to enhance the learning outcomes and needed skills of the students. This study about the perspectives of the teachers and students toward the advantages and challenges of a STEAM-centric curriculum during the COVID-19 pandemic was based on the STEAM approach and pedagogy for the COVID-19 pandemic situation.

STEAM Education

The key reason why STEAM education was important was because it could result in innovation, which could develop a strong economy. Correspondingly, in China, they were also interested in STEAM education because the Chinese government believed that it would lead to the phrase "invented in China" rather than "made in China." Another significant goal of supporting the inclusion of STEAM programs in schools is to encourage students to be more creative and empathic, which consequently bring them pleasure (Catterall 2017). Thus, STEAM education has clearly been recognized as having five roles, as described later (Honey, Pearson, and Schweingruber 2014; Huser et al. 2020; Yakman and Lee 2012).

Science is the study of natural phenomena. This content-driven subject is linked to biological, physical, and chemical laws. Science encompasses both the methods of scientific investigation used to generate new information and the body of knowledge that has been accumulated over time.

Technology encompasses the entire systems of people and organizations, as well as knowledge, procedures, and equipment. It is a tool for creating and operating both technological artifacts as well as the artifacts themselves.

Engineering is the study of structural and mechanical designs and the creation of products and processes in accordance with the purposes of solving problems or meeting demands. Engineering design is used in conjunction with any limits imposed by natural or scientific laws, such as time, money, available materials, ergonomics, environmental requirements, reparability, and manufacturability. In most cases, engineering makes use of science, mathematics, and technology tools.

Arts have been integrated with STEM to become STEAM for providing opportunities to make an educational environment which enables and strengthens the students' creative and innovative thinking. The four art disciplines in STEAM consist of the following: (1) language arts are the way in which all learners communicate; (2) physical art is the manual and athletic arts, including the ergonomic movement; (3) liberal arts consist of various types of education: history, philosophy, politics, psychology, sociology, theology, and science technology society (STS); (4) fine arts are aesthetic arts that are the oldest surviving cultural pieces from the records of civilizations.

Mathematics is the study of logical arguments based on presumptions. Science, engineering, and technology are all supported by mathematics. Mathematics is also the study of patterns and interactions between quantities, numbers, and space in general. Numbers and arithmetic, algebra, function, geometry, statistics, and probability are among the conceptual categories in K-12 mathematics.

Hence, STEAM education can develop problem-solving abilities in learners and create an interest in and understanding of science and technology. It is a necessity to nurture the creative talents in young people who will drive the future advances in science and technology (Connor, Karmokar, and Whittington 2015; Kim and Chae 2016). Recently, technology has been integrated into our lives and has introduced many changes in numerous aspects, including education (Hyun and Park 2020). During the outbreak of the COVID-19 crisis, schooling began to be conducted on online platforms to ensure its continuity. Thus, the STEAM setting has had to change; the "T" component has transferred a traditional teaching activity from a whiteboard or blackboard to an electronic device that has been shared through online platforms (Dana-Picard and Hershkovitz 2020). As a result,

teaching and learning have the opportunity to develop twenty-first-century pedagogy. However, each STEM and STEAM researcher indicated that COVID-19 has had a negative impact on schools. The STEM approach, which was the origin of STEAM, had a negative impact on student performance, and teachers anticipated that students would withdraw from school if the COVID-19 pandemic continued to spread (Sintema 2020).

Pedagogy for the COVID-19 Pandemic Situation

Culture affects the perception and effectiveness of the learning experience. There was a general assumption that people from various cultures and linguistic backgrounds would develop their own approaches and assumptions for their learning experience; as a result, the growth of diverse cultures necessitated concerns about the diversity of learners. The backgrounds of the learners were related to the new learning environment of the digital era. As a result, the distribution of the internet system and informal education communities has led to the development of a new teaching method. As distance learning courses are on the rise, Western approaches need to be reconsidered carefully when designing an online course. The key to this issue is seen as providing culturally appropriate instruction. The pedagogy could underpin technological education to deliver knowledge and skills for learners effectively. The cognitive approach, which informed the principles of early distance learning practices, was dependent on paper-based technology. While the technology of the cognitive approach had been essential at that time, the social constructivism approach was then established in the age of social media technology that was utilized in developing multiple ways of instructional interactions. Finally, the connectivism approach was developed, and the kind of technology which could be implemented for distance learning was developed to deliver educational activities (Saykili 2018). Since then, the popularity of distance learning has increased in many countries worldwide. Some elements of distance education include the physical isolation of the instructors and learners, teaching and learning in the educational context, utility of technological media, and the communications of the instructors and learners. More recently, distance learning has been seen as an educational practice where the instructors and learners are separated in space and time, thus being physically absent from the on-campus experience of academic institutions (Fidalgo et al. 2020).

In addition, the twenty-first-century world necessitates the use of technology in daily life. Educational institutions and teachers have globally manipulated educational reforms to respond to this changing situation (Naidoo and Govender 2019). However, the COVID-19 outbreak has changed the curricular contexts. This disease introduced the need to use digital platforms and brought certain knowledge and competencies into the new curriculum which was more relevant to the present and future contexts. Therefore, these adjustments needed to prioritize the values and competencies, self-directed learning, empathy, emotional skills, health, resilience, and learning environments that occurred within the changes in the current situation. Since the spread COVID-19, schools are suitably equipped with digital platforms, digital devices, and online tools for teaching and learning (OECD 2020b). Some of the online platforms, such as Microsoft Teams, Google Classroom, Canvas, and Zoom Meetings have allowed teachers to create educational courses, trainings, and programs of skills development to support learners. These platforms have also included options of workplace chatting, video conferencing, and file storage that have helped classes and work to continuously operate. Furthermore, during the COVID-19 pandemic, UNESCO and the

European Commission recommended two educational methods for distance learning, as described later (FrantiŠek and Jan 2021).

Synchronous learning is a learning environment with real-time, specific virtual interactions between students and instructors. The commonly used methods of synchronous learning include video conferencing, teleconferencing, live-steamed lectures, and live chatting. These settings enable both students and teachers to see each other when teaching and learning. However, synchronous learning is primarily effective for learners who have a stable internet connection and compatible digital devices, behave in an active learning manner, and constantly interact with their peers and instructors in the learning activities.

Asynchronous learning happens on students' schedules, in which the learning does not happen in real time. In this case, the instructional materials comprise different forms, texts, completed assignments, and videos that were provided by the instructor, which students had to access and then satisfy the lesson requirements by themselves. The frequently used methods of asynchronous learning include lecture notes, self-guided lesson modules, virtual libraries, audio content, interesting content from internet sources, and online discussion boards. Students perform self-directed learning and may occasionally interact with the instructors through social media, learning platforms, or email. The obvious advantages of this mode of learning are the flexibility, pacing, and affordability; students can satisfyingly access the available materials and complete them at their own convenience as long as they meet the given deadlines.

Likewise, distance learning provides the following benefits: (1) teachers and students can interact with each other from anywhere and anytime; (2) students can learn wherever they can access a computer or digital devices with an internet connection; (3) time is not wasted in commuting to and from school. However, self-directed learning is one of the most important factors of successful online distance learning. Students would become lifelong learners when they take the responsibility for their own learning (Sadeghi 2019).

Methodology

The Ethics in Human Research Committee of Nakhon Ratchasima Rajabhat University in Thailand approved this study. The interview research method was used to perform the study. This research was conducted in the 2021 academic year. The population consisted of 60 teachers and 226 students from 3 underprivileged elementary schools in Nakhon Ratchasima province, Thailand, which were under the Office of the Basic Education Commission. However, the sample group consisted of 6 teachers and 47 students from Grades 5 and 6, who were selected from the whole population using simple random sampling. As a result, both synchronous and asynchronous learning were adapted to design STEAM activities through distance learning. Teachers implemented the STEAM-centric curriculum via distance learning for four weeks using three online learning platforms: Google Meet, Zoom Meetings, and LINE application. They were used in combination with a variety of materials, including PDF files, learning equipment, worksheets, textbooks, and video clips of the content from which students could learn as much as they would like at any time. The four themes of the learning activities across the STEAM-centric curriculum through the distance learning methods consisted of the following:

1. The "highest building" activity was the first theme, which included a package of equipment and materials covering knowledge of scientific force and motion, measurement and angles, drawing, and software for presentation. The students had to

collaboratively construct the prototype of the highest paper building into a beautiful and strong building without adding other materials between the pieces of paper.

2. The "electric boat" activity was the second theme, which included a package of equipment and materials covering knowledge of an electric circuit, geometric shapes, balance of the visual arts, and planning and working. The students had to invent the prototype of an electric boat that could move on the surface of the water by utilizing a dry battery.
3. The "fantastic turbine" activity was the third theme, which included a package of equipment and materials covering knowledge of mechanical and electrical energy, three dimensions of shapes, painting, and investigation. The students had an opportunity to create an electric turbine that could generate electricity. The success of generating electricity could be determined from the brightness of the lamp.
4. The "tasty jelly" activity was the fourth theme, which included a package of equipment and materials covering knowledge of chemical solutions and states of matter, fractions and calculation, designing packages, and planning and working.

The students were assigned to make tasty jelly in a beautiful and attractive appearance for sales purposes.

Table 1: Knowledge and Skills of a STEAM-Centric Curriculum

Theme	Science	Technology	Engineering	Arts	Mathematics
The Highest Building	Scientific force and motion	Software for presentation	Engineering design to construct the highest building prototype	Drawing	Measurement and angles
Electric Boat	Electric circuit	Planning and working	Engineering design to invent the electric boat prototype	Balance of visual arts	Geometric shapes
Fantastic Turbine	Mechanical and electrical energy	Investigation	Engineering design to create the electric turbine	Painting	Threedimensional shapes
Tasty Jelly	Chemical solution and states of matter	Planning and working	Engineering design to make tasty jelly	Package design	Fractions and calculation

A structured interview form, which had a Pearson's correlation of 0.82, was used as a research instrument. Both teachers and students were asked the following five structured interview questions:

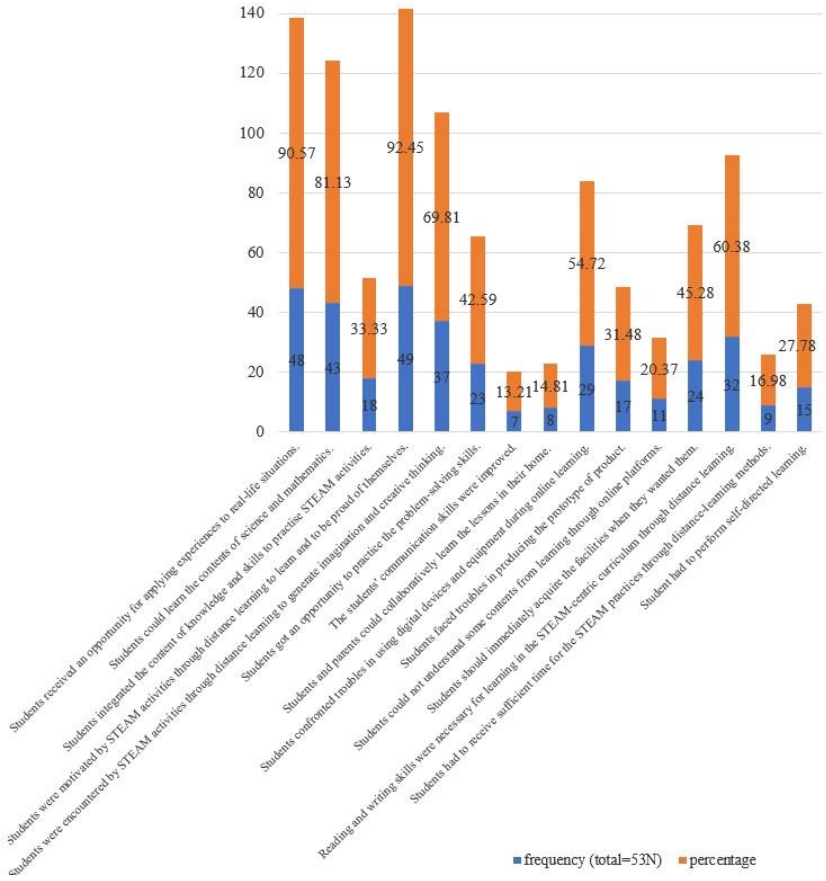
1. How did distance learning STEAM activities improve the students' knowledge and skills?
2. What were the students' reactions to the STEAM activities they participated in via distance learning?
3. What were the outstanding benefits of STEAM activities for students through distance learning?
4. How did teachers and students prepare to use electronic devices in the classroom and for learning during the COVID-19 pandemic?
5. What were the challenges for students participating in STEAM activities via distance learning when they had to learn at home?

When the instructional processes of STEAM-centric curriculum through distance learning were completely implemented, the teachers and students were interviewed via Zoom Meetings, and the interviews were recorded to infer the advantages and challenges of the STEAM-centric curriculum via distance learning methods. The collective data of the perspectives were analyzed by employing the content analysis method. These perspectives were encoded to be divided into fifteen categories. Each category was obtained by grouping key words of conceptual STEAM, synchronous learning, and asynchronous learning. The first to the eighth categories represented the benefits, while the remaining categories represented the challenges. Each category's result was statistically displayed in terms of frequency and percentage.

Evidence and Findings

The research findings included the teachers' and students' viewpoints on the benefits and drawbacks of using the distance learning approach for teaching the STEAM-centric curriculum. These categories are depicted in Figure 1.

Figure 1: Proportion of Students' and Teachers' Perspectives



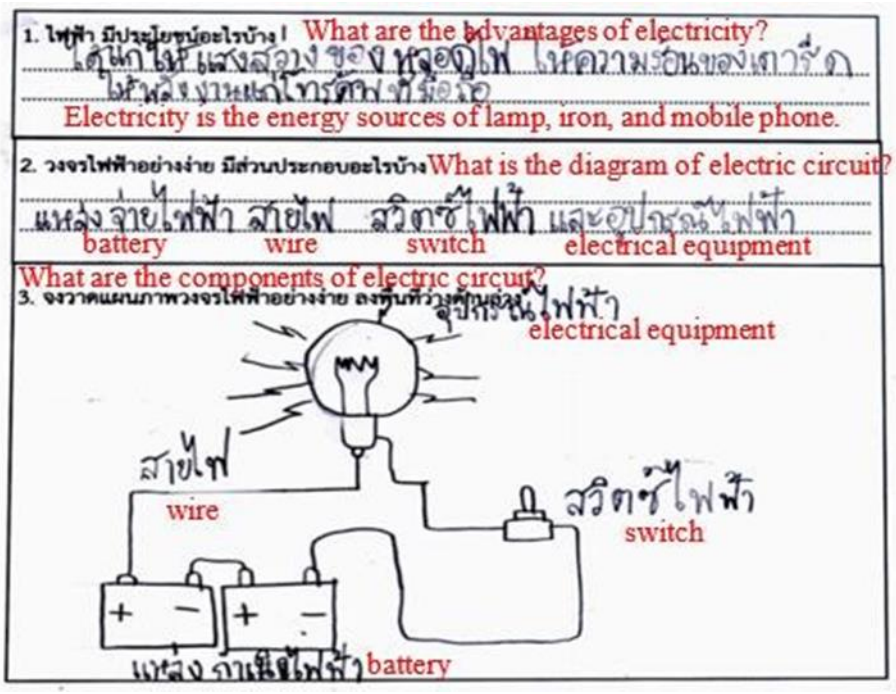
Tackling the STEAM-centric curriculum through distance learning generated both advantages and challenges. The positive effects of using the STEAM-centric curriculum via distance learning were: (1) students were motivated by the STEAM activities through distance learning to learn and to be proud of themselves (N = 49; 92.45%); (2) students received an opportunity for applying their experiences to real-life situations (N = 48; 90.57%); (3) students could learn the contents of science and mathematics (N = 43;

81.13%); (4) students were encountered by STEAM activities through distance learning to use their imagination and creative thinking (N = 37; 69.81%); (5) students got an opportunity to practice problemsolving skills (N = 23; 42.59%); (6) students integrated the content of knowledge and skills to practice STEAM activities (N = 18; 33.33%); (7) students and parents could collaboratively learn the lessons in their home (N = 8; 14.81%). Simultaneously, the students' communication skills were improved (N = 7; 13.21%); however, this perspective was the weakest advantage. There was some evidence of advantages of learning via the STEAM-centric curriculum as shown in Figures 2 to 4.

Figure 2: Prototype of an Electric Boat

Figure 3: Creative Prototype of a Turbine

Figure 4: Sample of Student's Work



The challenging aspects of tackling a STEAM-centric curriculum through distance learning were: (1) reading and writing skills were necessary for learning in the STEAM-centric curriculum through distance learning (N = 32; 60.38%); (2) students confronted problems in using the devices and equipment during online learning (N = 29; 54.72%); (3) students needed to immediately acquire the facilities when they wanted them (N = 24; 45.28%); (4) students experienced problems in producing the prototype of the product (N = 17; 32.08%); (5) students had to perform self-directed learning (N = 15; 27.78); (6) students could not understand some content from learning through online platforms. Simultaneously, students had to receive sufficient time for the STEAM practices through distance learning

methods (N = 9; 16.98%); nonetheless, this was the weakest challenge. An example of the challenges with learning the STEAM-centric curriculum through distance learning is represented in Figure 5.

Figure 5: Challenges of Learning by Oneself through Worksheets and Textbook

In general, students in underprivileged elementary schools thought that science and mathematics were difficult. When students learned across the four themes of the STEAMcentric curriculum via distance learning, they participated in those activities and attempted to learn new information. They were excited to independently create the prototypes of the engineering products at home by themselves. Moreover, distance learning STEAM activities encouraged students to communicate with their peers, teachers, and parents when they needed assistance with studying a lesson or practicing engineering designs. When the students were able to complete the final product of the STEAM activities, they were especially proud of themselves. The following were the outstanding benefits of the STEAM activities via distance learning that were discovered through the interviews with the students and teachers:

- I believed in myself when I completed an assigned task.
- I could create an engineering invention despite having to learn a body of knowledge through online platforms.
- Students were delighted when they were able to successfully create STEAM subject products by themselves.

During the COVID-19 pandemic, however, the learning procedures of STEAM through distance learning courses overwhelmed the students who were forced to study new knowledge and skills alone at home, especially when they had to rely on well-developed reading and writing skills. Basically, almost all the students in the underprivileged primary schools lacked basic reading and writing skills, as well as effective equipment and a consistent internet connection to learn the subjects in the curriculum. Because of these limitations, the students required assistance from their parents and teachers in the form of suggestions, practical equipment, and incentives to learn. The following remarkable challenges were discovered through the interviews with the teachers and students:

- When I learned alone at home, I couldn’t perform any reading comprehension, so I needed help from my parents, teacher, and peers.
- I had terrible communication with my teacher because I had to use online platforms due to a loss of the internet connection.
- I couldn’t create engineering products if I didn’t understand the materials.

- When they had to do worksheets and communicative writing by themselves, the students couldn't spell many words correctly.

Due to the importance of reading and writing skills in constructing new knowledge to apply in STEAM activities via distance learning, teachers could easily establish an interactive channel for communicating with the students. Most students needed to improve their reading and communication skills when they were required to engage in distance learning.

Summary and Recommendations

Distance learning has been a crucial method of providing education during school closure in the COVID-19 pandemic. On another note, the engineering design process has long been centered on a STEM approach; however, it has now evolved into a STEAM one. Previous researchers have rarely reported the effects of applying STEAM through distance learning during the COVID-19 outbreak.

In practice, a STEAM-centric curriculum delivered via distance learning during the pandemic had a significant positive impact on the instructors' and students' attitudes in underprivileged primary schools. In particular, it generated benefits for the students to apply in their real life and facilitated their mastery of scientific and mathematic contents. When students constructed a final product successfully, they were proud of themselves. Similarly, Jamil, Linder, and Stegelin (2018) and Spyropoulou et al. (2020) reported that the students were able to apply their interdisciplinary knowledge to solve creative challenges in a variety of contexts, both in and out of the classroom, in a transdisciplinary practice. The STEAM disciplines further developed the necessary abilities for the twenty-first century, such as creative thinking, critical thinking, cooperation, and communication, that could be used in everyday life. Teachers held a consensus that the STEAM approach had the potential for increasing the children's interests in these fields. STEAM was not only interdisciplinary, but also transdisciplinary, as it extended beyond the boundaries of specific disciplines. Furthermore, Khazaee and Sabourian (2020) discovered that classroom interventions related to cooking in early education resulted in children increasing their nutrition knowledge, adjusting themselves to form healthy eating patterns, and having self-efficacy. They boosted the students' learning attainment and global capabilities by encouraging their interests and motivation through the STEAM discipline. In addition, an online course could better enhance learners' performance (Thanji and Vasantha 2018).

Nevertheless, students also faced the obstacles that were the negative effects of the STEAM-centric curriculum through distance learning. Although the STEAM subjects did not have a negative impact themselves, students could not strongly master the skills of reading, writing, and self-directed learning during this discipline. Moreover, students had to be essentially equipped with effective digital devices to access online learning environments, and they were also asked to build their own knowledge and create products. Al Rawashdeh, Mohammed, and Al Arab (2021) reported that teaching and learning through e-learning might not guarantee the quality of effective learning. There is a strong need for an efficient e-learning system, which both students and teachers can rely on. Zboun and Farrah (2021) further revealed that learners did not interact or were not stimulated in the online platforms. The biggest challenges of an online course were weak internet connections and poor abilities to understand the lessons. Additionally, Arkorful and

Abaidoo (2014) and Masilo (2021) found that e-learning as an educational method made the students experience boredom, alienation, as well as depletion of interaction. Hence, it required strong inspiration as well as skills to manage the time to support learning. When the teachers had the aim to develop the communication skills of the students, an e-learning setting could lead to a negative result. Even though the students have excellent academic knowledge, they may not have the necessary skills to share their acquired knowledge to their peers.

Because of the immediate shift in education to STEAM via distance learning, teachers who did not receive adequate supports and oriented plans were made insufficient sense of their actions. In particular, most students also needed to improve their reading and communication skills when they were required to engage in distance learning stage, because reading and writing skills were necessary in constructing new knowledge to apply in the STEAM activities via distance learning. Although students had access to digital devices and the internet, these students may be in the minority in most countries. Likewise, while students could learn through electronic media and online courses, teachers should appropriately consider utilizing online platforms in different school conditions (Jita and Akintunde 2021; Karlimah, Islamiati, and Ali 2021). Hence, during the COVID-19 pandemic, the governments created an educational continuity plan by including some of these resources directly into their plan or utilizing them as a model for developing their own online educational materials. The materials are divided into major categories based on their intended use (OECD 2020a):

1. Curriculum Resources: These include lessons, videos, interactive learning lessons, and any other materials that could help students gain knowledge and skills.
2. Professional Development Resources: These are resources that could assist teachers and parents in facilitating students, guiding them to use the content, developing their skills to teach remotely, or more broadly enhancing their capacity to assist students who are learning more independently at home rather than at school.
3. Tools: These include communication tools, learning management systems, and other tools that teachers, parents, and students could use to create or access educational contents.

In addition, teachers should have more time to complete the STEAM lessons and decrease their workloads for managing the STEAM activities (Park et al. 2016).

Acknowledgment

This study was completed entirely during the COVID-19 outbreak. Teachers and students from underprivileged elementary schools in Nakhon Ratchasima province, Thailand under the Office of the Basic Education Commission, who volunteered for the study were gratefully acknowledged by the researchers. The National Research Council of Thailand was deeply thanked for providing funds to conduct the research findings.

Informed Consent

The authors have obtained informed consent from all participants. Conflict of Interest
The authors declare that there is no conflict of interest.

REFERENCES

Almaiah, Mohammed Amin, Ahmad Al-Khasawneh, and Ahmad Althunibat. 2020. "Exploring the Critical Challenges and Factors Influencing the e-Learning System Usage during COVID-19 Pandemic." Education and Information Technologies 25 (4): 5261–5280. https://doi.org/10.1007/s10639-020-10219-y.

Alodwan, Talal. 2021. "Online Learning during the COVID-19 Pandemic from the Perspectives of English as Foreign Language Students." Academic Journals: Educational Research and Reviews 16 (7): 279–288. https://files.eric.ed.gov/fulltext/EJ1309640.pdf.

Al Rawashdeh, Alaa Zuhir, Enaam Youssef Mohammed, and Asma Rebhi Al Arab. 2021. "Advantages and Disadvantages of Using e-Learning in University Education: Analyzing Students' Perspectives." Electronic Journal of e-Learning 19 (3): 107–117. https://files.eric.ed.gov/fulltext/EJ1296879.pdf.

Alsoud, Anas Ratib, and Ahmad Ali Harasis. 2021. "The Impact of COVID-19 Pandemic on Student's e-Learning Experience in Jordan." Journal of Theoretical and Applied Electronic Commerce Research 16:1404–1414. https://doi.org/10.3390/jtaer16050079.

Arkorful, Valentina, and Nelly Abaidoo. 2014. "The Role of e-Learning, the Advantages and Disadvantages of Its Adoption in Higher Education." International Journal of Education and Research 2 (12): 397–404. https://www.researchgate.net/publication/348335311.

Catterall, Lisa G. 2017. "A Brief History of STEM and STEAM from an Inadvertent Insider." STEAM Journal 3 (1): 3–4. https://scholarship.claremont.edu/steam/vol3/iss1/5.

Connor, A. M., S. Karmokar, and C. Whittington. 2015. "From STEM to STEAM: Strategies for Enhancing Engineering & Technology Education." International Journal of Engineering Pedagogies 5 (2): 37–47. https://doi.org/10.3991/ijep.v5i2.4458.

Dana-Picard, Thierry, and Sara Hershkovitz. 2020. "STEAM Education: Technological Skills, Students' Cultural Background and Covid-19 Crisis." Open Education Studies 2:171–179. https://doi.org/10.1515/edu-2020-0121.

Fakcharoenphol, Witat, Kanitha Chaowatthanakun, Pinda Varasunun, Kulthida Nugultham, Kitisaorn Laohammanee, Sineenuch Suwannaphichat, and Sumit Suwan. 2020. "Readiness to Implement Online Learning Management under the Covid-19 Pandemics." Journal of Education and Human Development Sciences 4 (1): 44–61.
https://kuojs.lib.ku.ac.th/index.php/jehds/article/view/3528/1711.

Fidalgo, Patricia, Joan Thormann, Oleksandr Kulyk, and José Alberto Lencastre. 2020.
"Students' Perceptions on Distance Education: A Multinational Study." International Journal of Educational Technology in Higher Education 17 (8): 1–18. https://doi.org/10.1186/s41239-020-00194-2.

FrantiŠek, Rigo, and MikuŠ Ján. 2021. "Asynchronous and Synchronous Distance Learning of English as a Foreign Language." Media Literacy and Academic Research 4 (1): 89–106. http://cejsh.icm.edu.pl/cejsh/element/bwmeta1.element.desklight-817e667f71c4-4fda-8f1c-187c82669197.

Giovannella, Carlo. 2021. "Effect Induced by the COVID-19 Pandemic on Students' Perception about Technologies and Distance Learning." In Ludic, Co-Design and Tools Supporting Smart Learning Ecosystems and Smart Education, edited by Óscar Mealha, Matthias Rehm, and Traian Rebedea, 105–116. Singapore: Springer.

Honey, Margaret, Greg Pearson, and Heidi Schweingruber. 2014. STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research. Washington, DC: The National Academies Press.

Huser, Joyce, Andy Meadows, Dustin K. Loehr, M. H. Haley Honeman, Lana Hallmark, Jack Mitchell, Allison Frenzel, et al. 2020. STEAM and the Role of the Arts in STEM. New York: State Education Agency Directors of Arts Education.

Hyun, Jung Suk, and Chan Jung Park. 2020. "Research Analysis on STEAM Education with Digital Technology in Korea to Prepare for Post-Corona Era Education." International Journal of Contents 16 (3): 101. https://doi.org/10.5392/IJoC.2020.16.3.101.

Jamil, Faiza M., Sandra M. Linder, and Dolores A. Stegelin. 2018. "Early Childhood Teacher Beliefs about STEAM Education after a Professional Development Conference." Early Childhood Education Journal 46:409–417. https://link.springer.com/content/pdf/10.1007/s10643-017-0875-5.pdf.

Jita, Thuthukile, and Moruf Abiola Olaide Akintunde. 2021. "Pre-Service Teachers' Competence to Teach Science through ICTs: A Case Study of Lesotho." International Journal of Science, Mathematics and Technology Learning 28 (1): 27–40. https://doi.org/10.18848/2327-7971/CGP/v28i01/27-40.

Karlimah, Dindin Abdul Muiz Lidinillah, Ginna Islamiati, and Siti Rahaimah Binti Ali. 2021. "Steam-Powered Boat Engineering in Elementary STEM Learning." International Journal of Science, Mathematics and Technology Learning 28 (2): 73–85. https://doi.org/10.18848/2327-7971/CGP/v28i02/73-85.

Khazaee, Mohadeseh, and Layla Sabourian. 2020. "Improving Children's STEAM Education and Their Global Competence through Collaborative Cooking." In Proceedings of the AHFE 2020 Virtual Conference on Human Factors in Training, Education, and Learning Sciences, edited by Waldemar Karwowski, Tareq Ahram, and Salman Nazir, 137–143. Cham, Switzerland: Springer Nature Switzerland AG.

Khine, Myint Swe, and Shaijan Areepattamannil. 2019. STEAM Education: Theory and Practice. Cham, Switzerland: Springer Nature Switzerland AG.

Kim, Hyoungbum, and Dong-Hyun Chae. 2016. "The Development and Application of a STEAM Program Based on Traditional Korean Culture." Eurasia Journal of Mathematics, Science & Technology Education 12 (7): 1925–1936. https://www.ejmste.com/download/the-development-and-application-of-a-steamprogram-based-on-traditional-korean-culture-4581.pdf.

Lindeman, Cheryl. 2020. "Informal STEM Learning: Cultivating Curiosity." International Journal of Science, Mathematics and Technology Learning 27 (2): 25–32. https://doi.org/10.18848/2327-7971/CGP/v27i02/25-34.

Maldonado, Joana Elisa, and Kristof De Witte. 2020. "The Effect of School Closures on Standardised Student Test Outcomes." British Educational Research Journal 48 (1): 49– 94. https://doi.org/10.1002/berj.3754.

Masilo, Motshidisi. 2021. "Exploring the Effect of a Community of Inquiry on Geometry Education Studies in Open Distance Learning." International Journal of Science, Mathematics and Technology Learning 29 (1): 24–25. https://doi.org/10.18848/2327-7971/CGP/v29i01/17-28.

Mayesky, Mary. 2002. Creative Activities for Young Children. 7th ed. Albany, NY: Delmar, Thomson Learning.

Naidoo, Jayaluxmi, and Reginald Govender. 2019. "Exploring In-Service and Pre-Service Teachers' Perceptions of Integrating Technology-Based Tools When Teaching Circle Geometry." International Journal of Science, Mathematics and Technology Learning 26 (2): 29–49. https://doi.org/10.18848/2327-7971/CGP/v26i02/29-49.

OECD. 2012. "Equity and Quality in Education: Supporting Disadvantaged Students and Schools." https://www.oecd-ilibrary.org/education/equity-and-quality-ineducation_9789264130852-en.

OECD. 2020a. “Supporting the Continuation of Teaching and Learning during the COVID19 Pandemic.” https://www.oecd.org/education/Supporting-the-continuation-ofteaching-and-learning-during-the-COVID-19-pandemic.pdf.

OECD. 2020b. “The Impact of COVID-19 on Education: Insights from Education at a Glance 2020.” Accessed January 27, 2023. https://www.oecd.org/education/the-impact-ofcovid-19-on-education-insights-education-at-a-glance-2020.pdf.

Park, Hyunju, Soo-Yong Byun, Jaeho Sim, and Hyesook Han. 2016. “Teachers’ Perceptions and Practices of STEAM Education in South Korea.” Eurasia Journal of Mathematics, Science & Technology Education 12 (7): 1739–1753. https://doi.org/10.12973/eurasia.2016.1531a.

Sadeghi, Manijeh. 2019. “A Shift from Classroom to Distance Learning: Advantages and Limitations.” International Journal of Research in English Education 4 (1): 82–83. http://ijreeonline.com/article-1-132-en.html.

Saykili, Abdullah. 2018. “Distance Education: Definitions, Generations, Key Concepts and Future.” International Journal of Contemporary Educational Research 5 (1): 13–14. http://hdl.handle.net/20.500.12424/2257769.

Sintema, Edgar John. 2020. “Effect of COVID-19 on the Performance of Grade 12 Students: Implications for STEM Education.” EURASIA Journal of Mathematics, Science and Technology Education 16 (7): 1–6. https://doi.org/10.29333/ejmste/7893.

Spyropoulou, Constantina, Manolis Wallace, Costas Vassilakis, and Vassilis Poulopoulos. 2020. “Examining the Use of STEAM Education in Preschool Education.” European Journal of Engineering Research and Science Special Issue: CIE 2020: 1-6. https://doi.org/10.24018/ejeng.2020.0.CIE.2309.

Tadesse, Seble, and Worku Muluye. 2020. “The Impact of COVID-19 Pandemic on Education System in Developing Countries: A Review.” Open Journal of Social Sciences 8:159–170. https://doi.org/10.4236/jss.2020.810011.

Thailand Development Research Institute. 2015. “The Alternative Methods to Solve Problems of Thailand’s Underprivileged Elementary Schools.” Accessed December 20, 2021. https://tdri.or.th/wp-content/uploads/2015/07/TDRI-Report-march-web-preview.pdf.

Thanji, Meenakshi, and S. Vasantha. 2018. “A Study of Benefits and Limitations of eLearning—A Learner’s Perspective.” International Journal of Pure and Applied Mathematics 118 (5): 179–182. https://acadpubl.eu/jsi/2018-118-5/articles/5/13.pdf.

UNESCO. 2009. “Framework for 21st Century Learning.” Accessed December 25, 2021. https://www.teacherrambo.com/file.php/1/21st_century_skills.pdf.

UNESCO. 2020. “Education in the Time of COVID-19.” Accessed December 25, 2021. https://repositorio.cepal.org/bitstream/handle/11362/45905/1/S2000509_en.pdf.

United Nations. 2020. “Policy Brief: Education during COVID-19 and Beyond.” Accessed December 20, 2021. https://unsdg.un.org/sites/default/files/202008/sg_policy_brief_covid-19_and_education_august_2020.pdf.

Williamson, Ben. 2013. The Future of the Curriculum: School Knowledge in the Digital Age. London: MIT Press.

Yakman, Georgette, and Hyonyong Lee. 2012. “Exploring the Exemplary STEAM Education in the U.S. as a Practical Educational Framework for Korea.” Journal of Korea Associated Science Education 32 (6): 1073–1074. https://doi.org/10.14697/jkase.2012.32.6.1072.

Zancajo, Adrián, Antoni Verger, and Pedro Bolea. 2022. “Digitalization and Beyond: The Effects of COVID-19 on Post-Pandemic Educational Policy and Delivery in Europe.” Policy and Society 41 (1): 116. https://doi.org/10.1093/polsoc/puab016.

Zboun, Jomana S., and Mohammed Farrah. 2021. “Students’ Perspectives of Online Language Learning during CORONA Pandemic: Benefits and Challenges.” https://journal.uniku.ac.id/index.php/IEFLJ/article/view/3986/2475.

Zeidler, Dana L. 2016. “STEM Education: A Deficit Framework for the Twenty First Century? A Sociocultural Socioscientific Response.” Cultural Studies of Science Education 11:11–26. https://doi.org/10.1007/s11422-014-9578-z.