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Promoting prospective teachers' conceptual knowledge through web-based blended learning

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ABSTRACT

Fractions remain a difficult concept for students at the elementary level. On that ground, prospective teachers need to develop the conceptual knowledge to have a deep understanding of the concept and how the concepts are related to each other. Furthermore, they must be able to explain the concepts through media in the form of concrete objects or images to help students grasp the whole concept of fractions. This research investigates the effect of web-based blended learning on the development of Conceptual Knowledge of prospective teachers. Web-based blended learning is a combination of online learning and face to face classroom group discussion. Prospective teachers use Edmodo as the learning management system that contains various learning resources such as videos, documents, and students' assignments in the form of Google Forms. This study design is a non-experimental post-test. The data obtained by using open tests and analyzed descriptively. Participants are prospective teachers who enrolled in the Teaching Arithmetic course in the 7th semester of the 2018/2019 academic year at the Department of Primary School Teacher Training, Universitas Negeri Jakarta, Indonesia. This study found web-based blending learning is an effective learning system to develop prospective mathematics elementary teachers' conceptual abilities of fractions. It is recommended that this learning system be included in the prospective teachers' Education module.

Introduction

Professional teachers are the key to the success of Mathematics learning. Mathematics teachers in elementary schools must be professional because they have the role of providing a foundation of basic knowledge and skills on the mathematical abilities of subsequent students. Shulman (1986) identified teacher professional knowledge consist of content knowledge, pedagogical content knowledge, and general pedagogical knowledge. Content knowledge is referred to as the amount and organization of subject matter in the mind of the teacher. Pedagogic content knowledge is an understanding about representations, analogies, examples of mathematical concepts, and skills on how to teach students mathematics. General pedagogic knowledge related to teaching methods and class management.

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In mathematics, there are several opinions about content Knowledge. Baumert et al., (2010) identified Mathematical Content Knowledge (MCK) is mathematical abilities at school level up to the university level where individuals considered being mathematically literate (Reid & Reid, 2017). Teachers with higher mathematical literacy will be more creative in teaching mathematics and able to formulate quality mathematical problems. MCK for teachers is General Content Knowledge (GCK); and Special Content Knowledge (SCK) (Ball et al., 2008; Hill et al., 2005; Reid & Reid, 2017). CCK is mathematical knowledge that is commonly known by adults, including teachers. SCK emphasizes knowledge of mathematical concepts and teaching skills to students.

Previously, conceptual knowledge is defined as knowledge networks (Hiebert and Lefevre, 1986), core concept knowledge for domains (Byrnes & Wasik, 1991). Next, conceptual knowledge is the basis of mathematical structure, interconnecting ideas, explaining, and giving meaning to mathematical procedures (Eisenhart et al., 1993). Star (2005) adds, conceptual knowledge not only knows about the concept but also how to understand the concept. Conceptual knowledge refers to concepts abstraction, including an understanding of concepts and their relevance (Rittle-Johnson et al., 2015). They extend the definition of conceptual understanding to the understanding or structure of concepts and the relationships between concepts (Schneider & Stern, 2010; de Walle et al., 2017). Someone who has conceptual knowledge able to explain the concept, understand the relationship between concepts, and how to find concepts (Zuya, 2017).

Conceptual knowledge is described as the information that can be linked to each other, networks in which linkages are as important as separate pieces of information (Österman & Bråting, 2019). Several studies have found that conceptual knowledge plays a role in the success of learning mathematics. Hutkemri and Zamri (2016) reported that conceptual knowledge positively influences learning achievement and conceptual considerations to obtain procedural knowledge. Good conceptual understanding makes children able to develop strategies when solving problems, for example making connections between concepts, therefore children with good conceptual understanding usually have good procedural skills (Rittle-Johnson & Schneider, 2015). Rittle-Johnson et al. (2015) suggested that a conceptual understanding of prospective teachers must be developed. This is in line with NCTM (2000) that the basic aim of mathematics teacher education is to teach mathematics to understand. Teachers need special knowledge to teach mathematics (Ball et al., 2005; Hiebert & Morris, 2009). Therefore, the development of conceptual knowledge must be the focus on teacher education (Schneider & Stern, 2010; Osterman and Bråting, 2019), consequently, it will increase student learning achievement (Ball et al., 2005). Besides, promoting teacher competency and overcoming learning difficulties will reduce students' conceptual misconceptions (Zuya, 2017). This underlines the need for teacher education mathematics programs to encourage the mathematics competencies of prospective teachers, so they are better equipped to meet the needs of their students through effective mathematical pedagogy (Reid & Reid, 2017). However, some facts show that the conceptual knowledge of teachers is still low and has not increased (Schneider & Stern, 2010). In this case, there should be efforts to improve prospective teachers' conceptual knowledge for them to be able to teach effectively.

Several attempts have been made to improve the teacher's conceptual knowledge. Chinnappan and Forrester (2014) examined the development of procedural and conceptual knowledge of pre-service teachers in factions by applying Representational Reasoning Teaching and Learning (RRTL). They conducted a study on 223 Pre-service teachers in the

Bachelor of Basic Education in Australia. The research findings show that the RRTL approach is more effective in increasing conceptual knowledge than procedural knowledge. Sumarna et al., (2016) examined the effects of Mathematical Investigation on conceptual knowledge and the geometry of prospective teachers. Their finding is that there is a significant influence on the conceptual and procedural knowledge of prospective teachers for those who learn through Mathematical Investigation compared to expository approaches. Yurniwati (2018) conducts classroom action research on prospective teachers in the geometry domain. The results showed that the multisensory model made it easy for prospective teachers to understand fractions, fraction operations, and space properties.

Different from former research, this study applies: (1) Web-Based Blended Learning (WBBL),(2) video to deliver teaching and learning mathematics in classroom,(3) manipulative tools for developing conceptual knowledge, and (4) group discussion in the classroom. Web-based Blended Learning is a combination of online learning and face to face classroom group discussion. Prospective teachers use Edmodo as the Learning Management system (LMS) that contains various learning resources such as videos and documents and assignments for students in the form of Google Forms. A chat facility is also provided to build better communication between the lecturer and the students. Through the website, learning materials are arranged following the syllabus which is equipped with supporting teaching materials (e-books, pictures, geometry applications, and learning videos). On the website, there is a communication forum between students and students or lecturers. The website can be accessed via a computer, tablet, or smartphone.

According to Carman (2005), WBBL has 5 principles: (1) Live Events: communicate directly so that all students attend at the specified time simultaneously, (2) online content: learning experiences where students complete independent assignments according to their abilities based on the Internet, (3) collaboration: learning conditions allow students to communicate with each other such as e-mail and online chat, (4)assessment: measuring the ability of students before and after learning, and(5) reference: learning resources in the form of e-books, multimedia, videos, etc.

This study answers the following research questions:

1. Does the WBBL increase the conceptual knowledge of prospective teachers in the fractions domain?
2. How the WBBL developed conceptual knowledge of prospective teachers in fractions domain?

The findings of this study can provide information about educational innovations in learning mathematics for prospective teachers.

Research Methods

The design of this study was a non-experimental post-test only. Current research is experimental but does not meet randomized control groups, because there is no access to an equivalent control group. Participants are prospective teachers who enrolled in the Teaching Arithmetic course in the 7th semester of the 2018/2019 academic year at the Department of Primary School Teacher Training, Universitas Negeri Jakarta, Indonesia. Teaching Arithmetic is one of the subjects in mathematics teacher education, studying numbers and its computation (whole numbers, integers, and fractions) and how to teach them to elementary school students. This study involved 34 prospective teachers, divided into 2 cohorts. Cohort 1 learns through WBBL and cohort 2 learns with props objects congress.

Data collected using an open-ended test. The instruments are shown in Table 1.

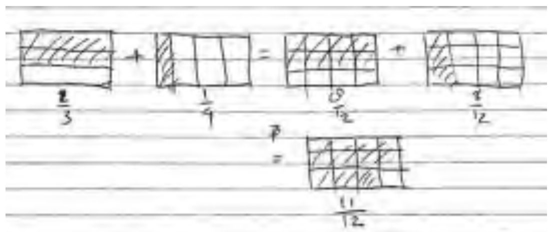
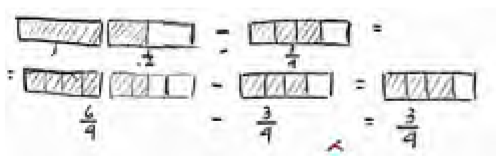
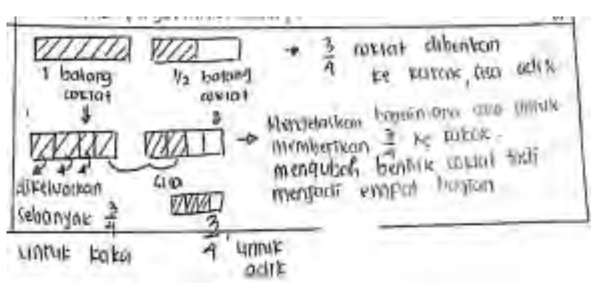
Table 1
Fraction tasks

No	Topics	Questions
1	Addition	How can you illustrate $\frac{2}{3} + \frac{1}{4}$ using a picture?
2	Subtraction	There is one and a half bars of chocolate. Mother wants to give $\frac{3}{4}$ of chocolate to Ani's sister and the rest for Ani. How can you explain the word problem using pictures?
3	Multiplication	Explain $1\frac{3}{4} \times \frac{1}{5}$
4	Division	How we can we help students to solve: $1\frac{1}{2} \div \frac{1}{3}$

Table 2 shows the coding scheme for analyzing conceptual knowledge (CK) and examples for each category

.

Table 2
Coding scheme

Code	Description	Example Answer
0	No evidence Conceptual Knowledge	No Answer
1	Trying to answer and showing understanding	
2	Correct illustration without/with incomplete explanation	
3	Correct illustration with explanation	 Translation: ¾ bar of chocolate given to my sister, how long the rest of chocolate? 1 bar of chocolate is divided into 4 parts, each of them gets 1/4, and give away 3 parts. The rest is ¾

Furthermore, the data are analyzed descriptively by comparing cohort 1 and 2 conceptual knowledge performance.

Content Delivery and Pedagogy of Subjects

Cohort 1. Learning is conducted by applying the WBBL and Edmodo applications as LMS. Previously, all participants registered at Edmodo, and the lecturer gave directions on how to use the Edmodo application. Edmodo has various features such as Folder (a facility to upload learning material), assignments (i.e. summarizing, chapter reviews, and quizzes), Posts are provided to enhance lecturer-participant and participant-lecturer interaction. Learning lasts for six face-to-face meetings, and each meeting is carried out in 150 minutes. The WBBL implementation is illustrated in Figure 1.

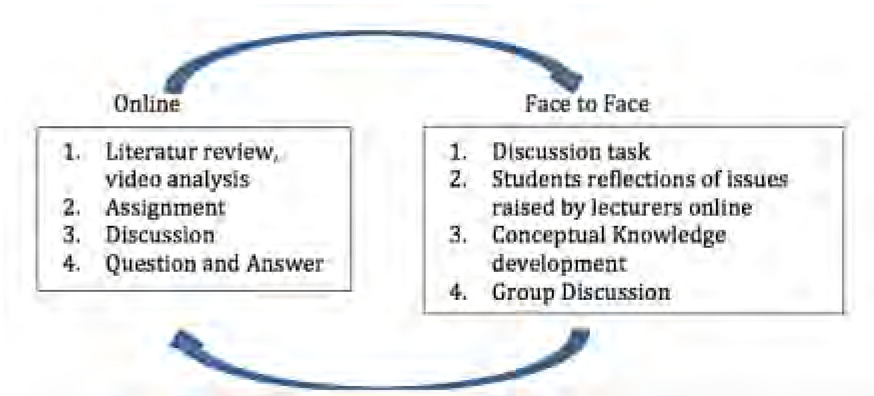


Figure 1. WBBL Implementation

For illustration, Figure 2 shows prospective teachers activities on Edmodo. The teacher gives two video links about fractional subtraction. The teacher asks participants to analyze the videos and compare them and choose which one is appropriate for students development and easy for students to understand. Participants analyze videos from different points of view: child development, learning media, subject delivery (concrete, pictures, symbolic).

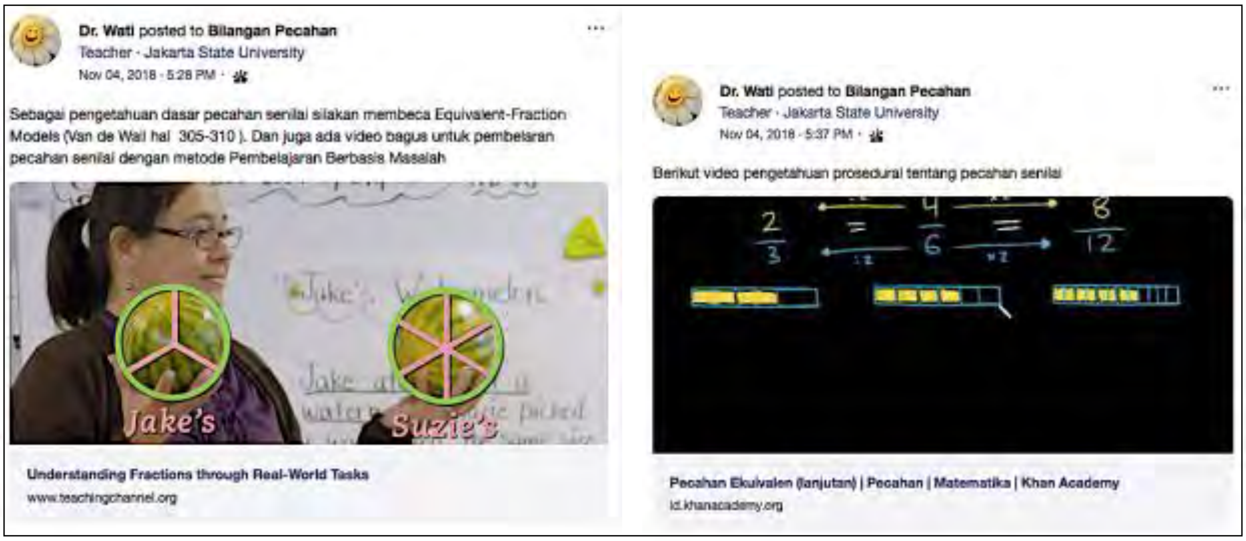


Figure 2. Prospective teachers activities

Prospective teachers analyzed the both video and upload the answer in assignment (Figure. 3)

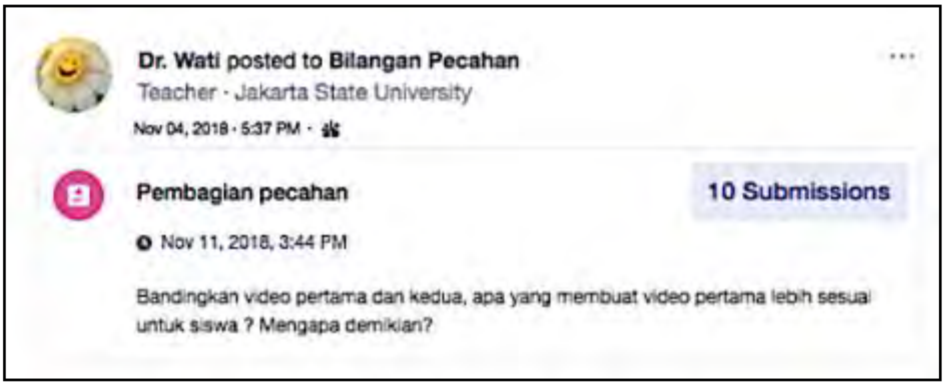


Figure 3. Prospective teacher assignment

In the face-to-face session, participants discuss assignments of specific concepts. After that, the group activities are carried out based on the questions and each group has different problems. For example, a word problem is given:

Tina has a 1.5 m ribbon. She wants to connect it with a ribbon which is 1.5 meters long.
How long is the ribbon now?
How do you direct students to answer the question?

The group thinks of a teaching aid that can be used and how to explain the problem to students using the teaching aid. When the group discussion is over, each group presents its strategy in front of the class. At the end of the session, the teacher directs participants to the topic for the next face-to-face session and reminds participants to study online.

Cohort 2, participants learned face to face. They learned using learning aids such as square paper, straw, millimeter paper, stick, etc. For example infraction subtraction, the process starts with the teacher's explanation. The teacher demonstrated fractions subtraction problem in front of the class.

I have 1 roll of bread.
Then I want to give $\frac{1}{3}$*(one-third) of the bread to Siti.*
How much is your bread left?

The teacher demonstrates the subtraction process using a paper roll. The teacher continues the explanation by using pictures on the blackboard. After that, the participants are asked to discuss the subtraction problem in the group and share their work with the class in the presentation. At the end of the session, the teacher gives the participants work to be done at home.

Result and Discussion

Research Question 1

Descriptive as well as inferential analyses were conducted on our dataset to test our hypotheses concerning the research questions. To answer research question 1, we compare both cohort data to investigate the effect of WBBL on conceptual knowledge of prospective teacher development.

Comparison of prospective teacher performance is shown in Table 3. The ability to make a visual model and explain the process of the addition of cohort 1 (35.3%) was higher than cohort 2 (17.6%). Even though 70,6% of cohort 2 can make a visual model of fraction addition. In subtraction, cohort 1 learning outcomes were better overall than in cohort 2. Prospective teachers can make visualizations and make an explanation in cohort 1 (41.2%) was higher than cohort 2 (17.6%).

In multiplication, overall cohort 1 learning outcomes are better than cohort 2. Participants in cohort 1 (58.8 %) could present visuals and provide more explanations than cohort 2 (29.4%). In division, prospective teachers who did not answer and tried to answer in cohort 1 (11.8% and 23.5%) were smaller than cohort 2 (58.8% and 35.3%). Prospective teachers make a conceptual model of division, cohort 1 (47.1%) higher than (5.9%). The ability to present the model with cohort 1 explanation was successful at 17.6%, while cohort 2 did not exist.

Table 3
Comparison of Cohort 1 and Cohort 2 Results

	Code	Cohort I	Cohort 2
Addition	0	0.0	5.9
	1	11.8	5.9
	2	52.9	70.6
	3	**35.3**	**17.6**
Substraction	0	5.9	41.2
	1	23.5	17.6
	2	29.4	23.5
	3	**41.2**	**17.6**
Multiplication	0	**5.9**	17.6
	1	11.8	5.9
	2	23.5	47.1
	3	**58.8**	**29.4**
Division	0	11.8	58.8
	1	23.5	35.3
	2	47.1	5.9
	3	**17.6**	**0.0**

Based on cohort 1 and cohort 2 comparison, we conclude that prospective teachers learned by WBBL have better performance in Fractions than prospective teachers learned in traditional methods. It means WBBL has significantly improved prospective teachers' conceptual knowledge in the fraction domain.

To provide an overview of the participant’s performance, the following answers are presented by several participants, starting from Task 1.

Task 1. How can you illustrate the process $\frac{2}{5}+\frac{1}{5}$ using picture?

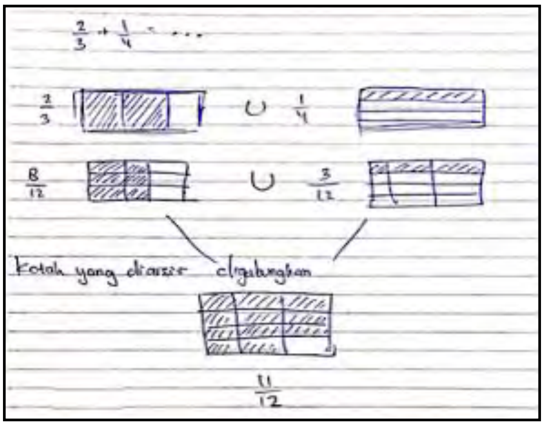
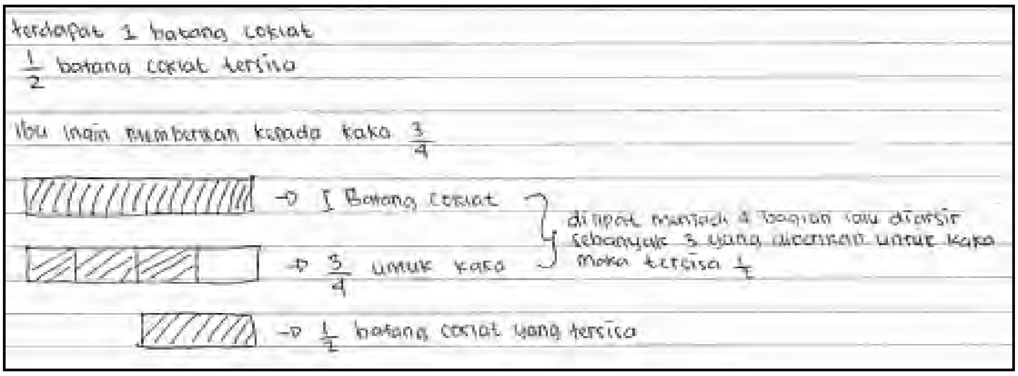


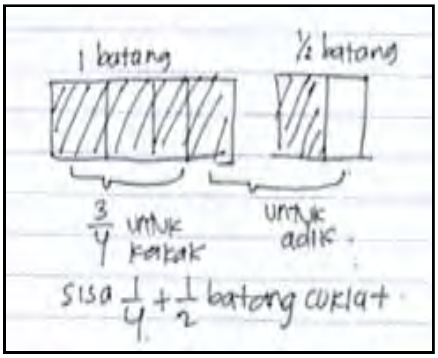
Figure 4. The student's answer to task 1

Mostly participants' answers are correct, but the explanation is incomplete as shown in Figure 4. The participants did not explain the change $\frac{2}{3}$ to $\frac{1}{4}$. The participants should have explained that the two fractions have different denominators and in the picture, the size of the shaded box is not the same. So it is necessary to equalize the size of the shaded box by dividing $\frac{2}{3}$ horizontally into 4 parts and $\frac{1}{4}$ vertically into 3 parts. This process is called by equivalent-fractions, where $\frac{2}{3} = \frac{8}{12}$ and $\frac{1}{4} = \frac{3}{12}$ so that $\frac{2}{3} + \frac{1}{4} = \frac{11}{12}$.

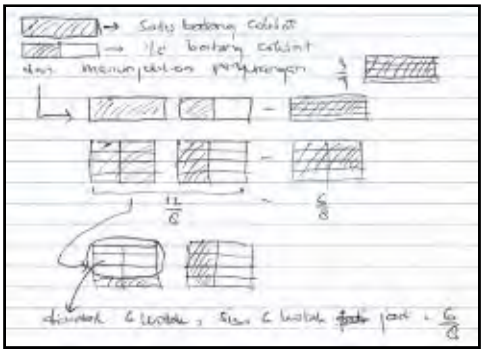
Task 2. There is a bar of chocolate and a half bar of chocolate. Mother wants to give $\frac{3}{4}$ (three fourths) bar of chocolate to Ani's sister and the rest for Ani. How can you explain the word problem using pictures?



(a)



(b)



(c)

Figure 5. The answer to task 2

The answer in Figure 5a shows that participants did not understand the problem. Participants give attention to one whole chocolate bar and $\frac{3}{4}$ the part that will be given to Ani's sister. So the answer is incorrect. The solution in Figure 5b, the participant showed an understanding of the questions. The illustrations made depict chocolate amount before given to Ani's sister, chocolate for Ani's sister, and chocolate left for Ani. But the chocolate for Ani has not been simplified. Figure 5c, the answer is more complete than answer b. It appears how to find of $1\frac{1}{2} = \frac{12}{8}$ and $\frac{3}{4} = \frac{6}{8}$. Then 6 shaded boxes are taken, therefore the remaining 8 shaded boxes, hence the answer is $\frac{6}{8}$.

Task 3. Explain $1\frac{3}{4} \times \frac{1}{5}$

(a)

(b)

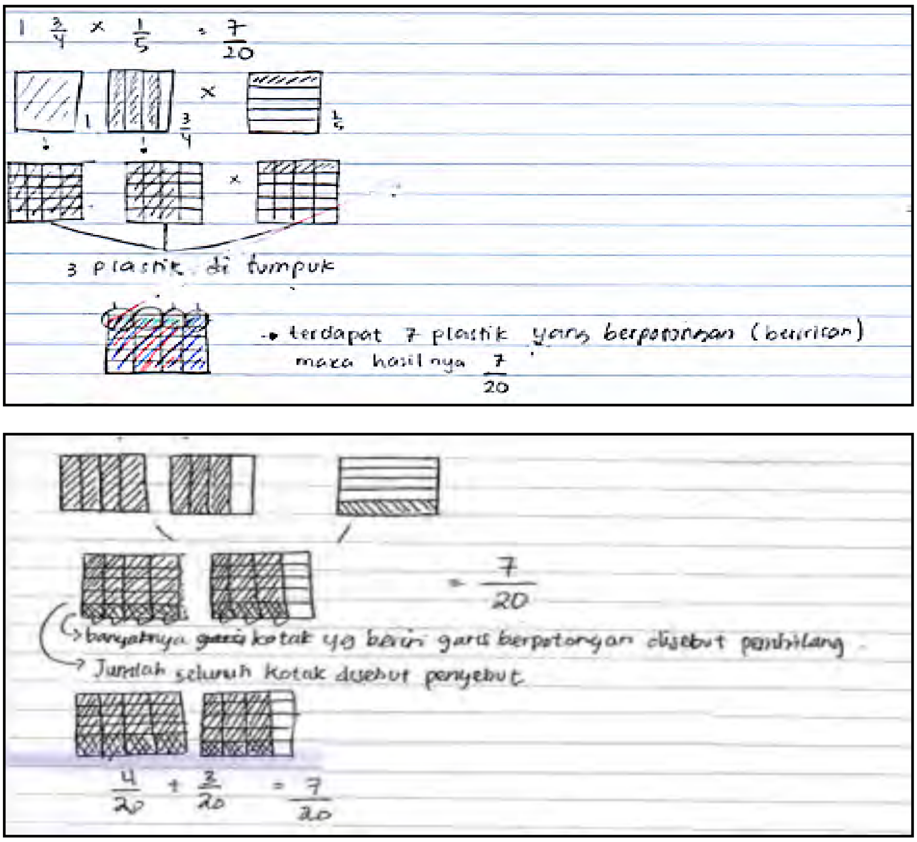
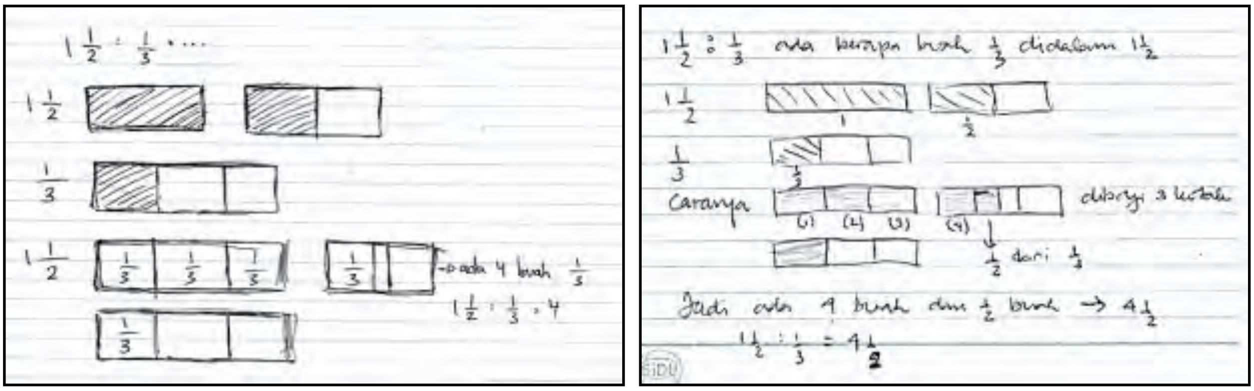


Figure 6. The student answer to task 3

Figure 6a, the participants seem to have an understanding of the concept of fraction multiplication by using the intersection regional approach. However, they do not understand how to solve multiplication for mixed fractions. In contrast to the participants in Figure 6b, they drew fractions for 1 or $\frac{4}{4}$ and ¾. Then each one is stacked with $\frac{1}{4}$ so that an area of 7 squares is intersected, and each square has 20 squares. Finally, the answer is $1\frac{3}{4} \times \frac{1}{5} = \frac{1}{5}$.

Task 4. How we can we help students to solve: $1\frac{1}{2} \div \frac{1}{3}$?

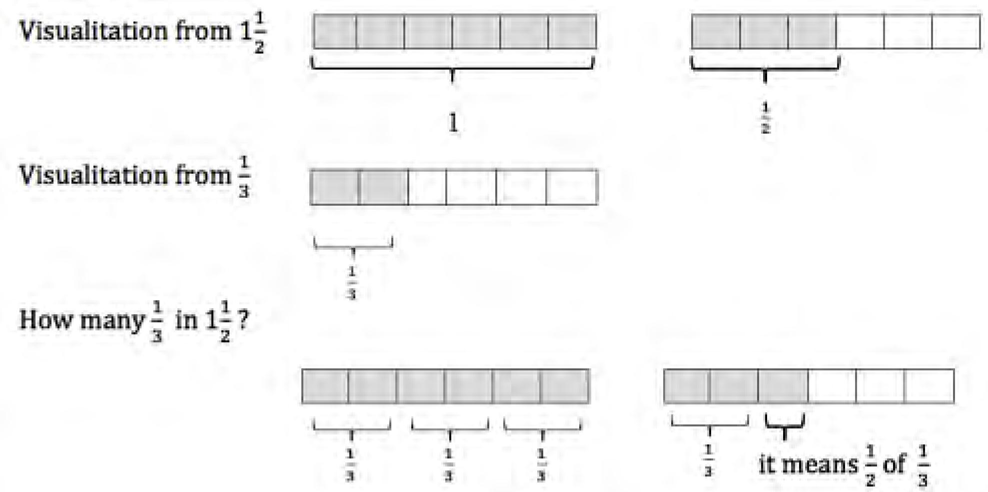


(a) (b)

Figure 7. The student's answer to task 4

In Figure 7a, the answer shows that the participants understood the conceptual knowledge of division on fractions, a: b means how much b is contained in a. But in general, many participants have difficulty with unlike denominators. In figure a, participants do not account for the remaining portion. In Figure 6b, the remaining part of the division of $\frac{1}{2} \div \frac{1}{3}$ is written of $\frac{1}{2}$ of $\frac{1}{3}$. So, $1\frac{1}{2} \div \frac{1}{3} = 4\ \frac{1}{2}$.

The division will be more easily completed if one section is divided into 6 boxes as follows:



Research Question 2

To answer the research question, the research findings are analyzed based on the theory stated in the relevant literature. The results showed that there were differences in the conceptual abilities between the group who learned through WBBL and the group who studied using teaching aids. The evidence can be seen from the percentage of prospective teachers that can explain conceptual knowledge in all fraction operations in cohort 1 greater than in cohort 2. This finding is similar to the previous study that Blended Learning enhanced academic achievement (Awodeyi et. al., 2014; Ceylan & Kesici, 2017). This is due to the advantages of online learning where prospective teachers can use richer and more varied learning resources than face-to-face. In connection with this condition, McDonald (2016) found that Blended Learning supports students learning more effectively than learning through e-learning or face-to-face alone. Chandler at al., (2011) found that students were able to transfer and synthesize knowledge obtained online to a hands-on activity. On the other hand, in cohort 2, the conceptual knowledge is still at a low level due to limited teacher candidate information. The limitations of these insights occur because of the source of knowledge and the information are mainly acquired from teachers and textbooks. Another cause of this constraint is the study time allocation in class. Furthermore, in terms of the cognitive process, prospective teachers tend to learn passively since they did not have initial knowledge of the concepts. However, those prospective teachers who already have the initial knowledge are more active and are able to easily understand the concepts.

The information received only comes from teachers and textbooks as well as the limitations of study time in class. Also, cognitive prospectively did not have initial knowledge so that they passively studied. Unlike the prospective teachers who already have initial knowledge, they are more active, and easier to understand.

Cohort 1 actively communicates with lecturers or with participants through chat facilities. Communication takes place among prospective teachers because they are more comfortable in asking questions rather than during face-to-face interaction. This means that WBBL provides an opportunity to grow a learning community outside the classroom through potential learning support facilities (White & Geer, 2009) and enhance students' support and competency development (Kleinert et al. 2015). Discussions between students revolve around how they understand the material and reflect problems from various perspectives. This finding is reinforced by Chen and Looi (2007) by suggesting that online discussion can broaden perspectives, increase participation in discussions, and develop cognitive thinking skills and information processing (Stacey & Gerbic, 2009). BL can be a liaison between students and lecturers who are not limited by space and time. In other words, BL facilitates productive communication through social networks and in unlimited time.

WBBL increases student involvement such as interacting with two-way collaboration between students and students or students with lecturers to develop learning and knowledge (El-Mowafy et. al., 2013). This findings in line with Boelens et al., (2017) and Voegele's (2014) statement that blended learning supports the occurrence of interactions and interactions resulting in increased learning outcomes.

El-Deghaidy and Nouby (2008) concluded that blended learning raises cognitive interactions among students. Learning in social environments is consistent with the Constructivist social view (Vygotsky) that the acquisition of knowledge can occur in the form of social interaction. The social environment is extremely conducive to develop an individual deeper understanding as well as gaining more knowledge on the mathematical concepts. In study groups, students can clarify, assess, and gain better perspectives on certain issues or phenomena. Actively engaging with the subject matter, learning together, and students can be empowered and motivated to achieve more in the classroom as a group.

Moreover, WBBL accommodates differences in student abilities. The learning activities are designed to cater for both fast learners and slow learners. Both learners are benefited because they learn according to their learning abilities. The students with higher needs will gain ample benefits from the blended classroom as well. They could intensively work one-on-one or in small groups with the teacher acting as the facilitator and the resource person. Moreover, the prospective teachers who have more knowledge on the content have the advantage of becoming autonomous learners since they can work at their place and explore concepts on their own. That is why WBBL as one of the digital learning environments has advantages in terms of personalization, flexibility, and efficiency (Laurillard, 2014). Blended learning provided all students with positive learning outcomes (Rozeboom, 2017), and enormous opportunities, for personalizing learning (Brodersen & Melluzzo, 2017; Wanner & Palmer, 2015).

WBBL fosters independent learning habits and increases learning motivation. As a result, cohort 1 of prospective teachers has a tremendous improvement in learning engagement management than cohort 2 (Bahji et al, 2015) where blended learning provided all students with a positive learning experience and generated higher student achievement (Rozeboom, 2017). Students being motivated in showing deep involvement in the learning process due to the engaging learning environment. They gained a longer-term commitment because of what they have learned from others. They are more willing to make use of their learned knowledge to solve problems more proactively and consistently (Hui at al, 2019).

Conclusion

The results showed the highest increase in appearance was the fraction multiplication, followed by addition, subtraction. and division. However, the prospective teacher's performance in explaining addition computation is not as good as their performance in explaining subtraction. This study concludes the conceptual ability of prospective teachers who learn through Web-Based Blended Learning is exceedingly superior to those teacher candidates who learn using a traditional method. The study could contribute to enhancing the Teacher Education readiness, and as a proactive prospect of WBBL courses in Mathematics Teaching Knowledge. The research could be of immense benefit to learners and lecturers. Curriculum designers could arrange appropriate WBBL for content knowledge courses and e-learning coordinators in the institution.

Moreover, a prospective teacher needs to have a depth understanding of procedural knowledge and mathematics pedagogic content knowledge. Therefore, future research needs to be done to investigate the impact of WBBL on both knowledge development.

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