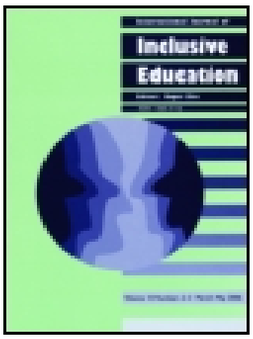

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Providing inclusive education through virtual classrooms: a study of the experiences of secondary science teachers in Malaysia during the pandemic

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ABSTRACT

During the COVID-19 pandemic, remote teaching was required to ensure that educators could continue teaching and that students could still attend classes. However, since the necessity for remote teaching occured, many teachers were not used to teaching virtually while ensuring that their students were given equal opportunities and environments to obtain a quality education. The aim of this study is therefore to explore the experiences of secondary school teachers in Malaysia in providing a more inclusive education during the pandemic specifically in science-related subjects via virtual classrooms. An online survey was conducted among 126 science teachers. The findings indicate that the readiness of science teachers in providing inclusive education is not high. Their scores in terms of affective attitude, behaviour, cognition, competence and awareness were barely sufficient. Issues such as lack of experience teaching virtually, insufficient training and support from schools and educational authorities, and parents lacking technological competence and skills to facilitate their children's virtual classrooms at home were identified. This study has implications for researchers and educational institutions that intend to promote inclusive education in the context of remote teaching and learning.

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Inclusive education; remote teaching; virtual classrooms; science teachers

Introduction

Due to COVID-19, many transmission and protective measures had to be implemented worldwide. Pandemic measures such as lockdowns and restricted travel have resulted in schools needing to switch to emergency remote teaching. Hodges et al. (2020) argues that there is a difference between ordinary remote teaching and emergency remote teaching. Ordinary remote teaching usually comes in the form of higher-quality online teaching with respect to planning, designing and delivering courses. In contrast, emergency remote teaching occurs as an immediate alternative in schooling enabling educators to

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continue teaching in an emergency situation. During this challenging time, it is important that teachers are aware of the importance of providing inclusive education to students.

The term 'inclusive education' is defined as follows:

> Real learning opportunities for groups who have traditionally been excluded – not only children with disabilities, but speakers of minority languages too. Inclusive systems value the unique contributions students of all backgrounds bring to the classroom and allow diverse groups to grow side by side, to the benefit of all. (UNICEF 2021)

Previous studies have focused on inclusive education more on the children with disabilities (Moriña and Carballo 2017; Connor et al. 2008; Ballard 1999). However, when the pandemic occurred and emergency remote teaching started to take place, many students with and without disabilities were unable to receive equally quality education due to several barriers. For instance, not all students lived in the same geographic area with equally fast internet connections. Access to the internet and connectivity was identified as one of the factors to consider when designing courses coping with emergency remote teaching (Green, Burrow, and Carvalho 2020). A study reported the challenges of students living in rural areas in South Africa in relation to having resources and access to the internet when they had to learn online under the pandemic (Dube 2020). According to Dube, besides access to the internet, other factors that hinder students from an inclusive education in the form of emergency remote teaching include access to electronic devices for remote teaching as some families might not be able to provide all their children with equipment, spatial arrangement whether students have their own spaces to follow remote teaching, and students' ability to follow classes online as not all students have the similar digital competence. Some of these factors might also be relevant to teachers. The digital divide among teachers and students, i.e. differences in the access and competency in technology use due to demographic factors such as age, income, race, gender, location, education, etc., makes their practice of adopting virtual classrooms varies between one other (Swain and Pearson 2001; Correia 2020). According to Nielsen (2006), the three stages of the digital divide begin with stage 1, economy divide; transitioning to stage 2, usability divide; and lastly at stage 3, empowerment divide. In the empowerment divide, technology design can be very easy and intuitive. However, users do not make full use of what the technology can offer.

In many countries, many teachers are used to face-to-face teaching (Moorhouse 2020; Louis-Jean and Cenat 2020). When they were asked to switch to emergency remote teaching, they might not have had the competence and awareness to provide inclusive education to the students digitally and remotely. A study exploring the role of educators at a higher education institution in Malaysia during emergency remote teaching, showed that educators were provided with the freedom to choose the platforms and applications they wanted to use (Juhary 2020). However, the choices were made based on what as most convenient to them, instead of to the students. This might result in students being excluded from receiving an inclusive education due to the lack of awareness and competence among educators in providing remote teaching.

Since the announcement of the Malaysian Government's Movement Control Order (MCO), i.e. lockdown restrictions and the subsequent closing of all educational institutions, the teaching and learning process shifted to remote teaching and learning. In

science education, teaching and learning not only covers theoretical classes but also involves practical classes. In the theoretical classes content such as science concepts, science theory and application can be conducted via lecture and peer discussion. Meanwhile practical science classes involve students' hands-on activities and experiments that need to be conducted in a science laboratory. This feature made teaching more challenging for science teachers when they had to use virtual classrooms. Both theory and practical classes had to be conducted remotely, and science teachers did not have any prior experience in anything but an in-person practical classroom. In addition, the sciences are full of abstract concepts that require students to imagine, visualise and conceptualise . Most science teachers face challenges adapting to such a situation, as they are not ready for such drastic change due to the pandemic.

Since remote learning has become a compulsory agenda during the pandemic period, science teachers' experiences in handling and providing a more inclusive remote class appear to be relatively important. Taking into consideration being inclusive towards diverse practice, Correia (2020) proposed strategies such as alternatives to video conferencing and using other form of assessment for online learners. In this study, we aim to explore the experiences of secondary school teachers in Malaysia attempting to provide more inclusive education during the pandemic specifically in science related subjects via virtual classrooms. By exploring their experiences, we intend to investigate what they have done and what could have been done better.

Research design and methodology

This study adopts a mixed quantitative and qualitative methods approach, using a questionnaire survey to assist the data collection. The quantitative data comprise Likert scale items of five domains (details are discussed in the instrument section) and other open-ended questions that attempt to seek more insights from the qualitative data. This survey method was suitable for reaching respondents from larger geographical areas while providing a border picture of what has been practiced by science teachers during remote learning in relation to providing a more inclusive education to their students (Creswell 2014, 3–24).

Sample

In this study, we focused on secondary science teachers. The subjects that these teachers teach are primarily biology, chemistry, physics and general science. The main reason secondary science teachers were selected to participate in this study was the nature of the science subject itself where the subject covered both theoretical and practical elements, whereby hands-on activities were required and also part of the curriculum. Hence, the teaching and learning strategies of science teachers could be more challenging as compared to those subjects that do not require laboratory activities. On the other hand, in primary science the main focus still falls heavily on the theoretical part, with more emphasis on students understanding the fundamental concepts of science, and the practical aspect being less explored than in secondary science. Besides that, the science subjects offered in secondary science are more concrete subjects as they cover biology, chemistry, physics and general science. This offers a wider spectrum for researchers to

look into how different science subject teachers offer a more inclusive education for their students. We adopted convenience sampling strategy, i.e. the survey link was sent via social media platforms to accessible networks such as teachers who we know teaching science-related subjects and school staffs who know teachers who teach science-related subjects.

Instrument

An online survey was created on Google Form and was divided into four main sections. First, the respondents were required to answer some demographic questions, for instance years and subjects of teaching, school area, living area, age, and ICT skills. The second section asked the respondents about their work in relation to virtual classrooms, such as what ICT tools they had used and whether their work had increased due to the implementation of virtual classrooms. Respondents who had experienced a work increase were asked to provide reasons or more details.

In the third section, the respondents were provided a list of statements which they had to express if they agreed or disagreed. To measure how the teachers perceived themselves in providing inclusive education, we identified five domains – affective, behavioural, cognitive, competence and awareness – based on relevant works (Mahat 2008; Gilligan 2020; Green, Burrow, and Carvalho 2020). The statements were then developed accordingly; that is to say, those in the affective, behavioural and cognitive domains were adopted from Mahat (2008) while the domains of competence and awareness were developed referring to Gilligan (2020) and Green, Burrow, and Carvalho (2020). In this research, the affective domain refers to science teachers' attitudes towards providing a more inclusive education; the behavioural domain reflects science teachers' behaviour towards providing an inclusive learning environment during virtual learning; the cognitive domain highlights science teachers' action in providing inclusive education to their students; and the competence and awareness domain mainly focus on science teachers' digital skills and their consciousness in providing inclusive education, respectively.

To ensure that the language use was appropriate and understood by the respondent, the survey was checked by an English language teacher. To retain the validity and reliability of the survey, a pilot study was conducted with non-participating secondary school science teachers prior to the field study. The results of the pilot study showed that all statements in the third section of the questionnaire were in the acceptable range with an alpha value more than 0.7 (Nunnally 1978). The final version of the questionnaire consists of 17 statements in five main domains. A Likert scale of 1 to 7 was used:1- Strongly disagree, 2- Disagree, 3- Somewhat disagree, 4- Neither agree or disagree, 5- Somewhat agree, 6- Agree, 7- strongly agree, and N/A (not applicable) was offered as an option as well. Table 1 shows the statements in each domain.

In the fourth and final section, we first asked the respondents about the resources they were aware of that their students did not have access to when attending virtual classrooms. The options given to the respondents were stable internet at home, devices to attend virtual classrooms, such as laptops, PCs, mobile phones and/or tablets, space for attending virtual classrooms, assistance from the parents, and others (kindly specify). More than one option could be selected. This section ended with some open-ended questions to gain more insights from the respondents regarding their experiences

Table 1. Lists of statements for each domain.

Domain	Statements
Affective	• I have experienced students having difficulty communicating with me in a virtual classroom. • My students are having difficulties understanding my teaching during the virtual classroom. • I face challenges adapting the virtual classroom to meet the individual needs of all students. • My students are willing to speak when they are in the virtual classroom.
Behaviour	• I am willing to encourage my students to participate in all activities in the virtual classroom. • I am willing to adapt the curriculum to meet the individual needs of all students in the virtual classroom. • I am willing to modify the virtual learning environment to adapt to the needs of my students. • I am willing to adapt my communication techniques to ensure that all students in the virtual classroom can participate in learning. • I am willing to adapt the assessment of individual students in the virtual classroom to achieve the learning objective.
Cognition	• I believe that students have similar learning experiences when they learn in a virtual classroom and physical classroom. • I believe that all students can learn in the regular curriculum in the virtual classroom. • I believe that virtual classrooms provide appropriate learning experiences to all students. • I believe that students should be taught in a physical classroom to obtain the best learning outcome.
Competence	• I am able to use the ICT tools and/or apps to provide quality education via virtual classrooms (such as Google Classroom). • I have received the necessary training and assistance from my school to teach in a virtual classroom.
Awareness	• I have been informed by the students regarding their difficulties in attending virtual classrooms. • I am aware that not all students have equal access to attend virtual classrooms.

with and opinions about providing inclusive education through virtual classrooms. These questions included: 'What do you think about virtual classrooms?', 'Comparing virtual classroom to physical classroom, how would you describe your effort in providing equal opportunities in learning to all students in the same class? ', 'Any positive or negative experiences/interesting stories you would like to share with us about when you conduct virtual classrooms? ' and 'Are there any other things you would like to inform us?'.

Data collection and analysis

Due to the COVID-19 pandemic and the MCO imposed by the Malaysian government, researchers replaced the physical paper-and-pencil questionnaire with a virtual questionnaire using Google Form as the data collection platform. This method reduces the risk of physical contact between teachers and researchers and manages to cover a broader geographical area. The data collection lasted three weeks, from 8 March to 29 March 2021.

The data obtained from the respondents were analysed using SPSS version 26. The demographic data were analysed using descriptive statistics to determine the distribution of science teachers who participated in the online survey. In order to examine how secondary science teachers perceived themselves as providing inclusive education during remote teaching, the mean value for responses to statements for each domain were obtained. Each statement was assigned a score from 1 to 7 based on its Likert scale answer (Malhotra, Nunan, and Birks 2017). The scores for each item within the five domains were summed up. The mean value and standard deviation for each domain were then calculated.

A higher mean value indicated that science teachers perceived themselves as providing a more inclusive education to their students. Inferential statistics such as independent samples t-test and one-way ANOVA (Analysis of Variance) were employed to determine the differences between two or more groups towards the inclusive education (affective, behaviour, cognition, competence and awareness) provided by the science teachers. For one-way ANOVA, post hoc tests were carried out when there were significant results, as the researchers were interested in which group had significant differences.

Results

Demographic data

A total of 126 respondents completed the online survey. We summarise the years and subjects of teaching and the age of the respondents in Table 2. In terms of the area where the school was located, 65 respondents taught in an urban school, 43 in suburban schools and 18 in rural schools. Among the respondents, 118 taught in a governmental public school and the rest were private. Concerning living area, 65 respondents lived in urban areas, 45 in suburban areas and 16 in rural areas.

In terms of resources that students did not have access to when attending virtual classrooms, 116 respondents (92.1%) stated a lack of stable internet at home, followed by devices used to attend virtual classrooms (94 respondents), assistance from parents (52 respondents) and space (44 respondents). Most of the respondents reported that either they managed to provide equal opportunities in learning to all students through virtual classrooms, or they were trying their best to do so. Some provided alternative materials. For instance, posting notes in Google Classroom after the online classes, providing PowerPoint slides instead of videos that students needed to stream, recording video for online classes and pre-recording some lessons (flipped classroom). Some teachers even changed their virtual timetables to students' 'available' times (when they

Table 2. Overview of respondents' years of teaching, subjects and age.

Variables	Total sample ($N = 126$)
Years of teaching	
Less than 1	2
1–5	7
6–10	14
11–15	46
16–20	34
21–25	9
26–30	10
31–35	4
Subjects*	
Biology	28
Physics	17
Chemistry	55
General science	53
Age	
Below 30	6
31–40	66
41–50	36
51–60	18

* Some teachers taught more than one science subject

had available devices and space) and the time when their internet connection was most stable (usually at night).

However, there was reportedly a lack of competence and skills among the teachers with regards to remote teaching. Figure 1 illustrates an overview of self-rated ICT skills among the respondents. Ninety-one respondents rated their ICT skills above 7 out of 10 (1 was very low and 10 was very advanced), and no respondents rated themselves lower than 4. This indicates that most respondents had competent ICT skills in general. Despite this, they reported in the open-ended section that they had to spend more time and effort preparing for virtual classrooms. Virtual classrooms were new to many of them. Besides having to learn the software, mobile applications and virtual teaching aids, they had to ensure the students managed to use these ICT tools as well.

This finding in the open-ended section was aligned with the score of the statement 'I am able to use the ICT tools and/or apps to provide quality education via virtual classroom (such as Google Classroom)', where average score was 5.64 (1 was strongly disagree and 10 was strongly agree). The participants only somewhat agreed that they had competence and skills. One of the reasons that the teachers lacked competence and skills in remote teaching could be that the schools had yet to provide the necessary training and assistance to these teachers. In the statement asking if they had received necessary training and assistance from schools, the average score of the respondents was 4.60. Some respondents expressed the need for more training in the open-ended section.

In terms of the ICT tools being used, Google Classroom was used by almost every respondent (105 out of 126 respondents), followed by Zoom (32 respondents) and Microsoft Teams (31 respondents). Seventy-six respondents reported utilising videos on YouTube (both self-produced and others) so that students could watch them whenever they had a stable internet connection. Other social media platforms such as WhatsApp (95 respondents), Google Meet (28 respondents), Telegram (28 respondents) and Facebook (17 respondents) were used to assist students outside of ordinary virtual classrooms. This has been perceived as both positive and negative. According to the respondents, some students were more willing to reach out to ask questions 'privately' through

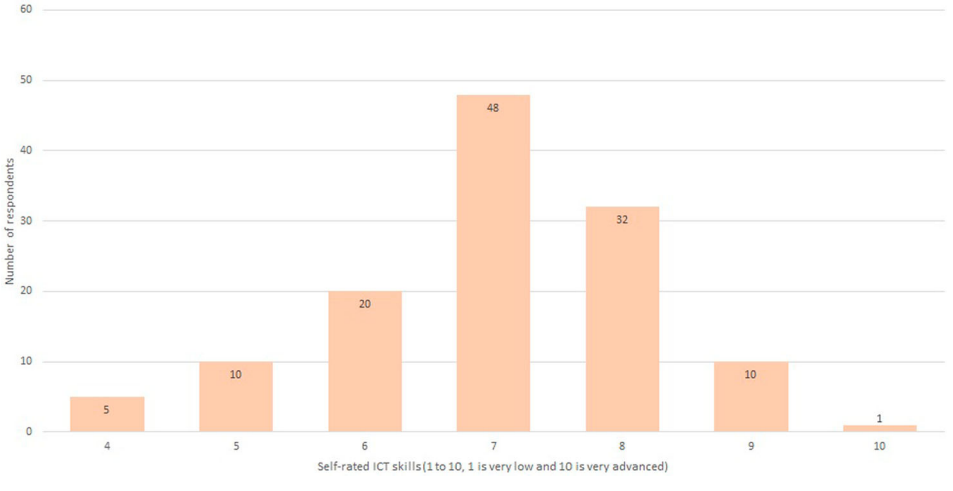

Figure 1. Overview of respondents' self-rated ICT skills.

such social media platforms, and the teachers were happy to be able to provide flexible and informal ways to assist the students. However, some students approached the teachers at night and on weekends. It is worth mentioning that some of these students might not have other choices but to approach the teachers during these times. One respondent mentioned that his/her students did that because their families had no internet at home. Therefore, the students could rely only on their parents' mobile data. The only time they had internet access was therefore when the parents had returned home after work, and were at home on the weekend. Most of the choice of social media platforms was based on the students' convenience. Out of 126 respondents, 102 noticed an increase in work since virtual classrooms took place.

Domains

Based on the SPSS analysis, it was found that in general, science teachers only slightly agreed that they were providing an inclusive education to their students (mean (M) = 4.64; standard deviation (SD) = 0.68). When looking into more detail for each domain, the mean scores ranged from neutral to agree. For instance, the science teachers showed slight agreement in the competence and awareness domains with the mean score of 5.09, and 5.20, and a standard deviation of 1.18 and 1.42, respectively. This result indicates that science teachers only somewhat agreed that they were competent in providing inclusive education for their students. Similarly, science teachers were also slightly aware that not all students had the capacity and resources to follow the virtual classes during the lockdown.

Science teachers felt uncertain in the cognitive domain, as they were unsure whether the virtual platforms used for the teaching and learning process were able to provide an inclusive learning experience to their students. This is most likely due to inadequate experience in conducting remote teaching and providing a similar learning environment quality to their students. There were similar findings in the affective domain, where science teachers felt uncertain about how they could handle the virtual classroom more effectively in order to provide a more conducive and effective science-learning environment for their students. In the behavioural domain, science teachers demonstrated agreeable behaviour where the teachers were willing to adapt and provide an inclusive education to students through virtual classrooms during the pandemic situation. The adaptive behaviour among science teachers managed to provide a more promising virtual learning environment and experience for students especially during the pandemic period. Table 3 summarises the mean score and standard deviation for each domain with the corresponding response.

Table 3. Summary of mean score, standard deviation and response for all domains.

Domain	Mean	Standard Deviation	Response (based on scale)
Affective	3.72	1.07	Neutral
Behaviour	5.36	1.10	Agree
Cognition	4.31	1.03	Neutral
Competence	5.09	1.18	Slightly Agree
Awareness	5.20	1.42	Slightly Agree
Overall	4.65	0.68	Slightly Agree

Associations between domains and demographic data

A few factors such as science teachers' residential area, type of school the teachers were teaching in, teachers' age group, years of teaching and subject taught in relation with the domains were further analysed. Based on the output from the t-test and one-way ANOVA, we noticed that the affective and behaviour domains were statistically significant. Table 4 shows the mean and standard deviation for each of the five domains. The grey-shaded columns indicate the groups with the highest mean scores for each domain.

From the perspective of the teachers' residential areas, significant difference was obtained in the affective domain. Science teachers from urban areas scored a higher mean (M = 3.49, SD = 1.02) compared to their counterparts from rural areas (M = 3.05, SD = 1.08) $t(124) = 2.36$, $p = 0.02$. For other domains, no significant difference was obtained from either groups of science teachers who stayed in different residential areas. Although these four domains did not show any significant difference, based on their mean scores, we could conclude that the science teachers perceived themselves as providing a positive inclusive educational learning experience for their students regardless of where the teachers lived.

In terms of the type of school where the science teachers taught, the data showed that there were no significant differences between teachers who taught in private and public schools. The mean scores for science teachers from public schools were relatively higher compared to private schools in behaviour, cognition, competence and awareness domains. Nevertheless, the overall mean scores indicate that science teachers regardless of private or public secondary school still managed to provide an inclusive education for their students in learning science subjects through virtual classrooms during the pandemic period.

Meanwhile, when looking into the science teacher's age group, it was found that science teachers younger than 40 years old (M = 3.46, SD = 1.09) had a significant mean difference in the affective domain compared to science teachers older than 40 years old (M = 3.01, SD = 1.01) $t(124) = 2.37$, $p = 0.02$. This result signifies that science teachers of the younger generation tend to be more concerned about two-way communication when providing an inclusive learning experience for their students. Although the other domains do not show any significant difference, the mean scores for the domains of cognition and awareness from science teachers older than 40 years old are slightly higher. The behavioural and competence domains had almost similar mean scores for science teachers in both age groups.

With respect to teaching experience, there were no statistically significant differences between the years of teaching experience and the domains. However, science teachers who had been teaching for 11–15 years had relatively higher mean scores in most of the domains (affective, cognition and competence) as compared to science teachers from the other experience groups. Science teachers with more than 21 years of experience had higher mean scores in the behavioural domain while higher awareness mean scores were found among teachers who had taught between 1 and 10 years. Overall, based on the mean scores, we can conclude that regardless of teaching experience, the science teachers provided quite an inclusive learning experience for their students during this pandemic period.

With regard to the science subject taught, it was found that there was a significant difference in the science teachers' behaviour towards inclusive education based on the

Table 4. Summary of mean and standard deviation for all constructs.

Domain	Teacher residential area		Type of school		Teacher's age group		Years of teaching				Subject Taught			
	Urban	Rural	Public	Private	< 40	> 40	1–10	11–15	16–20	>21	Biology	Chemistry	Physics	General Science
Affective	3.49*	3.05*	3.27	3.30	3.46*	3.01*	3.31	3.46	3.23	2.94	3.50	3.02	3.43	3.45
	1.02	1.08	1.10	0.66	1.09	1.01	0.98	1.13	1.06	1.02	0.99	1.11	1.23	0.90
Behaviour	5.28	5.45	5.41	4.65	5.37	5.36	5.36	5.48	5.10	5.52	5.16	5.50	5.90*	4.96*
	0.96	1.24	1.11	0.72	1.19	1.01	1.12	1.14	1.08	1.05	1.25	1.04	0.84	1.10
Cognition	4.34	4.27	4.35	3.75	4.26	4.39	3.97	4.52	4.36	4.13	4.14	4.40	4.56	4.14
	0.95	1.11	1.04	0.61	1.04	1.03	0.88	1.04	1.11	0.96	0.90	1.11	0.78	1.11
Competence	4.98	5.20	5.14	4.31	5.08	5.09	5.00	5.18	5.13	4.93	4.76	5.26	5.36	4.91
	1.10	1.25	1.18	0.75	1.32	0.98	1.13	1.32	1.09	1.10	1.19	1.19	1.19	1.08
Awareness	5.10	5.30	5.24	4.63	5.18	5.21	5.30	5.23	5.11	5.17	5.20	5.21	5.22	5.16
	1.33	1.52	1.45	0.92	1.37	1.52	1.13	1.36	1.56	1.65	1.39	1.43	1.52	1.47
Overall											4.55	4.68	4.89	4.52
											0.67	0.70	0.70	0.64

* sig value at 0.05

science subjects taught at the $p < 0.05$ level [$F(3, 122) = 3.47$, $p = 0.018$]. Due to the significant value obtained from the one-way ANOVA, a post hoc test was carried out to determine which group had a significant mean difference. Post hoc comparisons using the Tukey HSD test indicated that in the behavioural domain, both the mean scores for physics (M = 5.90, SD = 0.84) and general science (M = 4.96, SD = 1.10) were significantly different. However, biology (M = 5.16, SD = 1.25) and chemistry (M = 5.50, SD = 1.04) did not differ significantly from physics and general science. Although other domains did not show significance for science teachers providing inclusive education in different science subjects, the majority of the responses showed that science teachers slightly agreed with those domains in providing inclusive education for their students through virtual classrooms. From the mean value shown in Table 4, it can be concluded that physics teachers were more prepared to provide inclusive education to their students.

Discussion

In this study, science teachers in Malaysia reported scoring average in providing an inclusive education to their students (M = 4.65; SD = 0.68) in the context of remote teaching. Although these teachers had sufficient affective attitude, behaviour, cognition, competence and awareness (five domains derived from the statements in our survey) in providing a more inclusive education through virtual classrooms, none of these domains had a mean score higher than 6 (Agree with the statement). Such results indicate that the readiness of science teachers to provide inclusive education through virtual classrooms is not high. This is mainly due to the sudden change from a physical learning environment to a virtual learning environment following the MCO imposed by the government of Malaysia. In addition, prior to the implementation of fully virtual teaching and learning, the majority of science teachers in Malaysia had no experience with virtual classrooms. Hence, this paradigm shift in education especially in the context of the teaching and learning environment, shocked not only teachers but also parents, students and the entire education system itself.

Lack of competence and skills

It was reported that the teachers lacked competence and skills in providing inclusive education virtually, especially at the beginning of the pandemic, when the transition to virtual classrooms had to take place in a short time. Southeast Asian countries such as Malaysia, Singapore and Indonesia were not familiar with adopting remote teaching before the pandemic (Tay, Lee, and Ramachandran 2021; Mailizar et al. 2020; Lie et al. 2020; Wen and Kim Hua 2020). From the scores and answers of the survey, we could conclude that most of the respondents had gained sufficient competence and skills only after spending some time learning how to use the software, mobile applications and virtual teaching aids required for conducting virtual classrooms. These learning aids were viewed as essential in order to deliver inclusive and quality education, which is consistent with that of Lie et al. (2020) who found that secondary school language teachers intended to enhance their competence as none of them indicated practices at the

advanced level of remote teaching. This advanced level would require the teachers to have competent use of ICT skills in order to deliver quality education to the students.

Our findings indicate that the necessary support from schools and higher-level educational authorities is an important factor that could contribute to enhancing science teachers' competence and skills in providing inclusive education. In Indonesia, while bigger cities such as Palembang and Surabaya have implemented professional development programmes facilitated by local teacher professional organisations and local education authorities, remote regions would require a more top-down intervention from education authorities (Lie et al. 2020). The respondents in this study expressed that there was no training given to them, especially at the beginning of the MCO. Not only is such training essential to increase ICT competence among teachers, this form of training functions as a form of necessary resources to equip teachers and keep them up-to-date when adopting remote teaching (Tay, Lee, and Ramachandran 2021; Wen and Kim Hua 2020).

It was not only competence and skills in ICT use among science teachers that were crucial in providing inclusive education to students. In this study, parents were reported to lack the ICT competence and skills for setting up virtual classrooms for their children at home. Some science teachers needed to provide assistance to these parents, which required more of their time and effort. In Misirli and Ergulec's (2021) study, 50% of the 982 parents who responded to the survey required to provide help with technological equipment to their children and then left them alone with the virtual learning. Sixty-seven of them expressed having insufficient technological skills, which was identified as one of the challenges faced by these parents in assisting remote teaching.

Science teachers living in urban areas being more affective

From the SPSS' inferential analysis, a significant difference was found in the affective domain, where science teachers from urban areas scored higher than those living in rural areas. This indicates that science teachers living in urban areas tended to face more challenges adapting virtual classrooms to meet the individual needs of all students. They experienced students having difficulty communicating with them, understanding their teaching and/or speaking up in a virtual classroom. The things could be due to bad internet connections. Based on the finding of this study, a stable internet connection was identified by the science teachers as the main resource that students did not have access to when attending virtual classrooms. Many respondents living in urban areas commented that the internet got much slower when more people had to work and study from home during the MCO. This finding is consistent with that of Danjou (2020) who reported undergraduate students needing to share internet connections for attending virtual classrooms at a given time or following a live course, which resulted in slower internet. Science teachers living in rural areas on the other hand, did not experience slower internet, as internet sharing occurred less intensely in rural areas than in urban areas.

Slow internet was a challenge for many teachers and students utilising virtual classrooms. While studying the experience of remote learning among students at a university in Pakistan, students living in urban areas were reported to have slow network speeds, while students living in rural areas had no internet access (Mushtaque et al. 2021). In Selvanathan, Hussin, and Azazi's (2020) study exploring university students' learning

experience with remote teaching during the MCO in Malaysia, students living in rural areas faced more challenges due to limited internet access compared to students living in urban areas. Our findings are contrary to those of Mushtaque et al. (2021) and Selvanathan, Hussin, and Azazi (2020). This could be due to science teachers in this study living in rural areas that had higher internet speed compared to other rural areas reported in Selvanathan, Hussin, and Azazi's (2020) study. In Malaysia, the definition of urban and rural areas is based on the size of the population in a given area, as well as their economic activities (DOSM 2021). However, the internet speed was impacted by the density of population and not purely the size of population. Compared to rural areas with lower population density, rural areas with higher population density have faster internet speeds. It was therefore possible that the science teachers in this study lived in rural areas with high population densities. This is supported based on the open-ended answers, where we observed that fewer science teachers living in rural areas reported having slow internet connections compared to science teachers living in urban areas.

Younger science teachers being more affective

Inferential statistics have shown that a significant difference was found in the affective domain among younger-generation science teachers. These science teachers are mainly younger than 40 years old. This finding suggests that older generation teachers tend to face more difficulties and challenges when providing an inclusive virtual classroom and adapting virtual classrooms to meet students' individual needs. Specifically, these senior science teachers tended to have difficulties communicating with their students virtually, delivering the science-related content efficiently and facilitating the learning to fulfil students' personal needs. One possible reason for such a distinction could be the generation gap. According to Murga, Quinde, and Niama (2018), science teachers older than 40 are Generation X(1965–1980), while science teachers in Generation Y are younger than 40. The majority of the experienced science teachers from Generation X, were well equipped with pedagogical and science content knowledge. They are well-trained and experts in conducting classes in a physical learning environment where face-to-face teaching and learning take place. In Cuban's (2001) study, teacher efficacy in ICT was found to have an inverse relationship with years of teaching experience and age. It was found that teachers with more teaching experience (senior teachers) were not good at handling ICT-related matters, relatively speaking. This indicates that when teaching experience and age increase, teachers might face more difficulties in providing a more inclusive education for their students compared to younger generations.

During the COVID-19 pandemic, a sudden shift from physical to remote learning had a great impact on science teachers from Generation X. They might face difficulties with various aspects, such as adaptation to the new teaching and learning environment, learning to operate the technology, devices and applications and being mentally ready to conduct classes virtually. Such a situation might appear challenging to them, as virtual classrooms are a brand new teaching approach and the majority of their abilities with modern technology are less advanced than science teachers from Generation Y(1981–1999) (Murga, Quinde, and Niama 2018). This is in addition to the fact that the students experiencing virtual learning during the pandemic period are from Generation Z, where most of the students are tech-savvy and efficient with learning new technology. They have

significant exposure and high expectation regarding the use of technology and electronics devices. Hence, this generation gap might have contributed to senior science teachers being less affective in providing a more inclusive science-learning environment to their students. Senior science teachers were therefore facing challenges in communicating as effectively with their students as in physical classrooms and addressing students' personal need with regards to science content.

Higher readiness among physics teachers in providing an inclusive education virtually

Besides science teachers' competence and awareness with virtual teaching to provide a more inclusive learning environment to students, their willingness to adopt and modify the learning environment is also relatively important to the success of an inclusive education. In addition, the availability and usefulness of free online resources contribute to science teachers providing an inclusive education to their students (Crook, Sharma, and Wilson 2015). For instance, free virtual laboratories, meeting and discussion platforms, video clips and other teaching and learning resources might make the remote learning environment more interesting and meaningful for students.

Statistical results have shown that physics teachers showed significant positive behaviour in attempting to provide inclusive education during the COVID-19 pandemic period. One reason might be due to the variety of online resources in the subject of physics itself. In physics education, various well-established virtual learning platforms that cover the physics content are freely available for teachers to use. During the pandemic and the MCO, teachers could utilise resources available to design a more inclusive learning experience for their students. Despite the unavailability of face-to-face teaching, they could modify the learning environment to encourage students to participate in learning activities and increase their engagement and motivation in learning physics through virtual classrooms. For instance, the PhET interactive simulation (University of Colorado 2021) and eduMedia (eduMedia 2021) were some of the free interactive virtual simulation applications that appeared to be good resources for teachers to explain physics concepts. These virtual applications could be an alternative for physical laboratory experiments during this period of time. Such a learning experience would reduce monotonous and one-way interaction while conducting remote lessons, and at the same time enrich students' learning experience.

Limitation of the study

A limitation of this study is the number of respondents. We acknowledge that the sample size was small; therefore, the respondents are not representative of all secondary science teachers in Malaysia. One factor contributing to this small number of respondents was the hectic schedules of teachers due to the constant transition of practice in teaching remotely. In addition, we only reached out to respondents who were easily accessible and willing to spend time answering the questionnaire (Sedgwick 2013).

Conclusions

During the COVID-19 pandemic, remote learning became a compulsory teaching and learning alternative for most countries in the world including Malaysia. Providing an inclusive education for students particularly in a virtual learning environment is therefore crucial. However, limited studies have been conducted to investigate the experiences of teachers in attempting to provide inclusive education through virtual classrooms during the pandemic. This study has pinpointed that the readiness of science teachers in providing an inclusive education was not high; these science teachers' affective attitudes, behaviour, cognition, competence and awareness in relation to ensuring virtual classrooms being inclusive to their students were barely sufficient. The teachers were not used to teaching virtually, and they were not receiving sufficient training and support from schools and educational authorities. However, we were glad to see some of them had already adopted strategies such as providing alternatives to virtual classrooms by giving recordings and more flexible availability for answering students' questions. These accord with the strategies presented by Correia (2020). As this study only covers secondary science teachers and the number of respondents is small, a larger-scale study involving more science teachers should therefore be conducted to provide a more representative pattern and better understanding of how inclusive education can be implemented to ensure that no students are left behind especially during the pandemic situation.

This study has implications for researchers and educational institutions that intend to promote inclusive virtual education. From this research, it was found that training and support for teachers are relatively important in order to provide a more inclusive education for students. Without sufficient and proper support from schools and higher authorities, remote teaching during the pandemic might not achieve the intended outcomes. In addition, financial aids, facilities, stable internet access and understanding and respect for teachers' work time are other aspects that need to be urgently addressed in order to provide an inclusive learning experience for students. Necessary attention to science teachers' competence, readiness and self-efficacy in conducting virtual classrooms needs to be taken into consideration, as this will directly affect the successfulness of remote teaching and learning. Meanwhile, students' motivation, attitude, acceptance level towards virtual learning are also contributing factors for the success of remote learning.

Hence, a more holistic policy needs to be established to support remote teaching and learning. This can be a starting point for the Ministry of Education to look into the possibility of providing a more inclusive remote education for future generations. Training, such as professional learning communities and capacity building, needs to be given to in-service teachers to well-equip them in creating a more effective and inclusive virtual learning environment. In addition, good practices regarding how teachers provide an inclusive virtual education should be shared among teachers. Pre-service teacher providers (university and teacher training institutes) also need to restructure their curricula to accommodate such paradigm shifts as from pure physical classrooms to virtual classrooms and the mix of both. Collaboration between all parties involved can move the education system alongside the growth of digitalization and e-learning.

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