Increasing conceptual understanding and procedural fluency on teaching polyhedrons using blended learning strategy: a case study on 8th grader of SMP N 1 Sukawati

I G P Sudiarta* and D G A P Nugraha
Mathematics Department, Mathematics and Science Faculty Universitas Pendidikan Ganesha, Bali, Indonesia

*Corresponding author: gussudiarta@undiksha.ac.id

Abstract. This study aims to improve the conceptual understanding and procedural fluency in learning Polyhedrons using blended learning strategy. A blended learning strategy was done by combining face-to-face and online learning using Edmodo. The subject of this study consisted of 34 students of 8th Grader (14 males and 20 females) of SMP Negeri 1 Sukawati in the academic year 2017/2018. The study had taken place for 8 weeks (2-Cycles) on the topic of Polyhedrons. The research data were conceptual understanding and procedural fluency measured quantitatively by test and then coded, analyzed qualitatively using content analysis techniques of students' posts on online discussion. The results showed that (a) a very good category of conceptual understanding (score 88) and a good category of procedural fluency (score 75) had been achieved quantitatively, (b) Qualitatively, there was also an improvement in the quality of conceptual understanding and procedural fluency found on the student online discussion' posts. Of all 797 posts, there were 31.7% questions and 68.3% answers that significantly indicated a good conceptual understanding (39.65%) and procedural fluency (29.9%) on teaching Polyhedrons.

1. Introduction
One of the difficult and challenging mathematical topics for grade 8 is geometry, especially the polyhedron topic. Geometry lessons are not just about memorizing forms, but it is a study of spatial objects, relationships, and transformations. They have been mathematized or formalized into a system of axiomatical mathematics constructed to represent it [1]. At least there are 3 dimensions to learn geometry, namely (a) visualization, drawing, and construction of figures; (b) study of the spatial aspects of the physical world: (c) use as a vehicle for representing nonvisual mathematical concepts and relationships; and d) representation as a formal mathematical system (ibid). To understand geometry lessons well, besides requiring other mathematical skills, it is very important that the abilities are the so-called spatial reasoning. According to Clements and Battista [1] spatial reasoning is a set of cognitive process. In this process what is called "mental representation" for those spatial objects, relationships, and transformations will be constructed and manipulated. Spatial reasoning is very important in learning geometry, and most mathematics educators recommend to include spatial reasoning as part of the geometry curriculum. Another definition, for example, according to Kastens, Pistolesi, and Passow [2] spatial thinking in earth science includes visualizing, manipulating, drawing from the position, shape, orientation, trajectory, or configuration of objects or phenomena. Creating and extracting insights from spatial representations in form of 2D/3D is part of spatial thinking.
Some of the problems found in teaching polyhedrons are often related to conceptual understanding and low procedural fluency [3-5]. The causes of this matter also vary, such as (a) incompatibility of learning strategies, such as monotonous learning, lack of opportunities for students to explore ideas and concepts well [6,7] (b) lack of innovative learning media, only limited to the use of students worksheet and it has not been supported by various technology-based media such as interesting and challenging animation videos [8-9]. This is most likely to be one of the causes of low student learning outcomes in geometry, especially polyhedron learning, such as lack of understanding of concepts [10], low reasoning ability [11], and low spatial reasoning or spatial thinking [2]. Students tend to only memorize the steps of solving mathematical problems without an adequate understanding of the concept, why these steps produce the right answers. Students are only able to demonstrate limited abilities in using appropriate strategies to solve new mathematical problems [10]. Especially in geometry learning, it is needed, not only the ability of numerical reasoning but also the understanding of spatial reasoning. This will determine the success in solving geometry problems.

This research aims to improve the conceptual understanding and procedural fluency in learning Polyhedrons using a blended learning approach using the LMS Edmodo. The choice of this strategy is based on the reason that blended learning allows teachers to add independent learning through the online learning phase, as well as through face-to-face learning as usual. In this case, the concept of blended learning was adopted as a combination of face-to-face learning with online learning ([6,8,12-15]. In principle, blended learning involves profound redesign of a pedagogical approach, including (a) a shift from lecturers to student-centered learning in which students become active and self-regulated learners; (b) increased interaction among students and their teachers, and (c) integrated rich learning sources, the materials of the study, assignments and homeworks, or exams, which are in forms of text, figures, audio, or video which could be accessed for 24/7.

In the context of this research, especially in the online learning phase, the self-developed interesting videos featuring 2D / 3D aspects of Polyhedron are expected to be able to improve students' spatial reasoning and thinking. In addition, the online learning session also carried out asynchronous and synchronous online discussions, so that overall this strategy is expected to improve the conceptual understanding and procedural fluency in learning Polyhedrons. This is reinforced by the results of previous studies that blended learning with various media such as the use of video tutorials, Khan Academy-video likes, proved to have a positive effect on concept understanding, mathematical problem solving, student independence and attitudes [6-8]. Thus the formulation of the research problem in this study are (a) How does the blended learning strategy improve students' conceptual understanding and procedural fluency in learning polyhedrons, (b) Are there any evidence of improvement in the quality of conceptual understanding and procedural fluency found on the student online discussion' posts?

2. Methods
This study is a part of a larger research. A collaboration of a postgraduate student and an experienced mathematics teacher to apply Edmodo model of flipped blended learning in which both of them trained to create sources for online learning (in form of learning videos) for a week, to try practicing the developed scenario of blended learning and to become the moderator of students discussion in online platform. The subject of this study consisted of 34 students of 8th Grader (14 males and 20 females) of SMP Negeri 1 Sukawati Gianyar Bali in the academic year 2017/2018. The study had taken place for 8 weeks (2 cycles) on the topic of Polyhedrons. The research data were conceptual understanding and procedural fluency measured quantitatively by the test and then coded, analyzed qualitatively using content analysis techniques of students' posts on online discussion [16].

3. Result and Discussion
The students score in conceptual understanding and procedural fluency is shown in the chart 1. It seems that there is a significant improvement in students score. The improvement of conceptual understanding is higher than those of procedural fluency.
Table 1 shows the distribution of students’ post on the online discussion which took place for 4 weeks (8 meeting-2 cycles). The total students’ posts were 797 consisting of 31.62% questions and 68.38% answers. This means that the students engaged actively in answering and finding a solution in the online discussion. The female students proposed 67.60% answers and it is almost the same as the male students did (69.46%). The female students’ posts were 58.09% while the male students’ posts were 41.91%. This is in line with the fact that the number of female students is greater than the number of male students.

![Figure 1. The Students score of conceptual understanding and procedural fluency](image)

Table 1. The distribution of students’ post on the online discussion

| No. | Description                  | Male (14) | Female (20) | TOTAL |
|-----|------------------------------|-----------|-------------|-------|
|     | VOL | %     | VOL | %     | VOL | %     |
| 1   | The number of students       | 14  | 41.18% | 20  | 58.82% | 34  | 100% |
| 2   | Questions-Students’ Post     | 102 | 30.54% | 150 | 32.40% | 252 | 31.62% |
| 3   | Answers-Students’ Post       | 232 | 69.46% | 313 | 67.60% | 545 | 68.38% |
| 4   | Total number of students’ post| 334 | 100.0% | 463 | 100%  | 797 | 100% |
| 5   | Difference male and female students’ post | 41.91% | 58.09% | 100% |

Table 2 shows the significance of students’ posts on the online discussion dashboard. The result revealed that students’ post contained in total 69.5% mathematical proficiency, 21.3% social and communication skills and 9.2% unclear posts. In term of conceptual understanding and procedural fluency, it seems that their percentage is a bit higher for the female students than those of male students, but it is because of the number of female students is much higher than the number of male students. Interestingly, the percentage of clarification, critic, and suggestion proposed by the male students seems significantly higher than those proposed by the female students.

Table 2. The Significance of Students’ Posts on Online Discussion

| No | The Significance of Students’ Online Discussion | Male (14) | Students Female (20) | Total |
|----|-----------------------------------------------|-----------|---------------------|-------|
|    | Vol | %     | Vol | %     | Vol | %     |
| A. Mathematical proficiency  | 1 Conceptual Understanding | 127 | 38.0% | 189 | 40.8% | 316 | 39.6% |
| 2 Procedural Fluency         | 96  | 28.7% | 142 | 30.7% | 238 | 29.9% |
| SUM                          | 223 | 66.8% | 331 | 71.5% | 554 | 69.5% |
| B Social Communication Skill | 1 Clarification | 45  | 13.5% | 51  | 11.0% | 96  | 12.0% |
| 2 Critic and Suggestion     | 36  | 10.8% | 38  | 8.2%  | 74  | 9.3%  |
| SUM                          | 81  | 24.3% | 89  | 19.2% | 170 | 21.3% |
| C Unclear                    | 30  | 9.0%  | 43  | 9.3%  | 73  | 9.2%  |
| Grand Total                  | 334 | 100%  | 463 | 100%  | 797 | 100.0% |
3.1. Construction of Students’ Conceptual Understanding

The following is an example of how students build an understanding of the concept of cube surface area through online discussion. Online discussion conversations began with a student's question about the lack of clarity in understanding the surface area of the cube, according to what he saw in the video uploaded by the teacher. Some other students tried to help that student by explaining in their own words until finally, all the students stated that he had understood the concept in question.

Translation:

- Student 1: Sir, I watched your video about the cube surface area. $6 \times a^2$, what does it mean?
- Student 9: oh yeah. The cube is formed of 6 squares (a). The area of a square is equal to side times side.
- Student 3: Right. So it’s $6 \times s \times s$, because there are 6 squares. And each square’s area is $s \times s$.
- Student 9: Yes, that is right. Do you get it?
- Siswa 12: That’s right.

3.2. Construction of Students’ Procedural Fluency

The following is an example of how students demonstrate how they can do the procedures in an accurate, efficient, and flexible way and how they can apply such procedures to other questions with different content. Of course, this ability can be seen immediately when students are given problem-solving activities in the classroom. But even in online discussions, some of its indicators as shown in the conversation in the following online discussion can be also observed. Online discussion started when a student asked how to calculate the surface area of a pyramid, which was then answered by other students by giving their strategy using the Pythagoras theorem.

The results of this study have shown that the implementation of blended learning on teaching polyhedrons has succeeded to improve both the students' conceptual understanding and procedural fluency. This is due to the additional existence of independent activities in the form of online learning, besides the face-to-face classroom activities, in which students get two meaningful learning opportunities, namely (a) learning using interesting videos, so that enabling students in creating and extracting insights from spatial representations of Polyhedron in 2D/3D form and finally improving their spatial reasoning and thinking, (b) blended learning also provides a broad opportunity for students to be actively involved in online discussions, which can take place without having to be limited by time and place. It was proven in this study that there was a very meaningful online discussion that consist of 797 students posts. It has been also revealed that students' conceptual understanding and procedural fluency are significantly evident in the online discussion dashboard. This is in line with the results of previous studies that blended learning with various media such as the use of video tutorials, Khan Academy-video like, proved to have a positive effect on conceptual understanding [7], [17],[18]) solving mathematical problems [9], [19] building mathematical proficiency, self-independent, and student attitude ([8],[6],[20]).
In this study, the developed blended learning prototype, has provided a profound solution to the problems, such as lack of students conceptual understanding [10], low reasoning ability[11], and low spatial reasoning or spatial thinking[2]. In this study, it was also shown that students proved to have the courage and self-independence in conducting meaningful discussions with their friends, and were able to produce excellent conceptual understanding, as shown in the online discussion example above. The limitation of this study involves three folds; namely (a) the characteristics of students post based on gender, (b) the role and teacher's skills in online discussion, (c) and the relationship between online discussion activities and student performance has not been investigated. Further research is needed to explain these three things.

4. Conclusion
The implementation of blended learning strategy on teaching polyhedron had succeeded to improve the students' conceptual understanding and procedural fluency. Some remarkable result are (a) A very good category of conceptual understanding and a good category of procedural fluency had been successfully achieved. (b) There was also significant improvement of conceptual understanding and procedural fluency seen in the dashboard of the online discussion. (c) The posts by students contained mathematical proficiency, social and communication skills and a little of unclear posts relatively. (d) There were questions and answers that significantly indicated a good conceptual understanding and procedural fluency on teaching Polyhedrons which means that the students (both male and female) engaged actively in answering and finding solution in the discussion being held online. (e) There is no difference between male and female students in term of conceptual understanding and procedural fluency. (f) But interestingly, the percentage of Clarification, Critic and Suggestion proposed by the male students seems significantly higher than those proposed by the female students. (g) In order to explain the characteristics of students’ posts based on gender, the most effective role of teacher in moderating the
online discussion, and the relationship between student activities in online discussion and student performance, deeper investigations in further research is advised.

Acknowledgement

We are thankful for the supports and funds from the Directorate General of Research Enhancement and Development, Ministry of Higher Research, Technology, and Education of the Republic of Indonesia.

References

[1] Clements D H and Battista M T 1992 Geometry and spatial reasoning, Handbook of Research on Mathematics Teaching and Learning
[2] Kastens K A, Pistolesi L and Passow M J 2014 J. Geosci. Educ 62(2) 278
[3] Luneta K 2014 South Afr. J. Child. Educ. 4(3) 71
[4] Suarsana I M, Widiasih N P S and Suparta I N 2018 J. Math. Educ. 9(1) 145
[5] Purwadi I M, Sudiarta I G P and Suparta I N 2019 Int. J. Instr. 12(1). 1113
[6] Sudiarta I G P, Sukajaya I N and Suharta G P 2018 J. Phys. Conf. Ser. 1040 012031
[7] Sudiarta I G P and Sadra I W 2016 J. Pendidik. Dan Pengajaran 49(2) 48
[8] Sukawijaya I M G and Sudiarta I G P 2018 J. Phys. Conf. Ser. 1040 012030
[9] Apsari D M, Sudiarta I G P and Suharta I G P 2018 7(79) 4
[10] DeCaro M S 2015 Soc. Res. Educ. Eff.
[11] Zhonghong J 2002 Proc. Annu. Meet. North Am. Chapter Int. Group Psychol. Math. Educ. 24th Athens GA Oct. 26-29 2002 1-4 14
[12] Vine M M, Swanson C C, Maclachlan J, Brodeur J J and Bagg J 2016 Can. J. Scholarsh. Teach. Learn 7(2) 9
[13] Umoh J B and Akpan E T 2014 J. Educ. Learn. 3(4) 60
[14] Gagnon M P, Gagnon J, Desmarais M and Njoya M 2013 Nurs. Educ. Perspect. 34(6) 377
[15] Pindari D M, Sudiarta I G P, Sugiarta I M and M. Si 2015 J. Jur. Pendidik. Mat. 3(1)
[16] Kilpatrick J, Swafford J and Findell B 2001 Adding it up: helping children learn mathematics. (Washington, DC: National Academy Press)
[17] Kingpum P 2015 Educ. Res. Rev. 10(15) 2168
[18] Barbour M 2011 Int. Assoc. K-12 Online Learn.
[19] Lee J 2014 Int. Rev. Res. Open Distrib. Learn. 15(1)
[20] Ya-Wen L, Lung Tseng C and Jui Chiang P 2017 EURASIA J. Math. Sci. Technol. Educ. 13(3)