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Student Mathematical Communication in Online Discussion in Introduction to Geometry Course using Edmodo

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ABSTRAK

Komunikasi matematis merupakan bagian penting dalam pembelajaran matematika. Komunikasi matematika adalah cara siswa untuk mengungkapkan ide matematika baik secara lisan, tulisan, gambar, diagram, menggunakan benda, menyajikan dalam bentuk aljabar, atau menggunakan simbol matematika. Melalui komunikasi matematis, siswa dapat menyampaikan ide dan memperjelas pemahaman dan pengetahuan selama proses pembelajaran matematika. Keterampilan komunikasi matematis menjadi penting karena dalam pembelajaran matematika, penggunaan notasi, simbol, rumus dan istilah merupakan faktor penentu dalam pemecahan masalah. Karena adanya pandemi, kegiatan pembelajaran dilakukan secara daring melalui Edmodo. Hal ini dapat membawa perubahan pada komunikasi matematis siswa ketika melakukan diskusi. Untuk itu penelitian ini bertujuan untuk mendeskripsikan komunikasi matematis siswa pada saat sesi diskusi pada mata kuliah Pengantar Geometri melalui Edmodo. Penelitian ini merupakan penelitian deskriptif kualitatif. Subyek penelitian ini adalah 35 orang mahasiswa semester 1 pendidikan matematika yang sedang mengikuti mata kuliah Pengantar Geometri. Hasil penelitian menunjukkan bahwa dalam melakukan diskusi, siswa menggunakan komunikasi matematis tertulis, visual, dan simbolik. Dalam mengungkapkan pendapatnya, siswa juga dapat menggunakan lebih dari satu jenis komunikasi matematis. Selain itu, pendapat yang diungkapkan dalam diskusi berada pada berbagai tingkat kognitif.

ABSTRACT

Mathematical communication is an important part in learning mathematics. Mathematical communication is a way for students to express mathematical ideas either orally, in writing, pictures, diagrams, using objects, presenting in algebraic form, or using mathematical symbols. Through mathematical communication, students can convey ideas and clarify understanding and knowledge during the mathematics learning process. Mathematical communication skills are important because in learning mathematics, the use of notation, symbols, formulas and terms is a determining factor in problem solving. Due to the pandemic, learning activities are carried out online through Edmodo. This may bring changes to students' mathematical communication when doing a discussion. For this reason, this research aims to describe students' mathematical communication during discussion session in the Introduction to Geometry course through Edmodo. This research is a qualitative descriptive research. The subjects of this research were 35 students of first semester mathematics education who were taking the Introduction to Geometry course. The results showed that in doing a discussion, the students used written, visual, and symbolic mathematical communication. In expressing their opinion, students can also use more than one type of mathematical communication. In addition, the opinions expressed in the discussion were at various cognitive levels.

1. INTRODUCTION

Mathematical communication is an important part of mathematics learning (Rizta & Antari, 2018; Rohid et al., 2019). Mathematical communication is a way for students to express mathematical ideas either orally, in writing, pictures, diagrams, using objects, presenting in algebraic form, or using mathematical symbols. Through mathematical communication, students can convey ideas and clarify their understanding and knowledge during the mathematics learning process (Disasmitowati & Utami, 2017; NCTM, 2000). Mathematical communication skills are important because in learning mathematics, the use of notation, symbols, formulas and terms is a determining factor in problem solving (Jehadus et al., 2021; Parida et al., 2018). Students' mathematical communication skills need to be understood by teachers so that they can help in learning mathematics and monitor student progress (Primayanti et al., 2018; Zulkarnain et al., 2021). The importance of mathematical communication in mathematics learning is emphasized in the Regulation of the Minister of National Education no. 22 of 2006 which states that one of the objectives of learning mathematics is for students to have the ability to communicate ideas by using symbols, tables, diagrams, or other media to clarify situations or problems. This is in line with the establishment of

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mathematical communication as one of the standards of the mathematics learning process (NCTM, 2000; Qohar & Sumarmo, 2013).

Mathematical communication ability is the students' ability to convey ideas and discuss mathematical concepts coherently and clearly (Lomibao et al., 2016; Qohar & Sumarmo, 2013). Mathematical communication is a way of sharing ideas and clarifying understanding (NCTM, 2000; Rizta & Antari, 2018). Through communication, ideas become objects of reflection, refinement, discussion, and change. When students are being challenged to communicate the results of their thinking to others orally or in writing, they learn to be clear, convincing, and precise in using mathematical language. Mathematical communication is shown in activities such as organizing and consolidating their mathematical thinking through communication; communicating their mathematical thinking coherently and clearly to peers, teachers, and others; analyzing and evaluating the mathematical thinking and strategies of others; and using mathematical language to express mathematical ideas appropriately (NCTM, 2000; Qohar & Sumarmo, 2013). In learning mathematics, teachers can use various learning methods to improve students' mathematical communication skills. Several studies have shown that students' mathematical communication skills can be improved through constructivist learning based on Vygotsky's theory (Sinaga et al., 2021), project based learning (Prabaningrum & Waluya, 2020), open ended learning (Jehadus et al., 2021), cooperative and interactive learning (Wang et al., 2020) and computer technology-based learning (Mujiasih et al., 2021).

There are five types of communication in mathematics (Jehadus et al., 2021; Zevenbergen et al., 2004). The first type is oral communication, namely when students "talk" mathematics through discussion or small groups. The second type is visual communication, namely when students use 2-dimensional representations such as written projects and 3-dimensional representations such as building construction projects. The third type is digital communication, namely the communication by using computer technology. The fourth type is text/written communication, namely when students use texts for explanations, the basis for truth, proving errors, conjectures, and others. The fifth type is symbolic communication, namely when students use mathematical symbols, such as operation signs, geometric symbols, and so on.

There are four aspects of mathematical communication, namely speaking, listening, writing, and reading mathematics (Qohar & Sumarmo, 2013; Thompson & Chappell, 2007). The most natural forms of mathematical communication are speaking and listening. In the classroom, students should regularly engage in mathematics talk, both in terms of student-to-teacher talk and student-to-student talk. Some students learn best aurally (through hearing), so that the ability to hear is also something important in learning mathematics. Although listening may seem strange at first as a mode of communication, listening is just as important as speaking, namely a means to investigate and check the understanding of others to support the communication (Davis, 1994; Lomibao et al., 2016). In mathematics, writing can take the form of journaling, diaries, and explanations of problems and the process of solving them. Whereas reading can be considered as a form of speaking slowly, where students translate the written words from their text and understand what the written words mean. It involves translation and understanding for communication to occur. So, reading is also an aspect of mathematical communication (Esnawy, 2016; Kane et al., 1974).

Due to physical distancing, which was enforced to stop the spread of Covid-19, teaching and learning activities at schools and lectures at universities cannot be carried out face-to-face. One of the efforts to overcome this was by conducting online learning through e-learning. Based on research results, online learning provides many positive aspects for students, including saving preparation time, being more cost-effective than face-to-face learning, and being easily accessible by students (Hussein et al., 2020; Mares & Kretz, 2015; Trisniawati et al., 2019). This is in line with the opinion of (Boling et al., 2014; Kiili et al., 2018; Rusli et al., 2020; Volk et al., 2017) which stated that the implementation of online learning increases creativity, motivation, and can be accessed by students anywhere and anytime. One platform that is often used in learning process is Edmodo (Bond, 2020; Mohamad et al., 2015; Ramadiani et al., 2017; Varalakshmiw & Arunachalamw, 2020). Edmodo is a communication, collaboration, and coaching platform for schools and teachers. The Edmodo network enables teachers to share content, discuss learning materials, distribute quizzes and assignments, and manage communication with students, colleagues, and parents (Balasubramanian et al., 2014; Sarrab et al., 2018). Based on the results of a research, Edmodo can increase students' interest in learning (Trisniawati et al., 2019). Edmodo can be accessed via computers or smartphones so that it is easily accessible by users. For this reason, the lectures in this research used Edmodo as a lecture tool.

One of the courses taken by mathematics education students is the Introduction to Geometry course. Some of the materials in this course include definitions, postulates and theorems, angles and perpendicular lines, and geometric proofs. This material contains many two-dimensional and three-dimensional objects, therefore visual communication is highly necessary in a discussion. However, the indirect discussion (through the Edmodo application) certainly brought changes in student communication.

Therefore, to understand how students communicate in online discussions using Edmodo, this research aims to describe students' mathematical communication during discussion session in the Introduction to Geometry course through Edmodo.

2. METHODS

This research is qualitative descriptive research. This research was conducted on 35 students of first semester mathematics education at the Universitas Negeri Malang in the Introduction to Geometry course. Some of the materials in the course include definitions, postulates and theorems, angles, perpendicular lines, and geometric proofs. This research was carried out during the discussion in the Introduction to Geometry course through Edmodo. This research aims to describe the mathematical communication of students during a discussion in the Introduction to Geometry course through Edmodo. The data of this research were obtained from observation on student discussion notes on the Edmodo application. In analyzing the data, each opinion expressed in the discussion process will be grouped based on the type of communication, namely oral, visual, digital, text, and symbolic communication (Zevenbergen et al., 2004), with indicators as presented in Table 1.

Table 1. Types of Mathematical Communication

Communication Type	Indicators in Discussion
Oral	Using conversation or speaking to express student opinion in the discussion.
Visual	Using two- or three-dimensional representations to express student opinion in the discussion.
Digital	Using computer or mobile phone technology to express student opinion in the discussion.
Text/written	Using words or written text to express student opinion in the discussion.
Symbolic	Using mathematical symbols to express student opinion in the discussion.

In addition, opinions of the students will also be grouped based on the cognitive level according to the theory of Bloom, namely the level of knowledge (C1), understanding (C2), application (C3), analysis (C4), synthesis (C5), and evaluation (C6) (Bloom et al., 1956), with indicators as presented in Table 2.

Table 2. Cognitive Level of Student Mathematical Communication

Cognitive Level	Definition	Indicators in Discussion
Knowledge (C1)	Recalling an information.	Defining, describing, or mentioning a mathematical knowledge or concept, for example, stating a definition, postulate, or theorem.
Understanding (C2)	Understanding the meaning, translating, and explaining a mathematical problem or concept using their own language.	Using their own language in explaining a concept, not just restating a definition, postulate, or theorem.
Application (C3)	Applying a concept in a new situation.	Applying, changing, or manipulating mathematical knowledge in a new context, for example, applying a theorem to solve a problem.
Analysis (C4)	Separating materials or concepts into its components or parts so that the organizational structure can be understood, and distinguishing facts and conclusions.	Differentiating, comparing, or inferring a mathematical knowledge.
Synthesis (C5)	Building a structure or pattern from various elements, with an emphasis on creating new meanings or structures.	Combining multiple pieces of information to produce new information.
Evaluation (C6)	Giving an assessment on an information.	Assessing and criticizing the opinions of others.

3. RESULT AND DISCUSSION

Results

The Type of Communication used by Students in the Discussion

As many as 12 opinions out of the 69 opinions in the discussion used three types of communication at once, namely written, visual and symbolic communication by providing an explanation of a problem using words, drawing two-dimensional geometric objects such as triangles, lines, and angles, as well as using mathematical symbols. Figure 1 is an example of written, visual, and symbolic communication used by students in the discussion. In expressing their opinions, students use words, draw angles, and use mathematical symbols such as angles, line segments, and operations.

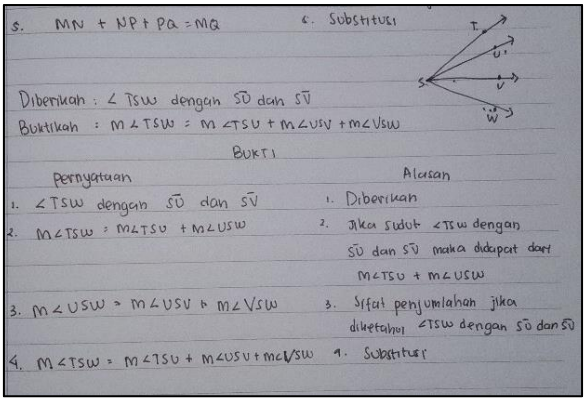

Figure 1. Example of Opinion with the Written, Visual, and Symbolic Types of Communication

Meanwhile, two opinions in the discussion used two types of communication at once, namely written and visual communication. The students provided an explanation of a problem using words, and drew two-dimensional geometric objects such as triangles, lines, and angles. Figure 2 shows an example of written and visual communication used by students in the discussion. In expressing their opinion, students used words and drew a ray of lines.

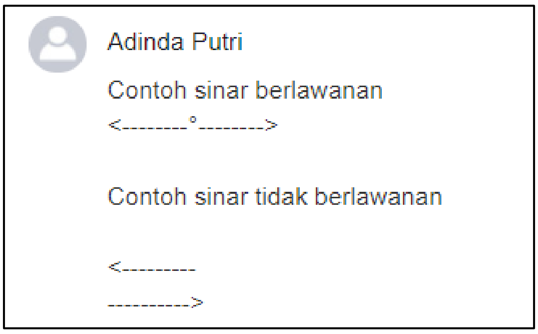

Figure 2. Example of Opinion with the Written and Visual Types of Communication

Other 15 opinions in the discussion used written and symbolic types of communication, in which some students provided explanation of a problem using words, as well as writing equations, using mathematical symbols such as angle symbol, line segment symbol, rays symbol, perpendicular symbols, parallel symbols, and so on. Figure 3 shows an example of written and symbolic communication used by students in the discussion. The student used the angle symbol in expressing his opinion.

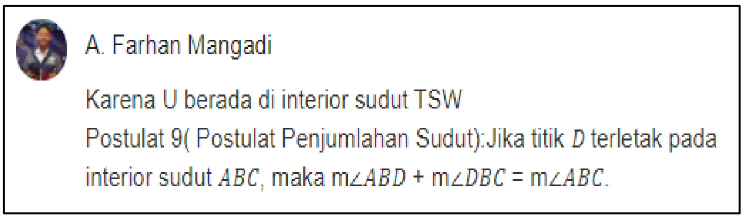

Figure 3. Example of Opinion with the Written and Symbolic Types of Communication

The remaining 40 opinions only used the written type of communication. Figure 4 is an example of written communication used by students in the discussion. The student used the words in expressing their opinion.

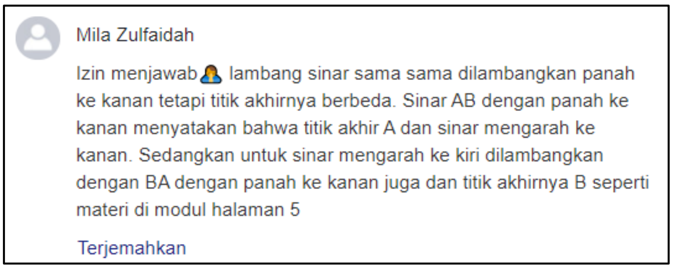

Figure 4. Example of Opinion with the Written Type of Communication

The discussion was carried out through the Edmodo application, so that the oral communication was not used. All students used digital communication because the discussion was carried out through the Edmodo application, which was accessed via computers/mobile phones. All students also used the written type of communication to express their opinion regarding the material using words.

Cognitive Level of Student Mathematical Communication in the Discussion

The first cognitive level is knowledge (C1), which is remembering information. The opinions with the cognitive level of knowledge are the opinions that define, describe, or mention a knowledge or mathematical concept, for example, stating a definition, postulate, or theorem. As many as 23 opinions out of the 69 opinions are at the cognitive level of knowledge (C1). Figure 5 is an example of an opinion with a level of knowledge (C1). The student stated the meaning of collinear point, coplanar point, and non-coplanar point.

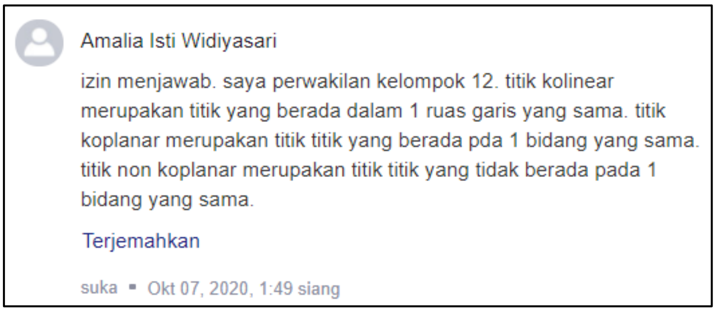

Figure 5. Example of Opinion with Cognitive Level of Knowledge (C1)

The cognitive level of understanding (C2) is indicated by understanding the meaning, translating, and explaining a problem or mathematical concept using their own language. The opinions with the cognitive level of understanding are the opinions of students who use their own language (words) in explaining a concept, not just restating a definition, postulate, or theorem. In the discussion of Introduction to Geometry course, 17 opinions are at the level of understanding (C2). For example, as shown in Figure 6 where the student stated, in their own language, that the bisector of an angle is singular.

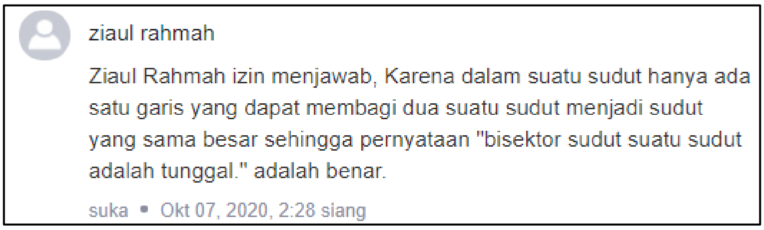

Figure 6. Example of Opinion with Cognitive Level of Understanding (C2)

The third cognitive level is application (C3), which is applying a concept in a new situation. The opinions in the discussion with the cognitive level of application are the opinions of students who apply, change, or manipulate mathematical knowledge in a new context. For example, applying a theorem to solve a problem. In the discussion, 19 opinions are at the level of application (C3), for example, as can be seen in

Figure 7. The picture was taken from a photo of a student's work sent via Edmodo. In this proof, the student applied postulates and algebraic properties to prove a statement.

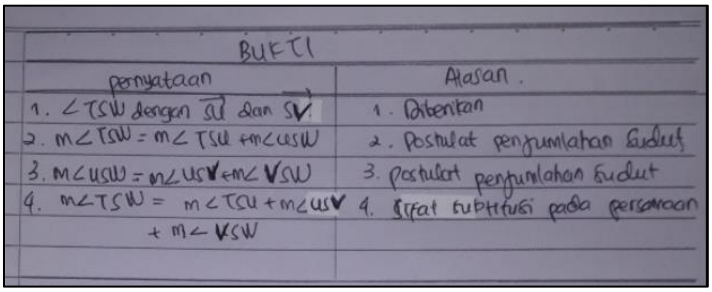

Figure 7. Example of Opinion with Cognitive Level of Application (C3)

The cognitive level of analysis (C4) is indicated by separating the material or concept into smaller components or parts so that the organizational structure can be understood, as well as distinguishing facts and conclusions. The opinions in the discussion with the cognitive level of analysis are the opinions that differentiate, compare, or conclude a mathematical knowledge. In the discussion, 7 opinions are at the level of analysis (C4), for example, as can be seen in Figure 8. The students can distinguish opposite rays and non-opposite rays and illustrate the difference.

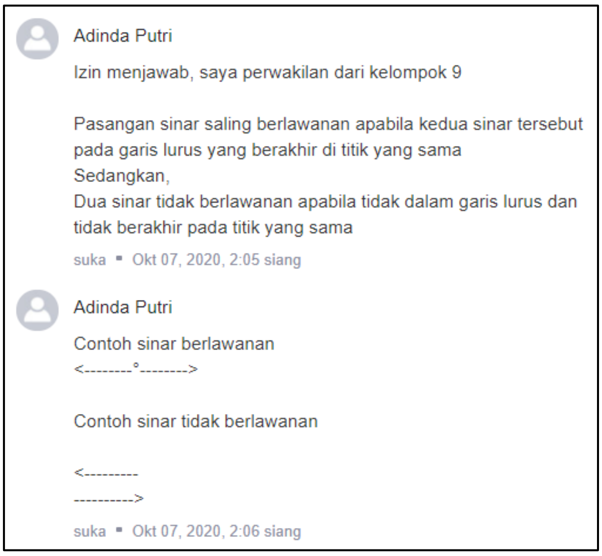

Figure 8. Example of Opinion with Cognitive Level of Analysis (C4)

The cognitive level of synthesis (C5) is indicated by building a structure or pattern from various elements, with an emphasis on creating new meanings or structures. In the discussion, this is demonstrated by combining several pieces of information to produce new information. In the discussion, 1 opinion is at the cognitive level of synthesis (C5), for example, in Figure 9. The student defined a new symbol for rays with a different direction by utilizing information about the symbols for lines and rays, even though this opinion is not correct.

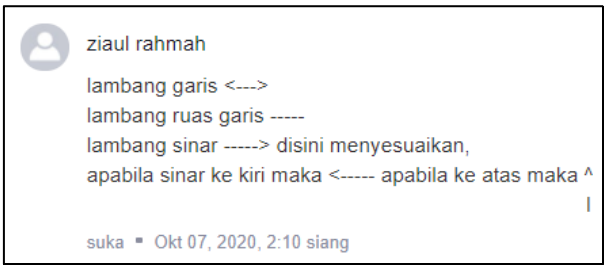

Figure 9. Example of Opinion with Cognitive Level of Synthesis (C5)

The cognitive level of evaluation (C6) is indicated by providing an assessment on an information. In the discussion, this is shown by assessing and criticizing the opinions of others. In the discussion, 2 opinions are at the level of evaluation (C6), for example, as can be seen in Figure 10. The student criticized the work of other (friends) regarding the use of inappropriate algebraic properties.

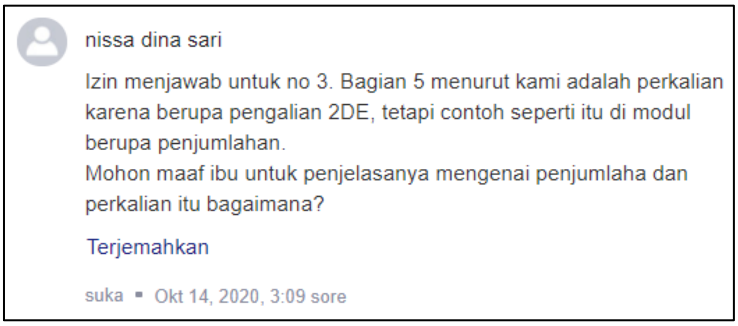

Figure 10. Example of Opinion with Cognitive Level of Evaluation (C6)

Discussion

Based on the results of the research, it was found that in the discussion, students used various types of mathematical communication. In this research, students used written, digital, visual, and symbolic types of communication. This is in line with the opinion which stated that mathematical ideas can be expressed in various ways, for example verbally, in writing, pictures, graphics, or symbols (Freeman et al., 2020; Hughes et al., 2020; Rohid et al., 2019). This is also in line with the opinion which stated that, in mathematical communication, students have the ability to express mathematical situations or ideas in the form of tables or pictures, and express situations, tables or pictures into language, symbols, ideas, or mathematical models, as well as explain mathematical ideas, situations, and relationships in writing and review descriptions or paragraphs (Rustam & Ramlan, 2017). Mathematical communication skills expressed in the form of mathematical models are also factors that support learning success (Disasmitowati & Utami, 2017).

In expressing their mathematical ideas, students use more than one type of communication, such as written and visual communication, written and symbolic communication, and written, visual, and symbolic communication at once. This is in line with the opinion of Thompson & Chappell which stated that students can use various types of communication in conveying a mathematical idea (Thompson & Chappell, 2007). This means that students are able to learn mathematics as an integrated unit, not as a set of disjointed concepts. The use of written and visual mathematical communication is also supported by the research which stated that in learning geometry, in addition to explanations in the form of words, students also need visual forms to facilitate their understanding (Kusumah et al., 2020). The use of three types of mathematical communication, namely written, visual, and symbolic, is also supported by the research conducted by (Pangaribuan et al., 2020; Sari et al., 2017; Tong et al., 2021) which stated that, in mathematical communication, students express mathematical situations, ideas, and relationships in the form of words, pictures, graphs, or algebraic expressions.

In this study, discussions were held online through Edmodo, oral communication was not used by students, however, good learning outcomes could be obtained. This is in line with the opinion which stated that in learning through Edmodo, only written, visual, and symbolic types of communication are used (Asih et al., 2020). Even so, students' communication skills carried out in online learning are not worse than direct learning where oral communication is used (Asarta & Schmidt, 2020; Asih et al., 2020).

The opinions expressed by students in the discussion are at various cognitive levels. Approximately, 33% of the opinions are at the cognitive level of knowledge (C1), 25% of the opinions are at the cognitive level of understanding (C2), 28% of the opinions are at the cognitive level of application (C3), 10% of the opinions are at the cognitive level of analysis (C4), 1% of the opinions are at the cognitive level of synthesis (C5), and 3% of the opinions are at the cognitive level of evaluation (C6). Based on Bloom's taxonomy, this means that only 14% of the opinions of the students are at the high thinking level, while the rest are at the low thinking level (Bloom et al., 1956). The difference in the cognitive level of the opinions expressed by the students is caused by the difference in the level of students' understanding of mathematics and students' communication skills. In addition to these two factors, student self-efficacy also affects the cognitive level of student communication. This is expressed that students' self-efficacy affects the level of students' mathematical communication competence (Rahmi et al., 2017). Furthermore, the results of another research show that students' cognitive styles affect students' mathematical communication (Kamid et al., 2020). The Independent Field Cognitive Style can explain the problem information well, use mathematical models appropriately, and be able to evaluate clearly and accurately (C6). While the Field Dependent cognitive style is able to describe the information about the question, but it is incomplete (Kamid et al., 2020).

4. CONCLUSION

Based on the results of research and discussion, it is concluded that in the discussion through Edmodo, students used mathematical communication in the form of written, digital, visual, and symbolic communication. All students are said to be doing digital communication because they conducted the discussion through Edmodo that was accessed via cellphones or computers. In expressing their opinion, students can use more than one type of mathematical communication, for example: written and visual communication; written and symbolic communication; or written, visual, and symbolic communication at the same time. Judging from the cognitive level, the opinions expressed by students in the discussion are at various cognitive levels. Approximately, 86% of the opinions are at the low thinking level as follows: 33% are at the cognitive level of knowledge, 25% are at the cognitive level of understanding, and 28% are at the cognitive level of application. While only 14% of the opinions are at the high thinking level as follows: 10% are at the cognitive level of analysis, 1% are at the cognitive level of synthesis, and 3% are at the cognitive level of evaluation.

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