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Online STEM Education Approaches during the COVID-19 Pandemic

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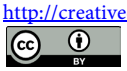

Abstract

The 2019 COVID-19 Pandemic has had a tremendous effect on education. This paper focused on how teachers of Science, Technology, Engineering and Mathematics (STEM) delivered content via online distance learning while face-to-face teaching was not possible during the Pandemic. The study was set in the Jempol district in Malaysia and was a meso-scale longitudinal study. This study identified suitable delivery platforms for Science content knowledge (STEM) via distance learning during COVID-19 pandemic. Also identified were suitable teaching aids, Science activities suitable for students to master the standard STEM content knowledge, methods of online laboratory learning and finally suitable online assessments. Fuzzy Delphi analysis was carried out using 10 experts in order to arrive at a consensus. Findings revealed that 84% believed that WhatsApp, Zoom and Google Meet were the most favourable online platforms to deliver STEM content knowledge. 88% stated that the most suitable teaching aids are YouTube modules due to their high accessibility among students. Meanwhile, 76% agreed that the most favourable assignments are module-based activities, writing reports or notes and online presentation. 80% of respondents felt that modules and sample experiments from YouTube would be favourable choices to teach laboratory skills. Finally, 89% of participants saw video presentation and online quizzes to be satisfactory assessment methods for STEM students. It was concluded that additional research should be carried out on challenges faced by teachers in conducting distance learning, which will be helpful when digitalization and virtual learning take place on a wider scale in the future.

Keywords

COVID-19, STEM, Fuzzy Delphi, Online Learning, Distance Learning

1. Introduction

1.1. Background

Institutions delivering education from kindergarten to university are being massively affected by the global COVID-19 outbreak (Kaur & Singh Bhatt, 2020; Mokhtar et al., 2020; Sivanisswary & Lubna Ali, 2020). In Malaysia, the worst-affected communities are teachers and students in primary and secondary schools (Kaur & Singh Bhatt, 2020).

School closures are seen as the best way to stop the virus from spreading in schools, but closing down schools automatically shuts down classroom pedagogy and forces online teaching to be implemented instead. A dramatic transformation can be seen clearly where classroom learning is transformed into distance learning using technology tools (Sahin & Shelley, 2020; Sunasee, 2020). Such technological transformation in content delivery was called for in the 2030 Agenda for Sustainable Development, which aims to ensure inclusive and equitable quality education and to promote lifelong learning opportunities for all. However, research has shown that teachers and students are not ready for the sudden shift from traditional face to face learning to distance learning using online platforms (Sivanisswary & Lubna Ali, 2020). Besides that, many school systems are experiencing major problems prior to COVID-19. The teaching and learning processes in schools are divorced from reality. Meanwhile, according to "Schools of the Future: Defining New Models of Education for the Fourth Industrial Revolution", "Numerous education systems, both in developed and developing countries, still rely primarily on passive modes of learning based on direct teaching and memorization, rather than interactive techniques that foster the critical and individual thinking required in today's innovation-driven economy." (Azorín, 2020).

Even though most of the countries around the world focusing in closing the educational institutions as a primary procedural to stop spreading COVID-19, in China mix innovative and renewed teaching approaches has been introduced especially delivering content knowledge via online methods (Zhu et al., 2020). It has been followed by other countries around the world, especially in Malaysia. However, online teaching method is considered as major and primary method in currents situation. Although certain digital skills such as digital literacy, understanding of machine language (programming), and information analysis have been introduced as part of educational transformation (UNESCO, 2018), in which the learning environment is moved to an online mode, these rapidly changing situations remain unclear due to the educational tactics used by teachers who are still stuck in the old paradigm. However, when a pandemic threatens the world, education digitalization proves to be a vital tool for delivering knowledge to learners. Rather of upgrading and adapting to the digitalization era, teachers have been given no other options (Azorín, 2020; UNESCO, 2018, 2020).

Nostalgia for the classroom has arisen among teachers, especially those who teach Science, Biology, Physics and Chemistry. This undoubtedly indicates the

extreme difficulties experienced in carrying out proper teaching on a digital platform. This has led the researcher to identify suitable STEM online teaching approaches for use during the COVID-19 Pandemic.

1.2. Purpose of the Study

Teaching science using digital approaches should be attractive and easy, assuming that all of the students are gathered together in class or in the science lab at the same time, with access to science equipment, apparatus and specimens for them to conduct experiments. However, during the Pandemic, teachers have often been in the classroom but the students are separated, often based at home. This has become the only delivery option for teaching while avoiding infection by the COVID-19 virus.

Therefore, it is necessary to ask what kind of evolution in STEM teaching approaches needs to be carried out by teachers so that they can effectively deliver STEM content knowledge via online teaching.

Recent developments in STEM pedagogical approaches reveal a wide range of digital learning approaches that can be selected when face-to-face Science teaching in class has to be replaced by the virtual classroom. Online approaches begin with the delivery platform, and include suitable teaching aids or tools, assignments, laboratory modes and appropriate assessment tools to properly evaluate the students' learning.

For these reasons, this study aims to address the following questions:

1) What are the most suitable platforms to deliver STEM content online?

2) What are the most suitable teaching aids to deliver STEM content online?

3) What are the most suitable assignments for delivering STEM content online?

4) What laboratory modes are most suitable for online STEM learning through experiments?

5) What assessment tools are most suitable to evaluate STEM learning online?

Teachers who conduct science lessons via digital learning and who carry out virtual laboratory experiments can be viewed as field experts in this area, able to provide valuable information on how to choose the best delivery online approaches and tools. Therefore, this study aims to arrive at an expert consensus on the most suitable approaches to deliver STEM subjects (Science, Biology, Physics, Chemistry, Geology, etc.).

1.3. Problem Statement

The knowledge, interest, behaviour and personality of teachers is an important element of student success in education (Kırbaş, 2020). However, the Pandemic challenges teachers to be adaptable in transitioning from face to face learning to remote or online learning (Kimmel et al., 2020; Sunasee, 2020). Distance learning via eLearning has become the only approach to reconnect teachers and students after face-to-face instruction has been suspended. More complicated issues

arise when teachers are demotivated to learn how to utilise digital media (Graumann, 2020).

OECD countries have reported that training in information and communication technology (ICT) is needed for teachers (Schleicher, 2020). When digital technology is the only answer for distance learning, large numbers of teachers who had not previously encountered digital teaching have now had to make a tremendous effort to reach their students using digital technology in the form of WhatsApp, educational software and mobile learning apps (Graumann, 2020; Schleicher, 2020). Although the COVID-19 crisis has opened an opportunity for technology use, the massive effort that has to be made to learn it needs to be taken into account to ensure that teaching and learning can be carried out.

Crucially, however, other challenges include identifying suitable technology platforms, appropriate instructional methods, learning activities and assessment tools for use during the COVID-19 Pandemic (UNESCO, 2021). Also, focusing on opening schools in future, school leaders and teachers eagerly look forward to the most suitable platform to deliver lessons in primary and secondary schools by providing help for vulnerable pupils. Regardless of the Pandemic, it is necessary for teachers to adapt from face-to-face learning to online distance learning, instead of always being in class (Dana & Kanematsu, 2020).

Even so, teachers are now affected by various internal and external challenges in order to give lessons via digital learning. Apart from anxiety about sudden change, teachers had to perform science experiments via virtual laboratories for students with limited technology devices. Laboratory classes are vital for students taking STEM education. When the traditional laboratory has been disrupted due to the Pandemic, another alternative computer-based laboratory is needed instead (Worrall et al., 2020).

Alongside this, many higher institutes are struggling to maintain active learning and to increase student engagement, especially in science laboratory practical classes (Sunasee, 2020; Worrall et al., 2020). Furthermore, online platforms have been brought in to ease the teaching and learning process for teachers and students. However, limited student uptake has been common due to recklessness and also students coming from low-income households without internet connections. These factors will seriously restrict the online learning process (Sunasee, 2020; Yıldız & Akdağ, 2017).

Furthermore, there is currently a greater focus on delivering content knowledge to students, rather than assessment. For instance, Sivanisswary & Lubna Ali (2020) report that Microsoft Team platforms had been created for online teaching, but assignments and examinations were omitted. Therefore, focusing on delivering the knowledge is insufficient without proper assessment to assess or evaluate student learning.

Therefore, as Sukendro et al., (2020) point out, online platform-based teaching has to be more flexible, efficient and effective in order to support the face to face learning. However, when teachers and students were suddenly switched

from face-to-face learning to distance learning (Kimmel et al., 2020; Sunasee, 2020) without the time and space to get used to this new regime.

Then, more complicated issues may arise, especially with STEM education. Although teachers and students were not ready for the sudden shift, the order from the Ministry of Education in Malaysia had to be followed by all schools and tertiary institutions (Sivanisswary & Lubna Ali, 2020). Instead of complaining about their situation, teachers have used this tough time to utilize the technology available to deliver STEM content.

1.4. Limitations

This study only focuses on those teachers who are teaching science (STEM) subjects in school under Kementerian Pendidikan Malaysia in Jempol. They were selected for their expertise in teaching Science, Biology, Physics and Chemistry face to face in the classroom. The teachers were also selected because they showed willingness to help other teachers who are delivering science lessons online and giving their best to educate their students. The data is an additional data which had been collected by the researcher after getting the permission from Negeri Sembilan State Education Department to conduct the research in Jempol (Secondary School in Jempol and Jelebu). Ethical approval was granted under JPNS.SPS.MTE.500-12/4 Jld.3(37). The researcher met with the principal before approaching the teachers to ensure that they were willing to allow the researcher to conduct the studies by approaching the teachers and students.

2. Literature Review

2.1. Face to Face vs Distance Learning

Face to face learning is the most preferred learning mode by all teachers and students (Sahin & Shelley, 2020; Sunasee, 2020; Worrall et al., 2020). Face-to-face teaching involves close contact between teachers and students, which directs students to acquire the proper skills as well as laboratory skills and knowledge through hands on activity in classrooms and laboratories (Kimmel et al., 2020; Sukendro et al., 2020). According to Graumann (2020), digitization is the only distance learning option to ensure that the content knowledge will be delivered to the students.

Various pedagogical approaches will be followed by teachers in class, but with distance learning, pedagogical approaches need to change according to current technology. This is also true for teaching science. One of the most important and well recognized methods to conduct science problem solving and inquiry-based learning is Model 5E (Lee et al., 2016). Model 5E is an instructional model developed by Biological Science Curriculum. It consists of 5 phases: Engagement, Exploration, Explanation, Elaboration and Evaluation.

Therefore, in order to identify features to enable the teaching of science online, a researcher needs to build a model to teach science based on Model 5E, which will incorporate inquiry-based learning and problem solving from face-

to-face science learning, and will also be appropriate to distance learning. Figure 1 below elaborates the essential steps to perform face-to-face learning and distance learning.

Delivering science content should be performed in a proper order so that it will be delivered to students via active learning. Merely providing notes and explanations in an online class is insufficient to meet the needs of students. Delivering science content via online classes also needs to be done attractively in a well-designed structure, so students eagerly participate in the class. For this reason, this study has to identify the important steps that should be taken by science teachers to deliver their content knowledge to their students.

These steps begin with firstly identifying the most suitable platform for the students to attend the class. This is then followed by selecting teaching aids to deliver science content. Next, online assignments need to be considered seriously because they will be the best way that students can learn actively. In particular, laboratory assignments are especially crucial and need to be taught to and understood by science students. Lastly, assessment is one of the essential ways to evaluate the students' ability and the quality of learning.

2.2. Appropriate Platforms to Deliver Science Content Online.

In order to ensure that online distance learning achieves its aims, it is important to start by identifying the most suitable ICT platforms to deliver STEM content to students (Mokhtar et al., 2020; Kimmel et al., 2020; Sunasee, 2020). At the same time, the chosen platforms should minimize technological and instructional challenges (Kimmel et al., 2020; Sunasee, 2020). Platforms must incorporate laboratory assignments and content knowledge in science, and teachers also need to take students' backgrounds into consideration before choosing suitable platforms (Graumann, 2020).

According to Nations (2021), there are a number of minimum standards that should be met or exceeded by all STEM online platforms. These are as follows.

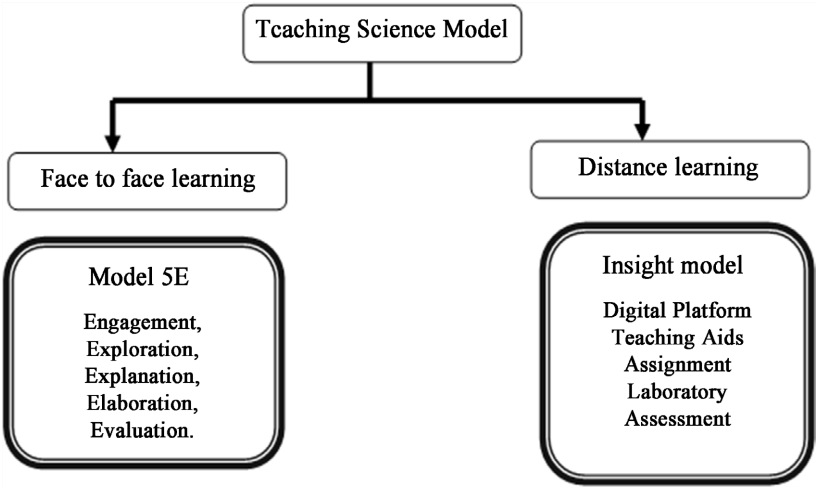

Figure 1. Science teaching model.

Firstly, platforms should be available via any web browser with no special servers required. This helps create a streamlined learning environment regardless of the content delivery method. Secondly, platforms must perform excellently on all popular devices used in education, such as Chromebooks and smartphones. This will ensure the largest possible user base. Thirdly, there should be a fast, straightforward set up and activation process so that all stakeholders can easily use the platform in class and remotely. Fourthly, the user interface design must be robust yet intuitive to be easier to use by teachers and students. Users must enjoy using the platform if they are to use it regularly.

Fifth, the platform must offer fast and easy single sign-on through relevant systems such as Google. Next, clear and up-to-date security and privacy features should be present, especially in remote learning, where students need to know that they are learning safely. The platform should also provide regular and detailed learner feedback, to enable teachers to provide interventions to those students who need it. Finally, there should be accessible user guides and FAQs to make it easier to deal with any issues that may arise while using the system.

2.3. Appropriate Teaching Aids to Deliver Science Content Knowledge Online

Once an appropriate platform has been chosen according to the standards described above, it is necessary to decide which teaching aids are to be utilized. Digital technology plays an important role in teaching science face-to-face, by supporting pedagogy to make it more flexible, efficient and effective in the classroom. However, the face-to-face instructional strategies used by teachers will be seriously affected when online teaching is suddenly imposed as it has been during the Pandemic (Kimmel et al., 2020; Sukendro et al., 2020; Worrall et al., 2020).

Various teaching aids have been introduced in hardcopy, but current circumstances have ruled out solid or touchable materials. Therefore, teaching aids need to be readable and easy to understand for students and should be able to be delivered on time. Videos which consist of more than 20 minutes of lecturing might be complicated for students who are out of range from internet facilities.

It is therefore the teachers' responsibility to choose the most convenient teaching aids which are rich in content and are easily useable for students from different areas (Kimmel et al., 2020). Such aids include video content, lesson plans, textbook content and educational tools for various subjects. According to the website topeducationdegrees.org (2022), 5 common sources of such teaching aids for teachers are CK-12, Lesson Planet, NASA, National Science Foundation and STEM-Works.

As pointed out by Sukendro et al., (2020), the behavioural intentions of teachers are linked directly to the use of e-learning during the COVID-19 pandemic. Therefore the teachers must find ways of bringing alive their teaching aids in order to enrich the students' knowledge and learning experience (Worrall et al., 2020).

2.4. Appropriate Assignments to Deliver Science Content Online

Assignments function to enrich a student's knowledge in a particular subject, as well as providing an effective method of assessment. Assignments will meet students' inner needs, and are normally carried out in class (Thirakunkovit et al., 2016) as problem-based learning and inquiry-based learning activities. Teachers will normally divide the task among groups of students in the form of questions so that they carry out discussions and also presentations (Sunasee, 2020). Sometimes, activities will be in the form of games or puzzles to solve science problems, or laboratory activities. These will normally be very effective during face-to-face learning.

The same types of assignment might be easy to administer under distance learning also. However, questions always arise about whether or not such tasks are possible online, especially for students who live far apart from each other (Kimmel et al., 2020; Sunasee, 2020). It might be the case that students linked to each other on the internet may appear to be doing their assignments, are not doing them or might not be fully engaged. For that reason, teachers must ensure that their online students are fully engaged, otherwise the effectiveness of online distance education for STEM will be affected (UNESCO, 2021).

2.5. Appropriate Laboratory Modes for Learning through Experiments Online

Several challenges have affected the process of acquiring science content knowledge and laboratory knowledge in learning science. Laboratory assignments should normally be carried out in a laboratory using special equipment and experimental tools. However, with online distance learning becoming the norm, students are forced to be apart from physically handling science equipment (Kimmel et al., 2020). Furthermore, according to Worrall et al. (2020), assessing students' laboratory work via computer-based analyses has also been found to be difficult and has failed to achieve the goal of learning synthetic chemistry.

Despite this, it was found that problems arise when the number of experiments available for students also decreased when practical chemistry activity was removed from the lesson (Worrall et al., 2020). Therefore, the science teacher should be creative and innovative in order to determine the most suitable laboratory work and the best mix between laboratory work and other forms of learning. This should contribute to fruitful lessons.

2.6. Appropriate Assessment Tools to Evaluate Student Learning Online

Learning objectives can be achieved when students acquire the learning content which can only be assessed through either formative or summative assessment (Papanthymou & Darra, 2018). Assessment has an impact throughout a student's learning progress and helps them to achieve their goals (Papanthymou & Darra, 2018). Meanwhile, formative assessment facilitates students' learning (Zhu

et al., 2020) and is an important tool to ensure the achievement of learning objectives. This particular assessment can be conducted very sucessfully online.

There might be a higher risk of academic dishonesty when an assessment is carried out online. High self-esteem in acquiring greater marks in exams or quizzes might lead to many negative consequences. Cheating and referring to the book while answering questions reflects low self-discipline and self-learning among students. This obstacle might be one of the reasons for failure of online assessments. Therefore, teachers have to come up with various strategies to assess students online which by-pass the risk of academic dishonesty.

3. Methodology

3.1. Participants

This is a quantitative study using a survey. The participants are 10 expert teachers who have been teaching science for more than 10 years. The survey instrument was distributed to the experts via Google Forms. The instrument contains five sections which contain items related to suitable platforms, suitable teaching aids, suitable assignments, suitable laboratory modes and suitable assessment tools to deliver science content knowledge via online classes.

The researcher identified and organized the items through the literature review. Then, the researcher identified a group of experts who have been teaching science for more than 10 years and who are willing to contribute their expertise in choosing suitable platforms, teaching aids, assignments, laboratory modes and assessments which can be used especially in a distance learning approach.

3.2. Instrumentation

The research instrument for fuzzy Delphi analysis was adapted by the researcher from the instrument used by Kimmel et al. (2020) to make it relevant to the learning environment in Malaysia. Fuzzy Delphi analysis is used to obtain expert opinions and consensus on given topics as part of a quantitative survey procedure. The technique is also useful for determining the suitability of implementing teaching programmes, and forecasting trends.

Besides this, the instrument underwent a validity and reliability process. The construction of the questionnaire items was analyzed for item validity according to the construct and content validity index (CVI) by 5 separate experts. The questionnaire was tested using a pilot study using 5 respondents who were science teachers not involved in the study. Based on the pilot study, the instrument was finalised, before being distributed to the 10 experts.

3.3. Collecting Data

Since this study was conducted during the COVID-19 Pandemic, a short briefing was carried out by the researcher to the teachers who took part in the research via Google Meet. The experts who were not able to join the Google Meet session were called by the researcher personally and briefed on the requirements of the

study. The experts then answered the questionnaire via Google Forms. The data was collected automatically by the Google Forms software.

3.4. Analysis

Next, the data analysis took place. The data analysis steps were as follows:

Step 1: identify the experts and number of experts. At the beginning there were 10 experts and after collecting their opinion and discussion, the experts provided their responses using a Likert scale, which incorporates the Triangular Fuzzy Numbers. Triangular Fuzzy Numbers comprise three fuzzy numbers assigned as m1, m2 and m3. M1 is the minimum value, m2 the medium value and m3 is the maximum value which is stated between the range of 0 and 1. A five-point linguistic scale was employed in this study as shown in **Table 1** below.

Step 2: The Fuzzy Delphi template was used to calculate the average responses for every Fuzzy Delphi number. First, the threshold value was identified, which indicated the consensus level among the experts. The equation used to compute the threshold value is shown below:

$$d\left(\bar{M},\bar{m}\right)=\sqrt{\frac{1}{3}\left(M_1-m_1\right)^2+\left(M_2-m_2\right)^2+\left(M_3-m_3\right)^2} \quad (1)$$

Aligned with the threshold value, the experts' group consensus percentage was identified. The consensus is achieved when the threshold value is less than or equal to 0.2, and the group percentage value is more than 75% (Sondakh et al., 2020).

Step 3: The next step is identifying the defuzzification value (DV). The defuzzification value refers to the real number which is identified from the fuzzy numbers using the following equation:

$$DV=\frac{1}{3}*\left(m_1+m_2+m_3\right) \quad (2)$$

The defuzzification number is important in order to rank the items. It is also known as an alpha-cut level. The commonly used α-cut > 0.5 (Ramlan & Ghazali, 2018). Items with α-cut less than 0.5, will be deleted, showing that a particular item did not reach the requirement needed to support the questions.

Table 1. Linguistic scale.

Linguistic Variable	Fuzzy Number	Likert Scale Value
Strongly Disagree	0, 0.1, 0.2	1
Disagree	0.1, 0.2, 0.4	2
Neutral	0.2, 0.4, 0.6	3
Agree	0.4, 0.6, 0.8	4
Strongly Agree	0.6, 0.8, 1.0	5

4. Findings and Discussion

The findings revealed the experts' opinions in selecting the suitable teaching platforms, teaching aids, assignments, and laboratory modes for learning through experiments, as well as the suitable assessment tools to evaluate student learning. The findings will be discussed according to each question, as follows (Table 2).

Question 1: What are the most suitable platforms to deliver science content online?

The threshold value shown above is 0.140 which is less than 0.2, therefore the items achieved consensus. Furthermore, the percentage of group consensus is 84%. This value indicates that the items met the requirements. The finding illustrates that teachers are more prone to choosing WhatsApp in their teaching and learning at Jempol. Besides that, Zoom Meeting and Google Meet are also popular. According to the experts, WhatsApp is the easiest online method to reach students so that they can receive and share content.

The findings support Sivanisswary & Lubna Ali (2020) who showed that it is most important for online methods of teaching and learning to use suitable and applicable online applications to deliver content knowledge. Furthermore, Sunasee (2020) stated that Zoom is the most suitable online platform for online content delivery. However, despite the growing popularity of Zoom during the Pandemic, challenges remain for students who are unable to attend scheduled Zoom sessions due to poor internet connections.

In summary, this survey indicates that WhatsApp is the most favourable platform to deliver content knowledge, but Zoom and Google Meet were focused on virtual lecture meetings. Although technology can never substitute for a teacher, in the current situation WhatsApp is the best tool to help teachers to provide proper guidance, according to the 10 experts (Table 3).

Question 2: What are the most suitable teaching aids to deliver science content online?

The threshold value shown above is 0.138 which is less than 0.2, therefore the items achieved consensus. Furthermore, the percentage of group consensus is

Table 2. Results for question 1.

Threshold value	Consensus percentage	Items		α-cut	Ranking
0.140	84%	A1	Zoom	0.700	2
		A2	Google Meet	0.680	3
		A3	WebEx	0.520	6
		A4	Video Conferences	0.620	5
		A5	WhatsApp	0.760	1
		A6	Virtual Class	0.660	4
		A7	Telegram	0.660	4

88%, which is acceptable. The defuzzification number lies between 0.760 and 0.700. The results show that teachers prefer using Modules, YouTube videos, hard copy notes, softcopy notes, videos and PowerPoint slides to deliver science content knowledge. Modules are important for giving better practice to students based on the Standard Curriculum from the Ministry of Education.

Along with this, Kimmel et al. (2020) emphasized that students who are living out of internet range might find difficulties in downloading videos of more than 20 minutes' duration. Therefore, virtual activities alone are insufficient for STEM students to acquire all the STEM knowledge they need, and hard copy notes and modules also play an important role to develop their skills in acquiring scientific knowledge (Table 4).

Question 3: What are the most suitable assignments for delivering science content online?

The threshold value shown is 0.167 which is less than 0.2, therefore the items achieved consensus. However, the defuzzification values were calculated between 0.720 and 0.580. Question 3 only has one Item C1; Folio, which achieved a group consensus of 50% and an average fuzzy Delphi number of 0.58. Based on this result, the experts are not strongly interested in giving folios as assignments. However, the percentage of group consensus is 88%. It shows that online presentation,

Table 3. Results for Question 2.

Threshold value	Consensus percentage	Items		α-cut	Ranking
0.138	88%	B1	PowerPoint Presentation	0.700	4
		B2	Videos	0.720	3
		B3	YouTube	0.760	1
		B4	Soft copy notes	0.700	4
		B5	Hard copy notes	0.740	2
		B6	Modules	0.760	1

Table 4. Results for question 3.

Threshold value	Consensus percentage	Items		α-cut	Ranking
0.167	76%	C1	Folio/ scrapbook	0.580	7
		C2	Online presentation	0.700	3
		C3	Writing report/notes	0.720	2
		C4	Prepare Presentation slides	0.680	4
		C5	Experiments	0.660	5
		C6	Group discussion	0.620	6
		C7	Module Based Activities	0.760	1

module based activity, scrapbooks, preparing presentation slides, simple home-based experiments and virtual group discussion can still be carried out virtually (Table 5).

Question 4: What laboratory modes are most suitable for online learning through experiments?

The threshold value shown is 0.177 which is less than 0.2, therefore the items achieved consensus. Furthermore, the percentage of group consensus is 80%. Even though modules were given based on the laboratory assignment, certain experiments need to be assisted by the teachers and some experiments need instruments which are only available in the laboratory (Sunasee, 2020; Worrall et al., 2020).

Therefore, a worksheet of science experiments which students ought to watch on YouTube, or a video created by the teacher are the most suitable tools to help students to acquire the basic laboratory skills, according to the field experts. Students have to understand each step by watching the virtual laboratory experiments given. This is supported by the experts who agree that modules and online science experiments (from YouTube or other sources on the Internet) are the most suitable tools during the Pandemic for the students in Jempol District (Table 6).

Question 5: What assessment tools are most suitable to evaluate student learning online?

The threshold value shown is 0.152 which is less than 0.2, therefore the items achieved consensus. Furthermore, the percentage of group consensus is 89%. This reveals that online assessment, quizzes, modules, recorded video, home flexible experiments and discussions and presentation during online class are the most favourable assessments. Recorded audio or video are useful tools for the teachers to see the student's capability and ability in absorbing content knowledge. Live worksheets and quizzes are also considered important tools to evaluate the student's achievement in specific topics learned.

According to Sivanisswary & Lubna Ali (2020), other online applications such as Kahoot, Padlet and Edmodo also have been used as a part of online applications

Table 5. Results for question 4.

Threshold value	Consensus percentage		Items	α-cut	Ranking
0.177	80%	D1	Watch Science experiments online (from YouTube or other sources on the Internet)	0.680	2
		D2	Modules	0.700	1
		D3	Virtual Science Laboratory by the teacher and students.	0.500	4
		D4	Virtual Science Laboratory by the teacher	0.560	3

Table 6. Results for question 5.

Threshold value	Consensus percentage		Items	α-cut	Ranking
0.152	89%	E1	Assessment during discussion through learning platform	0.660	4
		E2	Assessment through the Science modules supplied to the students	0.700	2
		E3	Assessment through online Science Quizzes	0.700	2
		E4	Assessment through online Science worksheets	0.700	2
		E5	Evaluation of student's presentations during online classes	0.660	4
		E6	Assessment of recorded tasks such as videos	0.720	1
		E7	Assessment of recorded tasks such as audio	0.680	3
		E8	Assessment of simple experiments at home with the help of modules	0.700	2

to learn languages. Hard-copy or online assessments also play an important role in students' learning progress and help them to achieve their goals (Papanthymou & Darra, 2018).

5. Conclusion and Recommendations

This study revealed that WhatsApp, Zoom and Google Meet are considered the most favourable online platforms to deliver STEM content knowledge. Besides that, the most suitable teaching aids are modules and YouTube due to their high accessibility among the students from all around the Jempol district, even those using limited data smartphones.

It is necessary to assign suitable assignments to students, in order to ensure that the learning process has occurred. The findings illustrate that module-based activity is the most suitable for Jempol district school students, who primarily come from remote areas. Besides that, writing reports or notes and online presentations are favourable STEM assignments for the students.

It is also necessary to conduct laboratory teaching in STEM. The field experts agreed that modules and sample experiments from YouTube would be favourable choices to teach laboratory skills to students. To achieve learning outcomes, assignments alone are insufficient, but the assessment is vital. Therefore the 10 experts listed all the possible assessment methods for STEM students. Such methods will provide the students with a wide range of example experiments which they can watch in order to internalize various scientific concepts such as gravity, light or chemical reactions.

This paper is a basic study to identify a consensus among a group of experts concerning the most suitable online platforms, teaching aids, assignments, teaching laboratory and assessment methods in delivering STEM content knowledge during the COVID-19 pandemic. Deeper research on the challenges faced by teachers in conducting distance learning will need to be carried out in future when digitalization and virtual learning become more common.

Finally, this paper demonstrates the resourcefulness and creativity of teachers when faced with external pressures such as the COVID-19 Pandemic. Such resourcefulness is in turn supported by a wealth of available ready-made solutions to reduce the disruption to STEM teaching and learning caused by the Pandemic. The extent to which different technologies become common will depend on factors such as usability, pedagogical suitability, technological issues and learner access. As a result, the availability and use of such technologies will enable an ongoing and lasting research effort to address existing social divides in access to education using both online and blended learning methods.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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