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Research Article

Alignment science curricula to scientific and engineering practices: Thereality of science teachers' implementation of scientific and engineeringpractices in distance education during the Corona pandemic.

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Abstract

The aim of the study is to determine the alignment of developed science textbooks for scientific and engineering practices (SEPs), and the reality of the implementation of these practices by science teachers in distance education during the Corona pandemic. The study used an approach of mixed design (quantitative and qualitative). First, these textbooks were subjected to a quantitative content analysis. Secondly, based on the results of the preceding content analysis, a questionnaire was prepared and distributed to (80) science teachers, to reveal the extent to which they implemented these practices. Third, nine of the study's teachers were interviewed. The results revealed that SEPs were available at a low level in developed science textbooks for the fifth grade, while some practices were not available. During the pandemic, Science teachers applied SEPs in distance education at a low degree (*M*=2.30). The results also showed that the successful application of SEPs in distance education during the Corona is dependent on the technological infrastructure of schools. Furthermore, science teachers faced obstacles and challenges that limited their ability to apply SEPs, including the lack of technology tools and programs, weak internet networks, a lack of remote interactive platforms, and the use of television broadcasting as a teaching method.

Keywords: SEPs, Science curricula, science teachers, Corona pandemic,distance education.

Introduction

The United States places a great priority on the science education reform. Various global projects including the Science Curriculum Reform Movement in the Light of Interaction between Science, Technology, and Society (STS), have previously been implemented such as, Project 2061 of the American Association for the Advancement of Science, AAAS, National Standards for Science Education (NSES), the Academy The National Academy of Science, NAS, and the National Science Teacher Association, NSTA (Bybee, 2013). Reforming science isn't a new idea. Since the launch of Sputnik by Russia in 1957, a number of initiatives aimed at boosting science education have been implemented and pushed in the United States (Yager, 2000).

Recently, the Next Generation Science Standards (NGSS) were developed and approved by

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ACHIEVE (NGSS Lead States, 2013), with high expectations that the NGSS will lead to an enrichment of science education and the delivery of better education by teachers (Harris et al., 2015). In light of prior revisions, there has been a lot of interest to develop the scientific curriculum in recent years; it is also created and improved in accordance with the needs of each historical period (Merritt, 2018). Students learn science best when they engage in SEPs comparable to scientists and engineers, when educational settings are established to support them and teachers are taught in this new type of instruction according to the NGSS scientific education reform movement. (Merrit, Chiu, Burton & Bell. 2018).

Generally, teachers can understand curricular reforms by training teachers in these improved curricula, allowing them to interpret these reforms in relation to their own aims in their work contexts, and providing them with the right conditions that support them use these reforms in their teaching practices (Supovitz & Turner, 2000). Learning how to implement these reforms in teaching practices necessitates extensive practice and the acquisition of the necessary abilities. (Kang, Donovan & McCarthy, 2018). Implementing these reforms in an unusual conditions such as the COVID-19 pandemic necessitates an understanding of how teachers are likely to adopt these reforms through distance education, as well as an understanding of how teachers implemented SEPs in science education during the pandemic (Otto, Williams, Moran, Ingram & Strime, 2021); this is the aim of this study.

The NGSS focuses on incorporating SEPs into science curriculum content. The development of students' practical and conceptual abilities, as well as their research methods reflects this integration. The focus is not only on content specific to specialized ideas or comprehensive concepts, but also on providing students with practices related to the nature of scientific research and engineering design. When students investigate the natural world and construct models, theories and explanations, they are practicing scientist behaviors that will help them comprehend how scientific knowledge evolves.(Moore, Tank, Glancy & Kersten 2015). While the integration of engineering into science education through designs provides the opportunity for students to design experiments, models, and computer programs, and to apply engineering practices such as building and designing systems and systems models; this allows students to practice engineer behaviors that help them understand the work of engineers (Pruitt, 2014).

The importance of integrating SEPs in science teaching is backed up by past research. According to Chiu and Burton and Merritt (2018),SEPs give students the opportunity to work and think like scientists and engineers. Moreover, the study of Concannon and Brown (2017) confirmed that students' implementation of SEPs enables them to reflect on the engineering design process in light of their experiences, which helps promote a greaterunderstanding, and provides them with a conceptual tool to systematically investigate problems. The study of Castronova and Chernobilsky (2020) emphasized the need for teachers to focus on implementing SEPs effectively during their teaching practices. According to Smith and Nadelson (2017), the NGSS requires teachers to make a considerable transformation in their teaching approaches in order to facilitate chances for their students to actively participate in SEPs.

Since the beginning of 2020, many countries have faced a global epidemic that completely switched traditional education to distance education. In March 2020, Covid-19 was declared an international pandemic by the WorldHealth Organization (WHO. 2020). As a result of the virus's spread, educational institutions have been compelled to stop traditional ducation in favor of totally online learning. A quick response has been made by some educational institutions to move to online education (Garad, Al-Ansi & Qamari, 2021). It was necessary to continue education in light of this pandemic, in multiple attempts by many countries towards providing distance education service (Lieberman, 2020) by using various technological applications to move from the traditional classroom to online interactive platforms (Mansur, Jumadi, Mastur, Utama & Prastitasari, 2021); this newform of education needs new basic requirements and new educational contexts.

Today, Virtual science classrooms are experiencing a new transitional period during the Corona pandemic; it requires teachers and students to adapt to the reforms that were made in the science curricula previously, on the one hand, and with the conditions of distance education during the Covid-19 pandemic, on the other. Incorporating SEPs into science textbook content requires students to think and act like scientists and engineers by becoming more involved in putting these techniques into practice (Moore, Tank, Glancy & Kersten 2015; NGSS Lead States, 2013; Osborne, 2014; Pruitt, 2014).Teachers' implementation of SEPs while teaching the science curriculumimproves the teaching process itself on the one hand, and learners' outcomes in science on the other (e.g., Akerson and Donnelly, 2010; Metz, 2008). But will science teachers be able to implement these practices in crises such as the Corona pandemic? This will be known in detail later.

According to the NGSS document created by ACHIEVE, the theoretical underpinning of this study is based on the standard SEPs that must be available in science textbooks for fifth grade (NGSS Lead States, 2013). To ensure the availability of these practices in science textbooks, the researcher conducted a content analysis to detect SEPs in the fifth grade science textbook. The researcher then used the questionnaire created in light of the content analysis results to determine the extent to which science teachers use these practices during their distance teaching during the Corona pandemic, in order to ensure that science education reforms are implemented during this crisis. Also, the researcher delved into the results of his study by conducting an interview witha group of teachers participating in the study, to reveal the factors that helped them implement SEPs effectively during the Corona pandemic, and the challenges that constrained them from implementing them effectively.

Methodology

A mixed research design was used in this study (quantitative and qualitative); the researcher conducted a content analysis of developed science textbooks for the fifth grade to verify the suitability of the SEPs based on the original NGSS document (NGSS Lead States, 2013). In response to the scienceeducation reforms mentioned earlier, the Jordanian Ministry of Education has developed science books for the fifth grade in the light of these reforms. These textbooks combine science and engineering in a unique way. Furthermore, because it is constructed in light of worldwide reforms in scientific education, Jordanian science books in general are similar to European and American books in terms of the integration of science and engineering in their content. The researcher also believes that the content analysis of these books willprovide a clear picture of the included SEPs, and the data on content analysis have been clarified in detail in this research. Particularly, the content analysis answered the following question: What is the degree of alignment between thedeveloped science textbooks and the NGSS document's SEPs for grade 5?

In addition, the researcher used the questionnaire to see how far science teachers implemented SEPs in distance education during the Corona pandemic. This is to ensure that teachers implement the reforms in the light of which science books were developed. The researcher visited the directorates of education in the Zarqa governorate , which is divided into three directorates, and a group of science teachers who taught science books developed for the fifth grade during the Corona pandemic were selected from all educational regions with a total of (80) teachers, out of 310 teachers who teach science in general, according to the criteria: must have a bachelor's degree in general science or one of the areas of science, to have completed the Jordanian Ministry of Education's designed curricula course, and to have taught scienceto the fifth grade for the previous two years. Following the collection of names,the researcher contacted the teachers who fit the criteria and requested their consent to participate. (43) males and (37) females, and the questionnaire was sent to them electronically due to the Corona pandemic (eg, Cahapay, 2020), and they were encoded with their first letter and they took numbers from 1-80.

To triangulate the data collection tools as in the study of Smith and Nadelson (2017), the researcher conducted an interview with a sample ofparticipants in the light of their responses to the questionnaire with procedures close to the study of Qablan and Abuloum and Abu Al-Ruze (2009). The researcher communicated with a group of participants, numbering (9) based on their total responses to the questionnaire, (4) participants whose implementation ranged from high to very high, they were classified within the category of implementation effectively, (5) participants whose implementation of all practices ranged from medium to very low and they were classified in thecategory of non-implementation effectively, and the researcher asked them to participate in the interview, and they were informed that the meeting would be confidential, and it would be recorded, and no one could view it, but theinformation would be used for scientific research purposes, and they asked not to mention their names, but to be satisfied with the symbols, and they agreed onit.

The researcher conducted the interview with the participants separately, and via the Internet, which is an acceptable method in light of the Corona pandemic (Cahapay, 2020), by communicating with them through theMicrosoft Teams platform with audio and video, and the meeting was recorded,to refer to it again and to analyze and document their responses. In light of their responses to the questionnaire, the participants were asked two specificquestions:

1. What are the factors that helped you implement SEPs effectively during the Corona pandemic, according to your response to the questionnaire?

2. What are the challenges that restricted you from implementing SEPs effectively during the Corona pandemic, according to your response to the questionnaire?

Table 1: Scientific and engineering practices that should be available in fifth grade science booksaccording to the original NGSS document

code	Scientific and engineering practices
PS1-1	I direct my students during the Corona pandemic to develop a model to describe that matteris made of particles too small to be seen.

PS1-2	Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
PS1-3	Make observations and measurements to identify materials based on their properties.
PS1-4	Conduct an investigation to determine whether the mixing of two or more substances resultsin new substances.
PS2-1	Support an argument that the gravitational force exerted by Earth on objects is directeddown.
PS3-1	Use models to describe that energy in animals' food (used for body repair, growth, motion,and to maintain body warmth) was once energy from the sun
LS1-1	Support an argument that plants get the materials they need for growth chiefly from air andwater.
LS2-1	Develop a model to describe the movement of matter among plants, animals, decomposers,and the environment.
ESS1-2	Represent data in graphical displays to reveal patterns of daily changes in length anddirection of shadows, day and night, and the seasonal appearance of some stars in the night sky.
ESS1-1	Support an argument that differences in the apparent brightness of the sun compared to otherstars is due to their relative distances from Earth.
ESS2-1	Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere,and/or atmosphere interact.
ESS2-2	Describe and graph the amounts and percentages of water and fresh water in variousreservoirs to provide evidence about the distribution of water on Earth.
ESS3-1	Obtain and combine information about ways individual communities use science ideas toprotect the Earth's resources and environment.
ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteriafor success and constraints on materials, time, or cost.

ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each islikely to meet the criteria and constraints of the problem.
ETS1-3	Plan and carry out fair tests in which variables are controlled and failure points areconsidered to identify aspects of a model or prototype that can be improved.

Content analysis: The developed science textbooks for the fifth grade, which include the Student's textbooks, and the Activity and Exercise textbooks for thefirst and second semesters, were analyzed as we previously stated. Also, frequencies and percentages of SEPs were calculated, see Table 2. Availability of SEPs in these books was judged in a similar way to study of Oliemat and AL-Mashaqba and AL-Mashaqba (2021): Available at low $F \leq 30\%$, available at medium level $30\% < F \leq 65\%$, available at high from $F > 65\%$. The resultsof the analysis are detailed in the research.

Questionnaire: The questionnaire was distributed to the participants in the study, and the means and standard deviations of each practice were calculated according to the participants' responses, to determine the extent to which science teachers in distant education implemented the SEPs during the Corona pandemic; the extent to which the plan had been implemented was assessed: a low degree $M \leq 2.33$, a medium degree $2.33 < M \leq 3.66$, a high degree $M > 3.66$.

Interview: An interview was conducted with nine participants who responded to the questionnaire, they were selected as stated previously, and the results of their interviews were listed according to their responses in the body of the research. The practices were classified into two categories based on the total responses in Table 3: those that were implemented effectively and to a high degree, and those that were not implemented effectively and to a low to medium degree. Through the interview, the factors that helped to implement some practices effectively during the Corona pandemic, and the challenges that restricted science teachers from implementing some practices effectively during the same period, were revealed. The results of the interview were detailed in the research.

Findings and Discussion

Aligning Science Textbooks for SEPs

The results of the analysis as shown in Table 2 showed that SEPs were available in the developed science textbooks for the fifth grade with a low degree ranging between 2.44%-17.07%, whereas some practices did not appearin the content of these textbooks.

We also note from Table 2 that the available SEPs are: PS1-1, PS1-2, PS1-3, PS1-4, PS2-1, PS3-1, LS1-1, LS2-1, ESS1-1, ESS2-2 , ESS3-1, ETS1-1, ETS1-2, ETS1-3. While not available: ESS1-2, ESS2-1. All SEPs that were available were at a low level. This finding suggests that SEPs were not given significant consideration in developed science textbooks. Rather, thesetextbooks were satisfied with providing SEPs superficially and not in depth. They did not focus on increasing the number of practices and employing them in various educational contexts. The practices (PS3-1, LS1-1, LS2-1, ESS1-1, ESS2-2) appear only once in these textbooks. This result is not in line with the study of Trygstad , Smith , Banilower and Nelson (2013), which emphasizedthe importance of focusing more on SEPs by diversifying how the practice is presented and allocating more space for practitioners, including the content of science textbooks, in order to increase students' ability to develop higher-order thinking skills and avoid excessive filling by focusing on specialized or comprehensive ideas at the expense of SEPs. It also doesn't align with Osborne's study (2014), which indicated the need to teach science in scientific and engineering contexts deeply, and in various forms of activities, teaching science superficially to SEPs reduces the opportunity for students to engage in the learning process, and to practice what scientists and engineers do.

In the same direction, we can see from Table 2 that the most common SEPs is the practice ETS1-1, which has seven repetitions, followed by ETS1-2, which has five repetitions; this is a significant difference from other practices. Thus, the focus will be only on implementing the practice of defining a simple design problem that reflects a need or desire that includes specific criteria for success considering materials, time, or cost, and the practice of creating and comparing several possible solutions to a problem based on how likely each one will meet the criteria and constraints of the problem. This repetitive work of practices without others, the student will feel monotonous and bored of repeating a practice more than once in a similar pattern, and he will not be able to employ the practice in more than one learning context (Osborne, 2014). Furthermore, a lack of variation in activities will result in a failure to consider individual differences among students, as well as a failure to fit their requirements and inclinations; consequently, students' motivation to learn science will decrease, this was confirmed by the study of Berry , Friedrichsen and Loughran (2015) on the need to diversify in scientific activities and practices, and not focus on one activity without the other.

The researcher reviewed the outlines of the science curriculum in the Hashemite Kingdom of Jordan where he discovered that it requires students to practice a variety of SEPs, including model building and development, scientific experiment implementation, description, measurement, scientific investigation, scientific argument, data representation and graphing, problem solving, comparison, and prediction. The results of the previous analysis indicated a deficiency in including SEPs in the science curriculum that the Ministry of Education worked on developing. Therefore, it is necessary to review the content of these books from the decision-makers in the Hashemite Kingdom of Jordan.

Table 2: Frequencies and Percentages of SEPs in Science Textbooks Developed for fifth Grade

SEPs	Frequent	Percentage	Degree
PS1-1	3	7.32%	Low
PS1-2	4	9.75%	Low
PS1-3	4	9.75%	Low
PS1-4	3	7.32%	Low
PS2-1	3	7.32%	Low
PS3-1	1	2.44%	Low
LS1-1	1	2.44%	Low

LS2-1	1	2.44%	Low
ESS1-2	0	0.00%	Low
ESS1-1	1	2.44%	Low
ESS2-1	0	0.00%	Low
ESS2-2	1	2.44%	Low
ESS3-1	3	7.32%	Low
ETS1-1	7	17.07%	Low
ETS1-2	5	12.20%	Low
ETS1-3	4	9.75%	Low
Total	41	100%	

Science teachers' implementation of SEPs during the Corona pandemic

As show in Table 3 that science teachers implemented the SEPs in the developed science textbooks for the fifth grade at a low degree (*M* = 2.30), and this indicates a shortcoming in the implementation of these practices in crises such as the Corona pandemic. This shortcoming in SEP implementation could be attributed to scientific teachers' lack of training on how to implement these practices in distance education during crises, or because they lacked the necessary technology tools and were faced with obstacles that prevented them from doing so effectively. A study of Mansur and others (2021) confirmed that distance education needs tools to help implement it, by providing computers, internet, and technological applications that help teachers and students to implement activities effectively. Also, a study of Tirnovali (2013) pointed out the need for teachers and students to have skills that enable them to deal with the internet, in order to carry out activities effectively from a distance. Arruda's study (2020) also emphasized the importance of training teachers to work in unusual situations and how to use interactive platforms remotely.

In the same context of the research related to the degree of implementation, as show in Table 3 that the practice LS1-1 came in the first rank, implemented by science teachers with a high degree (*M*=3.75), while practice PS1-1 came in the last rank, implemented by teachers with a low degree (*M*=1.18). This disparity in degree of implementation points to the presence of factors that influenced the degree of practice implementation. Perhaps some practices have tools that teachers use during their distance education, while other practices do not have such tools. It seems that the nature of the science curriculum in its focus on the practical aspect, which requires the learner to perform some practices in the school laboratory and in a face-to-face, restricted science teachers in the implementation of some practices remotely (Baxter, Ruzicka, Beghetto, & Livelybrooks, 2014). Burn (2010) found that learners' lack of ability to interact with technology applications at a distancehad a detrimental impact on activity implementation. As a result, the deployment of several SEPs was limited. Additionally, the study of Barnett , Grafwallner and Weisenfeld (2021) confirmed that providing the appropriate conditions for teachers in the technological infrastructure greatly helps to implement the practices effectively. On other hand, the study of Arruda (2020) confirmed that training teachers to implement curriculum reforms professionally helps them implement various activities; this prepares them to confront the problems that they will experience in their distance teaching practices.

In the same direction, schools differ in their technological infrastructure. There are schools that are adequately prepared and others that are not. The study of Williamson , Eynon and Potter (2020) emphasized that distance education has special technological requirements and tools, in order to work with these tools, both the teacher and the student must have technological abilities. As a result, it's probable that some schools offered these preexisting conditions while others did not, which had an impact on teachers' effectiveness in adopting SEPs with their students.

Referring to the results in Table 3, we note that argument-focused practices have been implemented to a high degree. The practice LS1-1 calls for arguments for evidence and scientific and mental proof, so it is possible to direct students to sources of information over the Internet, without the need for a practical application in the laboratory, which has helped teachers to implement this type of practice to a high degree, The previous finding isconsistent with Lervik, Holen, and Vold's (2020) study, which emphasizes that activities that do not require practical experiments can be carried out effectively remotely by teachers. whereas some practices that need to be implemented in a low degree of practicality, PS1-1 needs practical application, and practical activities in general require technological tools to be implemented remotely; some teachers may not have these technological tools that allow them to implement this type of practice effectively remotely, due to the weak technological infrastructure experienced by some schools. The preceding finding is consistent with de Souza and others (2020) study, which found that a lack of remote education infrastructure prevents teachers from carrying out practical tasks effectively from a distance.

Despite what was previously stated, there are practices that are implemented practically remotely without the need to provide a wet lab; because of the simplicity of the materials required by the implementation process, but the necessity of providing interactive platforms remotely between the teacher and the student. Relying on the interviews of the participants, the participants reported that the practice PS1-3 was implemented to a high degree (M=3.69), without the need for a wet school laboratory, because it was based on simple materials found in the student's environment, where the teacher through the interactive platform directs the student to bring materials such as: Stone, iron, water, oil, and a simple experiment is conducted on them to determine which is more dense. The participants also reported that in PS1-4, the student can use materials from his home or garden to conduct a simple experiment, such as mixing water with salt, burning a candle, and noting the properties of the resulting new material, which the teacher assigns to his students via the interactive platform. Participants also mentioned that PS2-1can bring a collection of things from its environment, and the teacher instructs him to execute a simple activity, such as throwing objects up and observing their behavior when they fall down, using the interactive platform. While participants recounted that students do not have concrete examples available in their environment of water reservoirs worldwide, linked to practice ESS2-2, this may be a challenge for teachers to implement such practices, although teachers, as they have pointed out in their interviews, can implement such practices by displaying images and drawings illustrating such phenomena, or models of sensors, but teachers appear to have once again clashed with the challenge of technology tools. A study by Williamson and Eynon and Potter (2020) on the necessity for simulation, multimedia, picture, and form presentation systems to support the implementation of activities related with abstract concepts during online education reinforced what was indicated above. Interviews with the participants were performed to learn more about the reasons that helped teachers apply some SEPs effectively during the

COVID- 19 epidemic, as well as the challenges that prevented them from doing so. This has been further outlined in the details of the upcoming search.

Table 3: Means and standard deviations of science teachers' implementation of science and engineering practices in distance education during the COVID-19 pandemic.

SEPs	*M*	*SD*	Degree
PS1-1	1.18	0.92	Low
PS1-2	1.30	0.86	Low
PS1-3	3.69	1.20	High
PS1-4	3.68	1.27	High
PS2-1	3.71	1.33	High
PS3-1	1.20	0.81	Low
LS1-1	3.75	1.54	High
LS2-1	1.19	1.22	Low
ESS1-1	3.72	1.31	High
ESS2-2	1.24	0.85	Low
ESS3-1	3.73	1.68	High
ETS1-1	1.25	1.12	Low
ETS1-2	1.22	1.26	Low
ETS1-3	1.32	1.29	Low
Total	**2.30**	**0.87**	**Low**

Factors that helped science teachers effectively implement SEPs during the COVID-19 pandemic

An interview was conducted with four science teachers who answered the study questionnaire, and they were asked about the factors that helped them implement SEPs (PS1-3, PS1-4, PS2-1, LS1-1, ESS1-1, ESS3-1) effectively during the Corona pandemic according to their responses on the questionnaire; to conduct in-depth research on the outcomes of each activity, and to ensure that science curricula reforms are implemented throughout distant educationteaching practices during the Corona pandemic.

The participants in the interview said that the practice PS1-3 was effectively implemented; because it is simple and does not require complex materials, it is easy to implement it remotely through the available interactive platform, and it doesn’t need a wet lab to implement it. Whereas some participants emphasized that providing an interactive platform equipped with a dry laboratory to carry out remote experiments helped to implement such practical practices remotely.

This practice is simple, and I instructed my students remotely through the interactive platform, to choose simple materials from their homes, and take measurements on them to determine their characteristics. (Interview of participant E2).

I was able to conduct this activity with my students from home using the dry lab app, rather than having them in the face-to-face school lab. (Interview of participant A1)

The platform purchased by the school for distance learning includes programs that help to carry out experiments remotely through the dry lab application. (interview of participantD3)

In the same context of in-depth research on the implementation of practices, the participants in the interview explained the reasons that enabled them to implement some practices effectively (ESS3-1; PS2-1; PS1-4), the presence of a remote interactive board, the availability of an interactive platform equipped with various applications, In addition to having tablet devices with Internet access, students have the ability to interact with the teacher when he exhibits various items (eg, videos, pictures, shapes, graphs, etc...). Furthermore, some participants stated that having an interactive platform taught by a teacher allows them to follow out the practices at home..

Having the interactive whiteboard remotely, I can display a video through the word wall for the games app provided by the school to implement the practice PS2-1 and other practices. (Interview of participant A1)

I have guided my students through the interactive platform provided by the school to carry out the practice PS1-4, bringing in an ice block and exposing it to heat, and observing what happens, to describe a natural change. While I directed them to burn a small piece of paper in a safe place, and note what happens, to describe the chemical change. (Interview of Participation E2)

The school provided small tabs for the students, provided them with free internet packages, and provided an interactive remote board to be used during the lessons, which helped me a lot to implement the practice ESS3-1.
(Interview of participant R4)

Despite what has been stated, some participants believe that some practices do not require students to participate in practical activities, but rather an interactive platform through which the teacher can directly practice brainstorming with his students, dialogue and discussion, utilizing students' prior experiences, and solving questions and exercises. On the other hand, some participants said that there are practices that require a simple activity that is implemented remotely through an interactive platform, and then the teacher talks to his students remotely about the scientific phenomenon.

The practice PS2-1 is easy to do remotely. I instruct my students to throw a bunch of simple things up, and then ask them what did you notice, and why did they all fall down as a kind of brainstorming for them. (Interview of participant A1)

The practice LS1-1 need to use my students' previous information on the topic, their interaction in the argument process, and the presence of an interactive remote platform helped me.

(Interview of participant D3)

I had no difficulty in implementing the practice ESS3-1, as it is not necessary to implement it through a practical activity, as I implemented it through dialogue and discussion by means of the interactive remote platform.
(interview of participant E2)

In the same direction, the availability of simulation design programs via the remote interactive platform, as well as the students' ability to work with such programs remotely, according to the participants, aids in the effective implementation of some practices. Also, some participants indicated that the provision of free internet packages for students by the school helps them to use databases for research and investigation on various topics. When students are taught how to search and investigate using the Internet during face-to-face schooling, they learn skills to cope with the Internet, making it easy to guide them remotely in times of crisis to do the same thing they were doing before.

The school has provided me with many technological programs via the interactive remote platform such as simulation design programs, which enabled me to design a simple scenario that simulates how plants obtain water and air for growth, and my students have the skill to deal with such programs, and provide their evidence during the discussion, which helped me vigorously to implement the practice LS1-1. (Interview of Participant D3)

Providing free internet packages for students from the school helped me a lot in guiding my students towards searching and collecting data online in databases to implement the practice ESS3-1. (interview of participant E2)

Before the Corona pandemic, my students used to do research skillfully via the Internet, and when we moved to distance education, it was easy for them with the availability of the Internet. Implementing the practice ESS3-1. (interview of participant R4)

Challenges that have restricted science teachers from effectively implementing SEPs during the COVID-19 pandemic

Five participants who answered the study questionnaire were interviewed and asked about the challenges that constrained them from implementing SEPs (PS1-1, PS1-2, PS3-1, LS2-1, ESS2-2, ETS1-1, ETS1-2,
ETS1 -3) effectively in distance education during the Corona pandemic, according to their response to the questionnaire; to expose the challenges that constrained them from implementing effectively.

The participants in the interview said that implementing some remote practices was difficult, due to reasons such as the lack of a remote simulation program, the lack of multimedia programs, and the lack of teachers' skill in dealing with technological applications remotely, due to the lack of prior training. Furthermore, the public school does not provide an interactive platform, instead relying on a non-interactive lesson platform that relies on direct teaching via the Jordanian Ministry of Education's television broadcast.

I am in a public school, and the school did not provide an interactive platform, and there is no remote simulation software, so I assign the students activities via text messages, and

sometimes I use Whatsapp, this is why I am challenged to implement the practice PS1-1 effectively.
(Interview of participant K5)

The implementation of the practice PS3-1 requires a simulation program that simulates the way energy is transferred from the sun to plants and then to animals, and this was not provided by the Jordanian Ministry of Education in public schools, and I have no skill in dealing with technological applications to implement them from a distance, as I have not previously trained in them. (Interview ofparticipant S6)

The Jordanian Ministry of Education has provided public schools with a non-interactive lesson platform that does not include interactive technology applications, and such the practice LS2-1 needs to provide multimedia programs with which the student interacts. (interview of participant F9)

The practice PS3-1 is complex and needs to design appropriate technological tools during their remoteimplementation, We discussed technology tools throughout our training on the developed curricula, but we didn't go into how to construct and apply them. (Interview of Participant N7)

In the same direction, the participants indicated the lack of a dry laboratory application in their schools, and the lack of appropriate tools in distance education, due to its reliance on television broadcasting in its teaching.The participants concentrated on using text messaging to implement their activities with their students. While some participants emphasized that some procedures require students to be able to use technology tools remotely, others emphasized that some methods do not.

I communicate with my students through text messages on their parents' phones to carry out the activities, and this method did not enable me to effectively implement the practice ETS1-1, your lesson platform is not interactive, and does not provide a dry lab application. (Interview of participant S6)

I know my students' level and skills, and such a complex ETS1-3 practice needs a face-to-face meeting, to explain to them, text messages to enable me to do this work, so I couldnot carry out this practice effectively. (Interview of Participant F9)

I found myself in front of students, who do not master the graph skillfully, and I tried to display pictures andillustrations from a distance, but the platform was not interactive, but was limited to the ability to send and receivemessages only, so I was not able to implement the practice PS1-2 effectively. (J8 participant interview)

In the same context as the interview about the challenges, the participants mentioned other issues they faced, such as the lack of internet for all students, the fact that some students live in remote areas where computers and smart phones are not readily available, and the fact that some students live in low-income areas where computers and smart phones are not readily available. The participants also pointed out that it is difficult to synchronize with their students at all times, so the process of communicating with students does not go smoothly, due to the constant internet outage in their remote areas.

My students are suffering from the problem of not having the internet for all of them, and I was satisfied with the explanation given to them via TV broadcast through your lesson platform, as my implementation of the practice PS1- 1 is ineffective. (Interview of Participant F9)

My students are from a remote area, and they do not have computers, and their families cannot provide a smart phone or a tablet for all family members, due to their low economic level. This is a challenge in implementing most ofthe activities. (Interview of Participant N7)

We live in a remote area, the internet is constantly cut off, and this was an obstacle for me to meet my students continuously and simultaneously. (interview of participant J8)

If my students do not have their own computers or smart phones, they are dependent on what is being broadcast on your non-interactive lesson platform; So I was not able to implement the practice ETS1-2 effectively. (Interview of participant K5)

Conclusion

One of the challenges in science education, according to the findings of this study, is the absence of presentation of SEPs in various forms within the content of science textbooks. This shortcoming increases the filling in them. While increasing the space for these practices in the content of these books helps to prepare a scientifically literate generation in light of the scientific and technological explosion, and provides the opportunity for students to practice the work of scientists and engineers alike. This conclusion is consistent with the findings of Oliemat and others (2021), who found that including specialized and comprehensive ideas in the content of science books leads to overfilling, which reduces students' chances of acquiring scientific and engineering skills, allowing them to work in a similar manner to scientists and engineers.

During the Corona pandemic, SEPs were implemented in distant education to varied degrees. This difference in the degrees of its implementation is due to a group of factors that facilitated the implementation effectively, such as factors that are related to the technological infrastructure of schools such as providing an interactive remote platform, providing technological applications (for example, dry laboratory, simulation programs, interactive remote smart boards, programs multimedia, and image display software). In addition to offering students with free Internet access, the school also provides computers. However, there are aspects that are specific to the teacher and the student, such as computer and Internet skills, as well as distant technical instruments. As a result, the following elements helped to ensure that SEPs were implemented effectively in distant education during the Corona pandemic.

On the other hand, science teachers have faced challenges in implementing SEPs in distance education during the COVID-19 pandemic. Among these challenges that restricted their work: First, science teachers were unable to implement SEPs due to a lack of interactive platforms for distance education and a reliance on television broadcasting platforms that do not allow for effective interaction and do not provide various technological programs (forexample, simulation programs, dry laboratory programs to conduct experiments, and multiple media programs). Second, in distant locations, there is a shortage of technology infrastructure in schools (for example, computers, smart phones for students in remote area and the Internet). Third, scienceteachers lack professional training in the use of modern applications and their application in remote work. Fourth, Students' inexperience with remote technological applications in general, and especially people in remote areas.

Consequently, these challenges restricted teachers from effectively implementing scientific and engineering practices in distance education during the Corona pandemic.

In light of the results of the study, the researcher concluded a set of recommendations: Increasing the number of SEPs in the content of scientific books for fifth graders than is already available. Diversifying SEPs in science textbooks content to present students with a variety of chances that match their needs and goals, and to motivate them to participate in educational scenarios while learning science. Training science teachers on technological applications that are used in distance education. Finally, providing schools with a technological infrastructure, such as: remote interactive platforms, various technological applications, computers connected to the Internet for students andteachers.

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