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Addressing Student Learning Gaps in Fractions: How Effective is Synchronous Videoconferencing?

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Abstract

The addition and subtraction of fractions are considered one of the most difficult topics in mathematics for students. However, interventions to improve student performance in this direction are not widespread. This action research study investigated the effectiveness of synchronous videoconference intervention in improving student performance in addition and subtraction of fractions. It also explored the perceptions of students about synchronous e-learning sessions. A total of 51 Year 7 students conveniently sampled from a government school in Brunei Darussalam served as participants for this study. The action taken included a pre-test, a videoconference lesson intervention, a post-test, survey, and interviews. The paired sample t-test revealed a significant difference in test scores $t(50) = -3.50$, $p<0.001$, with post-test scores (Mean = 8.47, SD = 1.78) higher than the pre-test scores (Mean = 7.1, SD = 3.10). These findings suggest that student performance improved after the videoconferencing intervention. The results of the survey and interviews revealed that the students had a positive perception of the videoconference lessons. They described the lessons as pleasant, collaborative, and convenient. However, they reported challenges, such as unstable internet connection, distractions, and inadequate teacher supervision. Despite these challenges, they equally preferred videoconferencing and traditional face-to-face lessons. This study concluded that videoconferencing could be a useful tool in teaching and learning fractions. It has the potential in improving student-centred teaching and learning, especially when the challenges that come with its use are controlled.

Keywords: Addition and Subtraction, Academic Performance, Fractions, Brunei Darussalam, Synchronous Videoconferencing

Abstrak

Penjumlahan dan pengurangan pecahan dianggap sebagai salah satu topik matematika yang paling sulit bagi pelajar. Namun, intervensi untuk meningkatkan prestasi pelajar ke arah ini tidak tersebar luas. Penelitian tindakan kelas ini menyelidiki efektivitas intervensi konferensi video sinkron dalam meningkatkan prestasi pelajar dalam penjumlahan dan pengurangan pecahan. Kajian ini juga mengeksplorasi persepsi pelajar tentang sesi pembelajaran elektronik sinkron. Penelitian ini melibatkan 51 pelajar Kelas 7 yang dijadikan sampel dari sebuah sekolah kerajaan di Brunei Darussalam. Tindakan yang dilakukan meliputi ujian pra, intervensi pembelajaran konferensi video, ujian pasca, survei, dan wawancara. Uji-t sampel berpasangan menunjukkan perbedaan yang signifikan dalam skor tes $t (50) = -3,50$, $p <0,001$, dengan skor ujian pasca (Min = 8,47, SD = 1,78) lebih tinggi dari skor ujian pra (Min = 7,1 , SD = 3.10). Temuan ini menunjukkan bahwa prestasi pelajar meningkat setelah intervensi konferensi video. Temuan dari survei dan wawancara mengungkapkan bahwa pelajar memiliki persepsi positif tentang pelajaran konferensi video. Mereka menggambarkan pelajaran sebagai menyenangkan, kolaboratif, dan mudah. Namun, mereka melaporkan tantangan, seperti koneksi internet yang tidak stabil, gangguan dan pengawasan guru yang tidak memadai. Terlepas dari tantangan ini, mereka sama-sama menyukai konferensi video dan instruksi tatap muka tradisional. Kajian ini menyimpulkan bahwa konferensi video dapat menjadi alat yang berguna dalam pengajaran dan pembelajaran pecahan. Ia berpotensi dalam meningkatkan pengajaran dan pembelajaran berpusatkan pelajar, terutamanya apabila cabaran yang datang dengan penggunaannya dikawal.

Kata kunci: Penjumlahan dan Pengurangan, Prestasi Akademik, Pecahan, Brunei Darussalam, Konferensi Video Sinkron

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INTRODUCTION

Since the outbreak of the COVID-19 pandemic, educational settings around the world continue to develop countermeasures to ensure educational continuity and improve student performance (Shahrill, Petra, Naing, Yacob, Santos, & Abdul, 2021a; Shahrill, Noorashid, & Keasberry, 2021b; Asamoah, Shahrill, & Abdul, 2022). Teaching and learning of mathematics have also seen changes, where several alternative approaches aimed at improving student performance continue to be developed (Jamil, Ramli, & Leong, 2021). Amongst such approaches are the tic-tac-toe games in teaching ratios, rates and proportions, the butterfly and bar model concept in solving fractions, and the social media-based e-learning in algebraic expressions lessons (Low, Shahrill, & Zakir, 2020; Laidin & Tengah, 2021; Rahmawati & Soekarta, 2021; Tsng, Shahrill, & Abdul, 2021). To contribute to effective mathematics teaching and learning amid the COVID-19 pandemic, this study aims to investigate the effectiveness of videoconferencing as a synchronous teaching approach in improving student performance in addition and subtraction of fractions.

Understanding fractions is essential for a satisfactory performance in other topics in mathematics such as numbers, algebra, geometry, measurement, and statistics. It is defined as one or an equal part of an object, which is mostly given by $\frac{x}{y}$ where $y \neq 0$, and is considered as one of the most imperative topics when learning mathematics (Bruce & Ross, 2009; Ye, Resnick, Hansen, Rodrigues, Rinne, & Jordan, 2016). Fractions are considered as one of the recurring topics that must be learned in both primary and middle schools. Understanding fractions helps students in their daily lives including completing tasks that involve number concepts (Lortie-Forgues, Tian, & Siegler, 2015; Abbas, Shahrill, & Indra, 2020).

The National Mathematics Advisory Panel stressed that students should have the skills to identify and represent fractions in Year 4. In Year 5, students should be able to compare, order, add, and subtract fractions. In Year 6 students are exposed to the multiplication and division of fractions. Finally, in Year 7, students should be taught how to add, subtract, multiply, and divide fractions (United States Department of Education, 2008). This suggests that students' prior knowledge and understanding of fractions is critical when teaching and learning fractions at advanced stages. This is because, like any topic in mathematics, teaching and learning fractions requires a systematic process that uses a clear understanding of concepts, prior knowledge, and computational skills (Sarwadi & Shahrill, 2014; Finti, Shahrill, & Salleh, 2016; Simpol, Shahrill, & Prahmana, 2018; Abbas et al., 2020; Low et al., 2020). Therefore, the difficulty in fractions at the primary level, procedural and conceptual knowledge gaps affect student understanding of fractions (Idris & Narayanan, 2011; Lortie-Forgues & Siegler, 2015).

Teachers should develop the ways to ensure that students grasp conceptual and procedural knowledge when teaching mathematical concepts including fractions (Fazio & Siegler, 2010; Hansen et al., 2017). In conceptual knowledge, students must understand the meaning and how to construct

fractions and, at the same time, link prior knowledge to new knowledge (Miller & Hudson, 2007). Procedural knowledge is required for students to be able to follow a set of procedures, especially when performing operations such as adding and subtracting fractions (Bailey, Zhou, Zhang, Cui, Fuchs, Jordan, Gersten, & Siegler, 2015). Therefore, solving problems involving fractions does not only require students to develop conceptual knowledge - sort and compare fractions depending on sizes but it also requires them to have adequate procedural knowledge – should be able to perform arithmetic operations (Bailey et al., 2015).

A common procedure when adding and subtracting fractions is to find the least common multiple. However, students are not able to understand and apply the procedures especially when the denominators are different (e.g., $\frac{1}{3} + \frac{2}{2}$). Empirically, it has been established that students are not able to understand the purpose of the least common multiple which led to several mistakes when adding and subtracting fractions (Khalid, 2007). A similar finding was shared by Goswami (2018) who found that students lacked conceptual and procedural knowledge in applying the least common multiple in solving fractions.

Existing studies have used several approaches to address the challenges students face when solving fractions. Examples are the butterfly method, fraction tiles, and other models such as bar, discrete, region, and number line (Bruce et al., 2013; Low et al., 2020; Laidin & Tengah, 2021). Given that the efficacy of videoconferencing in improving student performance in fractions has not received a large amount of research attention, this study contributes to the literature in this direction. Videoconferencing allows users from different locations to hold online face-to-face meetings and has become one of the essential mediums during COVID-19. This is because teachers and students are encouraged to develop alternative approaches to teaching and learning (Cicha, Rizun, Rutecka, & Strzelecki, 2021). As an online synchronous platform, it provides opportunities for greater interaction and engagement among students and teachers (Racheva, 2018; Lin & Gao, 2020). However, online teaching and learning can be time-consuming and challenging compared to other mediums (Chiasson, Terras, & Smart, 2015). Such challenges include but not limited to designing teaching materials, inadequate hardware and software, unstable internet connection, lack of training and gadgets such as mobile phones/tablets or laptops (Bernard, Abrami, Borokhovski, Wade, Tamim, Surkes, & Bethel, 2009; Keengwe & Kidd, 2010; Ni, 2013). Considering the advantages and disadvantages of the synchronous video conference teaching and learning, this study is framed on the media richness theory (Daft, Lengel, & Trevino, 1987).

According to theory, the media are classified from the “leanest” to the “richest” depending on their built-in characteristics. The criteria in assessing the effectiveness of a media are its ability to provide instant feedback, transmit audio and non-audio communication, and provide a sense of originality (Daft et al., 1987). The theory sees traditional face-to-face interactions as the effective/richest medium for giving information. The next effective medium is videoconferencing

because it also encourages online face-to-face interactions (Daft et al., 1987). This suggests that, as one of the richest forms of media, videoconferencing can be suitable for teaching and learning. However, a richer medium like videoconferencing can distract students compared to audio conferencing and text messaging, which are considered as "leaner" mediums (Olson & Olson, 2003). This is because videoconferencing allows student-to-student interaction similar to the traditional face-to-face classroom. In contrast, text messaging or audio-conferencing limits student interaction among themselves.

Drawing from the ideas of Daft et al. (1987), the most effective way of instructional delivery is traditional face-to-face pedagogy. However, during COVID-19, where alternative teaching and learning approaches, such as synchronous videoconferencing, can be used, how well does it improve student performance in instructional concepts? This question is asked because despite the paucity of studies on the effectiveness of videoconferencing in teaching and learning mathematics, findings in existing studies have been contradictory. Schultz (2003) found that online lessons produce lower grades compared to traditional face-to-face lessons. For Doggett (2008), there was no significant difference between videoconferencing and face-to-face interventions, while Rahmawati and Soekarta (2021) reported that e-learning based on social media networks was helpful in completing mathematical tasks in algebra.

While this study contributes to the literature by investigating the effectiveness of videoconferencing intervention in the teaching and learning of fractions, the Bruneian context is necessary for this inquiry given the poor performance of students in mathematics (Hamid, Shahrill, Rohani, Mahalle, & Mundia, 2013; Rosli, Shahrill, & Yusif, 2020; Chong, Shahrill, Asamoah, & Latif, 2022). For example, of the 70 countries that participated in the 2018 Programme for International Student Assessment in Mathematics, Brunei was ranked fifty-first. The problem of low student performance in mathematics has been attributed to teacher-centred teaching approaches, anxiety, and stress that affect students' satisfaction in life (Matzin, Shahrill, Mahalle, Hamid, & Mundia, 2013; Salam & Shahrill, 2014; Abdul, 2021). Students see mathematics as difficult and boring, which makes them to over-rely on past-examination questions (Zakaria, Solfitri, Daud, & Abidin, 2013; Shahrill, 2018).

The low performance of students in mathematics includes fractions. In Brunei, operations involving fractions are taught in Year 7. It is considered as one of the most difficult topics in mathematics for students, with the most difficult part being addition and subtraction of fractions (Suffolk & Clement, 2003; Vamvakoussi & Vosniadou, 2010; Trivena, Ningsih, & Jupri, 2017). Factors such as poor prior knowledge, poor instructional approaches, and weak computational skills affect students' understanding of fractions (Yusof & Malone, 2003). Therefore, teachers have the responsibility of using innovative and student-centred approaches in the teaching and learning of fractions. Despite this challenge, little is known about interventions that can be used to improve

student performance in fractions (Low et al., 2020), and videoconferencing as an intervention option has not received widespread attention.

During COVID-19, the teaching and learning of mathematics, including fractions, will be more meaningful if the efficacy of online learning technology that allows both students and teachers to have face-to-face interactions is investigated. The aim of the present study is to investigate the effectiveness of videoconferencing as an instructional approach in addition and subtraction of fractions. It also explores the perceptions of students after receiving the videoconferencing intervention. The following research questions guided this study: 1) How effective is videoconferencing in improving student performance in addition and subtraction of fractions?; 2) What perceptions do students have about synchronous e–learning sessions on addition and subtraction of fractions conducted through videoconferencing?

METHODS

This was an action research study aimed at designing a videoconferencing intervention to assess how well it would improve student performance in addition and subtraction of fractions (Denscombe, 2010). The action taken involved a pre-test, an intervention, and a post-test. A survey and interviews were also conducted to explore the perceptions of the students about the action taken. A total of 51 Year 7 students were conveniently sampled. The students were from a government school located in the Belait District of Brunei Darussalam. The selected students were suitable for this study because addition and subtraction of fractions are taught at that level. The 51 students participated in the intervention and the survey, while only six (6) of them were available to be interviewed.

Data were collected using tests, questionnaires, and a semi-structed interview guide. The tests consisted of both pre-test and post-test (see Appendix 1). The pre-test and post-test were conducted before and after the videoconferencing intervention, respectively. Both tests contained questions on addition and subtraction of fractions with similar test structure. The use of calculators was not allowed during the conduct of both tests. The total score in each test was 10 marks. The questionnaire was adapted from Fortune et al. (2011). It consisted of 11 statements measured on a four-point rating scale from 1-strongly disagree to 4- strongly agree. The semi-structured interview guide was developed to interview students after the post-test. To ensure content validity, four mathematics educators who had more than 10 years of teaching experience judged the instruments in the context of the intended objectives. The questionnaire was pilot tested with 12 Year 7 students in the Bandar District of Brunei. After pilot testing, a Cronbach alpha of 0.81 was achieved, which indicates high consistency (Pallant, 2010).

Before data collection, an approval letter was obtained from the Faculty's Ethics Committee of the university. To ensure voluntary participation, participants completed information sheets and consent forms. Approvals were sought from the teachers and the principal of the sampled school. All

information provided by the participants have been kept strictly confidential and their identities have been hidden in this research report. The first phase of the data collection was the pre-test. This was done to assess the prior knowledge of students on addition and subtraction of fractions. All the 51 students sat for the test in an organised, arranged and well-prepared online classroom. The duration of the test was 30 minutes. After the test, all scripts were collected, scored, and recorded. The second phase was the intervention. Two online applications: Microsoft Teams and Zoom were introduced in both classes, where students in each class randomly chose the online platform of their choice. Both online platforms allowed for a virtual audio or video meetings, and share documents and messages. There were four intervention lessons and each lesson lasted for 40 to 60 minutes depending on the application used in each class. The summary of the intervention lessons is provided in Table 1.

Table 1. Summary of intervention lessons

Lesson	Class A	Class B
1	• Adding Fractions - through Microsoft Teams	• Adding Fraction - through Zoom
2	• Subtracting Fractions - through Microsoft Teams	• Subtracting Fraction - through Zoom
3	• Adding Fractions - through Zoom	• Adding Fractions - through Microsoft Teams
4	• Subtracting Fractions - through Zoom	• Subtracting Fractions - through Microsoft Teams

The online lessons were divided into two separate classes (see Table 1). This was because engaging all the 51 participants on one videoconference call was ineffective and inefficient. It also helped ease the communication challenges between us and the students. The students were provided with a school e-mail address to enable them to log into the Microsoft Teams and Zoom application for the online lessons. During the online intervention lessons, we shared our screen and taught the students synchronously. The assessment of student progress was done using verbal and written feedback. This was done using the chat boxes in the applications.

We started the first lesson by recapping with the students on how to add and subtract fractions by providing them with a worksheet which involved sample questions on addition and subtraction of fractions. In the first class, we used Microsoft Teams, while Zoom was used in the second class. In lesson two, we followed the same pattern as in lesson one but using a different worksheet that contained questions other than the ones in lesson one. The main focus of the second lesson was to recall prior knowledge on solving addition and subtraction of fractions with the same or different denominator. The other lessons (third and fourth) were conducted by alternating the online applications (see Table 1). This was to ensure that both classes would experience both applications to control any form of biases in our intervention. Worksheets consisting of world problems involving addition and subtraction of fractions were used. The post-test was carried out after the four online

intervention lessons. All the 51 students sat for the test following the same requirements and procedures in the pre-test. After the test, all scripts were collected, scored, and recorded.

Quantitative data collected from the pre-test, post-test, and questionnaires were entered into the Statistical Package for the Social Sciences (SPSS) for further analysis. Paired sample t-test was used to investigate mean difference between the pre-test and post-test scores. Frequencies and percentages were used to analyse the survey responses, while the interview data were analysed thematically. For the sake of interpretation, we collapsed the measurement of the rating scale into 'disagree' and 'agree'. Excerpts from the interviews have also been provided to validate the findings obtained.

RESULTS AND DISCUSSION

Effectiveness of The Videoconferencing Intervention

The general results that indicate the mean difference between the pre-test and post-test scores of our videoconferencing intervention are presented in Table 2.

Table 2. Paired sampled t-test between pre-test and post-test scores

	Descriptive Statistics		95% Confidence Interval of Mean Difference							
	Mean	SD	Mean difference	SD	Std. Error	Lower	Upper	t	df	Sig. (2-tailed)
Pre-test	7.1	3.10	-1.37	2.8	0.392	-2.16	-0.585	-3.50	50	.000
Post-test	8.47	1.78								

N = 51, SD = standard deviation; mean difference is significant if sig<.05; Cohen's d = 0.197

From Table 2, the paired sampled t-test revealed a statistically significant difference in the test scores $t(50) = -3.50$, $p<0.001$, with post-test scores (Mean = 8.47, SD = 1.78) being higher than the pre-test scores (Mean = 7.1, SD = 3.10). This shows that student performance in adding and subtracting fractions improved after the videoconferencing intervention, although the effect of the intervention is small ($d = 0.197$, based on Cohen, 1988). Despite the effectiveness of the intervention, we were particularly interested in how students improved on answering the test items in both pre-test and post-test. In Figure 1 to 2, we present samples of both incorrect and correct responses of the students' pre-test and post-test.

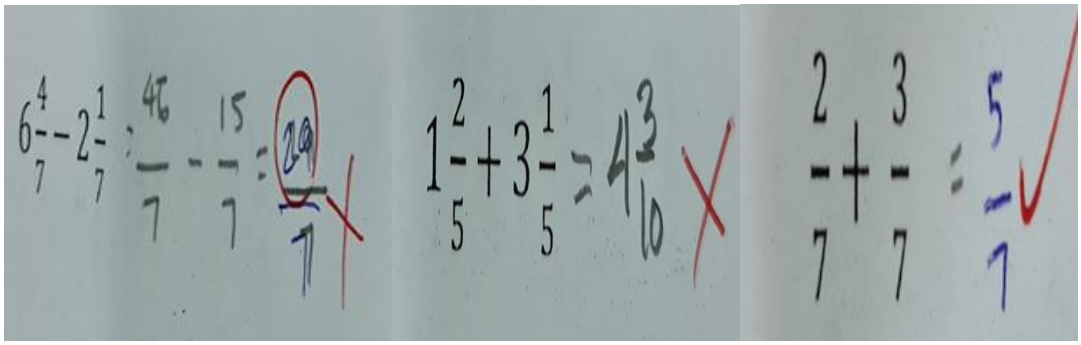

Figure 1. Students correct and incorrect responses of pre-test

Generally, we observed that at the pre-test level, most of the students managed to answer questions that involved the same denominator with the operation being addition or subtraction. Very few students were able to solve questions with different denominators. For those who were not able to solve fractions with the same denominators, we observed that they added or subtracted directly without taking into account the procedures they had to go through. Few students also made procedural mistakes by multiplying the correct number by incorrect calculations (See Figure 1).

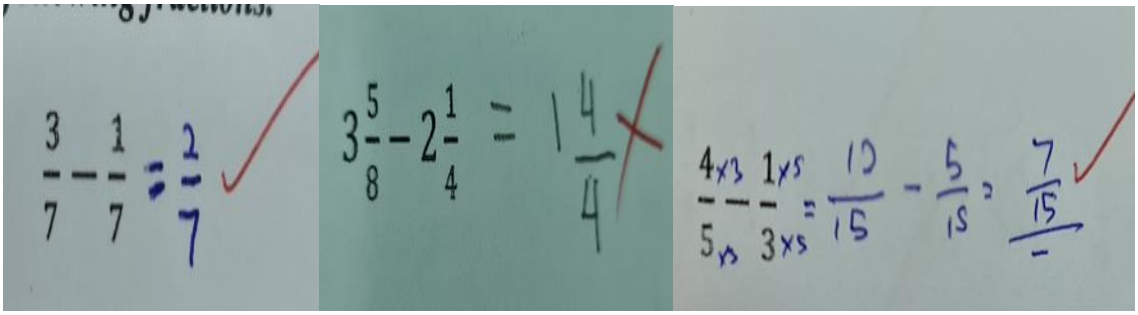

Figure 2. Students correct and incorrect responses of post-test

At the post-test level (see Figure 2), we still find some students multiplying the numerator instead of adding when converting from mixed to improper fractions. Another mistake was when students showed the correct working but incorrectly calculated the final answers. Some students also added or subtracted the numerators and denominators directly. We realised that at the post-test level, students made careless errors compared to conceptual errors. However, majority of the students understood the concept of addition and subtraction in fractions and were able to solve more questions in the post-test compared to the pre-test. This is illustrated in Figure 3.

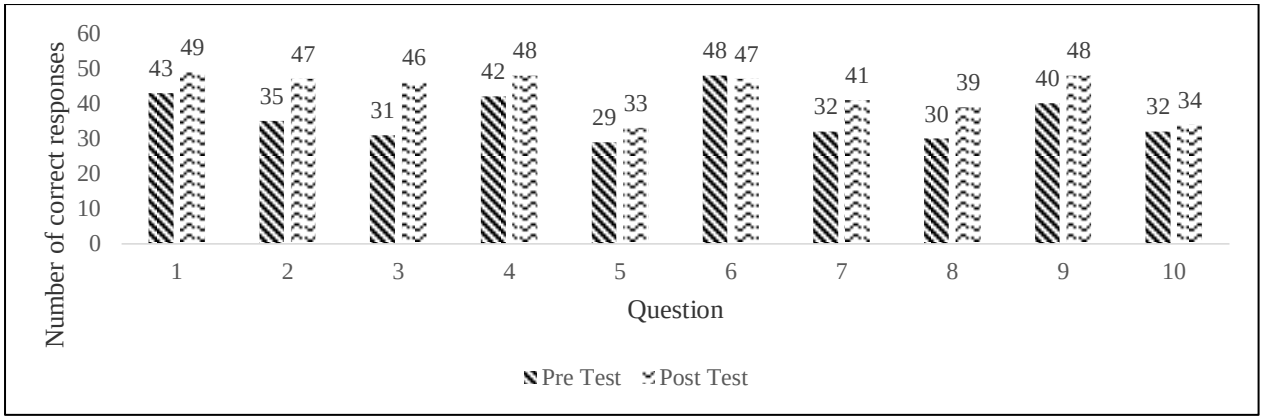

Figure 3. Bar chart representing the number of correct responses for pre-test and post-test

Figure 3 shows that there is an improvement in the number of correct responses in all the questions except for question 6 - the first question in both the pre-test and post-test that involved subtraction of fractions with the same denominator (see Appendix 1). For questions 1 and 4, there was an approximately 11.8% improvement in the correct responses. The students made an improvement of approximately 23.5% and 29.4% on questions 2 and 3, while approximately 17.6% was made for questions 7 and 8, and 15.7% for question 9. For questions 5 and 10, there was an improvement of approximately 7.8% and 3.9%, respectively. This indicates that the students were able to answer most of the questions after the intervention. Figure 4 shows the pre-test and post-test scores obtained by the students.

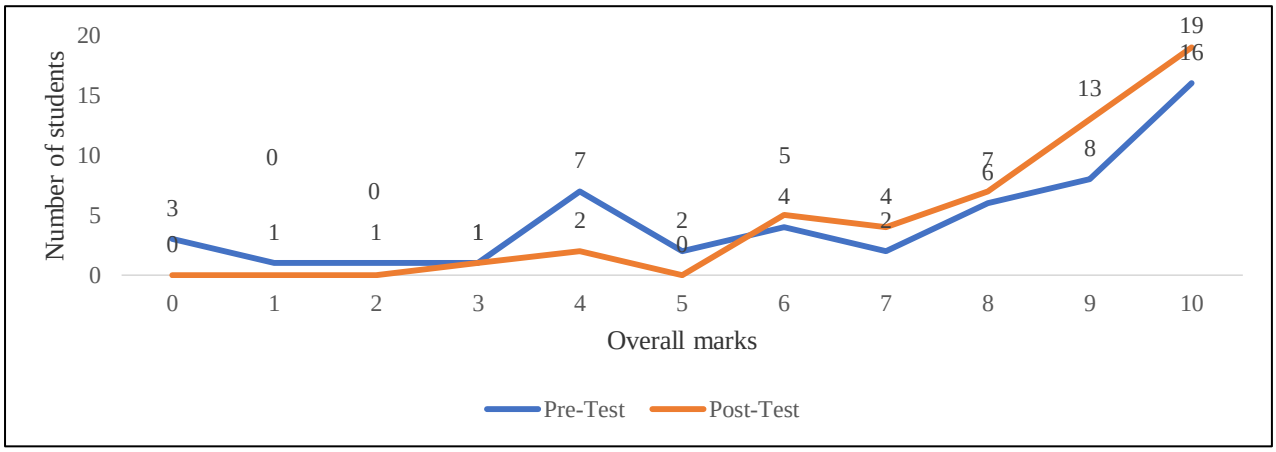

Figure 4. Line graphs showing overall students' marks in the pre-test and post-test

Most of the students scored between 6 and 10 in the post-test compared to the pre-test (see Figure 4). An improvement can be seen from the minimum mark where none of the students scored 2 or below for the post-test. 19 students achieved the maximum mark of 10 compared to the pre-test where 16 students scored the maximum mark. This confirms our earlier finding that the videoconferencing intervention is effective in improving student performance in solving addition and subtraction of fractions.

Perceptions of Students About Synchronous E–Learning Through Videoconferencing

We analysed the responses of students on synchronous e-learning using survey and interviews. Table 3 presents the summary of the survey responses.

Table 3. Student perceptions on synchronous e-learning through videoconferencing

Statements	Disagree	Agree
I enjoy learning mathematics when videoconferencing is used	48%	52%
I can follow what the teacher says without any problem	10%	90%
There are technical difficulties when learning through videoconferencing	74%	26%
Learning through videoconferencing is like being in the classroom	78%	22%
I can see what the teacher writes clearly when learning through videoconferencing	8%	92%
Learning through videoconferencing is affected by internet connections	68%	32%
I prefer to learn through video conferencing to traditional face-to-face learning	64%	36%
Learning through videoconferencing improves my understanding to add and subtract fractions	12%	88%
I prefer learning fractions through videoconferencing to traditional face-to-face classes.	64%	36%
Learning through videoconferencing is convenient to interact and revise with my teacher and my friends	46%	54%
When videoconference lessons are conducted, my teacher explains how to add and subtract fractions to my understanding	2%	98%

Generally, the students reported positive perceptions about the videoconferencing intervention. At the same time, they reported several challenges. In the latter, most of the students (52%, 90%, 74% and 68%) found the intervention as interesting, followed the instructions without difficulty as they did not have any technical problems nor internet difficulty, respectively. A greater percentage of students (88%, 54%, and 98%) were able to solve fractions, use video conferencing to revise fractions with both teachers and friends, and received clearer explanations on addition and subtraction of fractions from the teacher. Interestingly, most of them (78%) did not feel that they were in a classroom when videoconferencing was used, and many (92%) did not see what the teacher wrote on the screen. A higher percentage (64%) of the students did not see videoconferencing as an alternative to traditional face-to-face teaching and learning.

Despite the efficacy of videoconferencing in improving student performance in addition and subtraction of fractions, the majority (64%) did not learn fractions better compared to when they are in a traditional face-to-face classroom. The positive perceptions and the challenges of the videoconferencing interventions shared by the students are also reflected in their interview responses. We arrived at three themes from the interviews conducted: student perceptions towards e-learning through videoconferencing, preferences of students between videoconferencing and traditional face-to-face lessons, and the challenges faced by students during the videoconferencing intervention. Some of the experts under these themes are presented in Table 4.

Table 4. Sample excerpts on students' perceptions, preferences, and challenges of videoconferencing intervention

Student	Perceptions	Preferences	Challenges
1	*"I like videoconferencing sessions because we don't even have to go to class to gain knowledge and we can learn anywhere."*	*"I still prefer videoconferencing because I get to learn at home, and I need little preparation time compared to preparing for school."*	*"I get distracted to do other things as I am not in a physical class, so I don't understand some parts of the topic."*
2	*"We can access the video anywhere and learn about the topic."*	*"…it will be a traditional face-to-face class as I feel I don't really pay attention to what the teacher is teaching about during the videoconference."*	*"It is hard to show my work to the teacher as the others can see it too."*
3	*"I can spend my own time learning alone and take the time to understand the topic at my own pace without being pressured to do so."*	*"Unlike traditional face-to-face lessons, I had a limited opportunity to ask the teacher about the parts that I did not understand. However, I also prefer videoconferencing since questions can be asked without showing your face"*	*"Internet connection/wifi can be lagging sometimes which makes the video to freeze and when it gets connected, the teacher has already moved on to another part of the topic."*

The students confirmed their positive perceptions as they saw e-learning through videoconferencing as less time-consuming, accessible, fast, efficient, and convenient (see Table 4). On the preferences of students, we found that students have equal preference for videoconferencing and traditional face-to-face class. For example, a student recounted that questions can be asked without revealing their faces, while others prefer traditional face-to-face because it makes them pay more attention during lessons. Students also face challenges such as being easily distracted, difficulty understanding the topic, unstable internet connection, and lack of teacher supervision during videoconferencing lessons.

From our results, the use of videoconferencing in the teaching and learning of addition and subtraction of fractions improves student performance. We observed that students improved on their pre-test scores after the lesson intervention and were able to answer more questions. Our results agree with previous studies, for example, Francescucci and Rohani (2018) who found that effective online learning improves student performance. The results are also consistent with Rahmawati and Soekarta (2021) who shared that the use of social media-based e-learning is helpful in completing mathematics

tasks. We further confirm the effectiveness of using alternative approaches in the teaching and learning of fractions established in the literature (Low et al., 2020; Laidin & Tengah, 2021). Our results also validate the media richness theory suggesting that videoconferencing serves as one of the richest media after traditional face-to-face teaching and learning (Daft et al., 1978). However, the overall improvement that came with the use of videoconferencing, as indicated in this study, refutes Schultz (2003), who posited that online learning is less effective, and Doggett (2008), who found no significant difference in student performance after a videoconferencing intervention.

What interests us is that although few students committed some mistakes after the intervention, such mistakes were only careless compared to conceptual mistakes, and better at the post-test stage compared to the pre-test stage. This suggests that the use of videoconferencing cannot fully address the mistakes students make when adding and subtracting fractions, although our intervention has been proven to minimise such mistakes. Students found fractions with the same denominator relatively easier to solve compared to those with different denominators that demand in-depth procedures to find and use the least common multiple. With this insight, we agree with Goswami (2018) who found that students have inadequate conceptual and procedural knowledge when applying the least common multiple. This could have happened in the case of the students we used in this study, despite the effectiveness of the videoconferencing intervention. Hence, developing both conceptual and procedural knowledge remains important in adding and subtracting fractions (Bailey et al., 2015). We also observed that the students performed relatively well in fractions that involved addition compared to those that involved subtraction. In this regard, subtracting fractions may be difficult than addition because students might have deduced differences from their knowledge of sums (Kamii et al., 2001).

This study also provides evidence to support that the students positively perceived videoconferencing in the teaching and learning of fractions. This is not surprising given the improvement in their performance after the intervention. They found the lesson intervention enjoying, collaborative, efficient, convenient, and were able to follow the teacher especially when there are no technical challenges such as internet problems, which support the literature (e.g., Racheva, 2018; Lin & Gao, 2020). This indicates that videoconferencing encourages collaboration and student-centred learning; however, certain measures should be put in place before the intended goal can be achieved. Students must have materials such as mobile phones/tablets, laptops, and a stable internet connection before such lessons can be conducted conveniently.

Despite the positive perceptions held by students, they reported specific challenges such as internet connection problems, distractions, confidentiality issues as students thought others may see their work, and lack of teacher supervision. They generally did not feel as though they were in the classroom. These results support previous studies (Keengwe & Kidd, 2010; Chiasson et al., 2015), who found that online instructions can be challenging, especially when the needed resources such as a stable internet connection are not provided. Our results also agree with Olson and Olson's (2003) position that richer media, such as videoconferencing, can distract students.

During the COVID-19 pandemic, the use of videoconferencing can be effective in teaching and learning mathematical concepts such as fractions. However, the success of this approach depends on the availability of resources and how well the teacher will be able to control, if not prevent student challenges as reported in this study. Therefore, we are not surprised that the students equally preferred traditional face-to-face teaching and learning given the challenges that come with videoconferencing. This partially agrees with the media richness theory that argues that traditional face-to-face instructions is the ultimate avenue for teaching and learning (Daft et al., 1978). At the same time, this may not be the prioritised method of teaching and learning given the COVID-19 pandemic, and this makes the use of videoconferencing arguably relevant.

CONCLUSION

This study was conducted to achieve two aims. First, to investigate how effective a videoconferencing lesson intervention can improve student performance in addition and subtraction of fractions. Second, to explore the perceptions of students about synchronous e–learning sessions on addition and subtraction of fractions conducted through videoconferencing. Generally, student performance improved after the videoconferencing intervention. They scored relatively high and solved more questions with minimal mistakes after the intervention. The students had positive perceptions about the use of videoconferencing because they saw the lesson intervention as pleasant, collaborative, efficient, and convenient. However, they reported some challenges, such as an unstable internet connection, inadequate teacher supervision, confidentiality issues, and distractions during videoconferencing lessons. Despite these challenges, they equally preferred videoconferencing and traditional face-to-face instruction in the teaching and learning of fractions.

The implication of our results is that, amid COVID-19, videoconferencing can be a useful tool in teaching and learning mathematical concepts such as fractions. It has the potential of improving student-centred pedagogy, especially when materials and resources are available and when both teachers and students are able to control the challenges that come with the use of videoconferencing. We recommend mathematics teachers to use videoconferencing in the teaching and learning of mathematics and especially fractions. At the same time, stakeholders (e.g., parents and school leaders) should make the necessary resources and materials available to make videoconferencing as an alternative approach to teaching and learning during the COVID-19 pandemic feasible. We also recommend future studies to consider extending the efficacy of videoconferencing in teaching multiplications and division of fractions and other mathematical concepts in other local and international contexts.

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Appendix 1. Pre-test and Post-test Questions

	Pre-test			Post-test		
No.	Question	Denominator	Operation	Question	Denominator	Operation
1	$\frac{2}{7}+\frac{3}{7}$	Same	Addition	$\frac{2}{9}+\frac{3}{9}$	Same	Addition
2	$\frac{2}{3}+\frac{1}{5}$	Different	Addition	$\frac{2}{5}+\frac{1}{2}$	Different	Addition
3	$\frac{1}{4}+\frac{1}{3}$	Different	Addition	$\frac{1}{3}+\frac{1}{7}$	Different	Addition
4	$1\frac{2}{5}+3\frac{1}{5}$	Same	Addition	$3\frac{2}{5}+4\frac{1}{5}$	Same	Addition
5	$1\frac{2}{3}+4\frac{1}{5}$	Different	Addition	$1\frac{2}{5}+2\frac{1}{3}$	Different	Addition
6	$\frac{3}{5}-\frac{1}{5}$	Same	Subtraction	$\frac{3}{7}-\frac{1}{7}$	Same	Subtraction
7	$\frac{3}{4}-\frac{1}{3}$	Different	Subtraction	$\frac{4}{5}-\frac{1}{3}$	Different	Subtraction
8	$\frac{5}{8}-\frac{2}{5}$	Different	Subtraction	$\frac{5}{7}-\frac{2}{5}$	Different	Subtraction
9	$6\frac{4}{7}-2\frac{1}{7}$	Same	Subtraction	$5\frac{6}{7}-3\frac{2}{7}$	Same	Subtraction
10	$4\frac{5}{6}-1\frac{2}{3}$	Different	Subtraction	$3\frac{5}{8}-2\frac{1}{4}$	Different	Subtraction