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# IS COMMUNICATING MATHEMATICS PART OF THE EASE OF ONLINE LEARNING FACTOR?

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**ABSTRACT**

In this study, we focus on self-disclosure, communicating mathematics, and infrastructure support in determining the ease of online learning for students of mathematics education study programs. The sample in this study were students (n=465) who were asked voluntarily to fill out an online questionnaire. Participants consisted of 335 female students (72%) and 130 male students (28%) from various universities in Indonesia. The data were analyzed quantitatively using structural equation modeling. The results of the path analysis show that the ease of online learning is influenced by self-disclosure, communicating mathematics, and infrastructure support. The R square results show that these factors influence 47%. Each path analysis shows that self-disclosure (r = 0.556 p= 0.000) and infrastructure support (r = 0.243 p = 0.000) have a significant positive relationship with the ease of online learning. Meanwhile, communicating mathematics (r = -0.025 p =0.507) has an insignificant negative relationship to the ease of online learning. Further research is needed to see how the impact of mathematical application support communicating mathematics in online learning.



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## 1. INTRODUCTION

As we all know, the development of the internet is characterized by its use in all aspects of life. The internet of things provides convenience and breadth of face-to-face communication. This can be seen from the behavior of the people who are able to solve various social challenges and problems by utilizing various innovations that were born in the current era. as in the E-Learning System is a distance learning process by combining the principles of the learning process with technology. This system utilizes internet infrastructure in the teaching and learning process, so that students can access and understand a topic or material. Then, students can access learning materials anywhere and anytime.

Communication carried out online by teachers and students greatly influences the implementation of education. At least with internet facilities, online learning can provide flexibility (Bussey, 2021; Pham et al., 2019). Although for some areas which are considered blank spots, online learning experiences many problems, but it must be understood that expanding access to education through online learning provides opportunities (Szopiński & Bachnik, 2022) for people who are geographically distant from the center of the education provider to participate in education.

Online learning has differences with offline learning. Offline learning can be interpreted as direct learning such as students face to face directly with teachers without intermediaries, for example conventional learning. Online learning is a teaching and learning process that utilizes the internet and digital media in delivering material. For this reason, online learning requires teachers to be creative in preparing teaching tools, because the teaching tools that can be used in online learning are digital teaching devices. Conditions in the field, online learning is essentially the same as scheduled learning, it's just that it is held online so that face-to-face teacher-student interactions are carried out in a virtual space.

The COVID-19 epidemic has prompted significant educational changes, particularly in adopting e-learning platforms like Zoom and Google Meet (Irfan et al., 2020; Szopiński & Bachnik, 2022). The abrupt shift in online learning (Mseleku, 2020) has increased learners' interest in engaging (Assunção Flores & Gago, 2020; Szopiński & Bachnik, 2022). Obstacles to establishing online learning include equipment restrictions (Assunção Flores & Gago, 2020; Gay, 2016) and teachers' inability to use technology (Rasheed et al., 2020). Anxiety resulting from the abrupt shift in modes from offline to online must be addressed (Bao, 2020). The implementation of online learning in Indonesia has only recently been crowded due to the COVID-19 outbreak. The Indonesian government provides a policy to work from home, including implementing learning. This is aimed at reducing the spread of COVID-19. Online learning is undoubtedly the best alternative during the pandemic because learning can continue. However, online learning, which is still new, requires adjustment because, in Indonesia, almost all learning is face-to-face. Education providers usually provide feedback as part of the evaluation. The implementation of learning that is still new certainly raises the perception of students—moreover, Indonesia's vast geographical conditions and the characteristics of each existing island.

Perception is an essential part of the psychological aspects of students that impact the achievement of learning outcomes. This project focuses on developing an instrument to measure students' perceptions of online learning. Various developments of instruments regarding perceptions and attitudes in online learning have been carried out. However, the development still needs to include infrastructure support in the instrument. At the same time, the implementation of infrastructure learning impacts the sustainability of knowledge, which also becomes part of the determining factor of how perceptions are formed during online learning. Students' readiness is an essential factor that educators must address. Thorndike's (law of readiness) law states that a person's learning success is determined by readiness (Steiner, 1997). Watson differentiates learner preparation into psychological and pedagogical (Watson, 1998). The pedagogical framework is concerned with learners' preparedness to participate in instruction. Readiness to learn can aid in effective learning. Readiness to learn relates to a student's physical, mental, and emotional readiness (Dangol & Shrestha, 2019). Learners' readiness to learn is also associated with their ability to be independent and control their behavior to achieve learning goals (Chorrojprasert, 2020).

For decades, people have been experimenting with online learning (Volery & Lord, 2000). The adoption of online education has been widespread in industrialized countries (Joosten & Cusatis, 2020). Online learning is based on the ease and expansion of access. In addition, due to the increased interest in continuing education, the required capacity is being

raised. Growth in the number of students necessitates the construction of new buildings and accompanying infrastructure. Evidence shows that public awareness of the necessity of education has grown. Not only are young people between the ages of 18 and 24 encouraged to pursue higher education, but people of all ages are encouraged to do so. This is relevant to the implementation of online learning, which is flexible and hence easy to follow.

Organizing online learning enables various accomplishments for individuals, institutions, and countries (Akaslan & Law, 2011). Students participating in online learning situations show significant differences (Muilenburg & Berge, 2005). This learning experience also influences the impression of learning, which affects learning outcomes. As a result, support becomes a key component in achieving learning objectives (Muilenburg & Berge, 2005). Problems can occur in any learning; thus, while online learning provides convenient access (Volery & Lord, 2000), technical help is required (Lee et al., 2011) to minimize problems.

Online learning during the pandemic is a new approach for Indonesia. The COVID-19 pandemic has resulted in considerable educational improvements, particularly in using e-learning platforms such as Zoom and Google Meet (Szopiński & Bachnik, 2022). The rapid transition in online learning (Mseleku, 2020) has piqued learners' enthusiasm to participate (Assunção Flores & Gago, 2020; Szopiński & Bachnik, 2022). Obstacles to establishing online learning include equipment restrictions (Assunção Flores & Gago, 2020; Gay, 2016) and teachers' inability to use technology (Rasheed et al., 2020). Anxiety resulting from the abrupt shift in modes from offline to online must be addressed (Bao, 2020). Students must be mentally and physically prepared to attain learning experiences through online learning. As a result, assessing learners' readiness to engage in online learning in various circumstances is critical—the ability and willingness to use technology influence pupils' preparedness to use technology. Online learning preparedness is influenced by technical issues, content, human resources, and finances (Rohayani et al., 2015).

Research on developing online learning instruments has been widely conducted (Hashim & Tasir, 2014; Hung et al., 2010; Smith et al., 2003). Ledbetter created an online learning readiness test with five dimensions: self-efficacy, motivation, self-directed learning, learner control, and online communication efficacy (Hung et al., 2010). Hung had developed a more complex instrument than Smith had. However, Hung's instrument continues to focus on aspects of self-efficacy, while infrastructural supports significantly influence online learning readiness. Because they depend on individual psychological effects, efficacy, and attitude are inextricably linked. Instruments for measuring attitudes toward online learning have been developed (Bernhold & Rice, 2020; Ledbetter, 2014; Mazer & Ledbetter, 2012).

In learning mathematics, mathematical communication refers to the involvement of students not only in solving mathematical problems but also the involvement of students in speaking and listening activities to share ideas, opinions, and solutions (Kosko & Gao, 2017; Kosko & Wilkins, 2010). Mathematical communication skills include expressing real problem situations into mathematical models, explaining and evaluating ideas orally and writing using symbols and mathematical language (Hidayat & Sumarmo, 2013; Lomibao et al., 2016; Silver & Cai, 1996). Mathematical representations are also an essential part of mathematical communication (Tong et al., 2021). Online learning systems during the COVID-19 pandemic and the closeness of the younger generation to online media have encouraged higher education institutions to implement online learning systems (Elmunsyah et al., 2020). However, it is necessary to explore communicating mathematics in online learning.

In this study, we focus on self-disclosure, communicating mathematics, and infrastructure support in determining the ease of online learning for students of mathematics education study programs. Communicating mathematics is an essential part of learning

mathematics. Mathematics has the characteristics of an abstract science different from other social sciences, so it is necessary to explore how the response to online mathematics learning choices, especially in mathematics lessons.

## 2. METHOD

This study aims to investigate factors that significantly impact the ease of online learning for mathematics education students in Indonesia. In addition, this research wants to see how these factors affect the ease of online learning. Researchers identified self-disclosure, infrastructure support, communicating mathematics, and ease of online learning variables in the study. Based on a literature review, self-disclosure, infrastructure support, and communication impact the ease of online learning. This research more specifically explores communication in mathematics learning. Communication in learning mathematics in this study leads to the convenience of students to communicate when learning mathematics is held online. As for the instruments for self-disclosure, infrastructure support, and ease of online learning, the researchers adapted various instruments that researchers had previously developed.

The researcher made 18 question items (see Table 1). The questionnaire is presented in Indonesian. The question items were designed using the 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) for the level of student agreement with each of these items. The questionnaire that has been developed is presented in Google form.

**Table 1**. Items in the questionnaire

| Aspect | Items | Indicator |
|---|---|---|
| Self-disclosure | Items 1 | When I'm learning online, I feel comfortable discussing. |
| | Items 2 | I'm more open to communicating in online. |
| | Items 3 | When I communicate online, I feel more confident. |
| | Items 4 | I am comfortable sharing personal information online. |
| Communicating mathematics | Items 5 | When I learn online, I can think clearly |
| | Items 6 | When discussing online, I'm able to express mathematical ideas |
| | Items 7 | When I'm learning online, I can understand symbols, pictures and mathematical formulas |
| | Items 8 | when learning online, I can understand the explanation from the teacher and students |
| | Items 9 | when learning online, I can explain mathematical ideas systematically |
| Ease in Online Learning | Items 10 | I like online learning because I don't have to come to campus |
| | Items 11 | I like online learning because I can give feedback anytime |
| | Items 12 | Online learning is the best way during the COVID-19 pandemic |
| | Items 13 | I enjoy communicating online |
| Infrastructure support | Items 14 | Since the location where I live has an excellent internet connection, it facilitates online learning. |
| | Items 15 | I have no objections to funding internet packages to support online learning. |
| | Items 16 | When I study online, I don't have to deal with inclement weather. |
| | Items 17 | When I'm learning online, I don't have any issues with power outages. |
| | Items 18 | I have a suitable device for online learning (eg laptop, mobile phone) |

Researchers distributed questionnaires through social media networks. Researchers contacted lecturers from various Universities in Lampung. In the questionnaire, participants were asked to tick the answer that best represented them with the statement. Questionnaires are distributed at the end of the odd semester of the 2021/2022 academic year. The

questionnaire was broadcast for one week. Answering all of the participant's questionnaire items takes about 10 minutes. After answering all the questions, participants submitted the answers and recorded them on the researcher's Google Drive. Each questionnaire question is requested to be filled out so that all questionnaires must be filled out before they can be submitted.

**Table 2**. Demographic Information of participants

| **Demograpics** | | **N** | **Percentage** |
|---|---|---|---|
| Gender | Male | 130 | 28% |
| | Female | 335 | 72% |
| Academic Year | First | 157 | 34% |
| | Third | 116 | 25% |
| | Fifth | 102 | 22% |
| | Seventh | 90 | 19% |

The sample in this study were students (n=465) who were asked voluntarily to fill out an online questionnaire. Participants consisted of 335 female students (72%) and 130 male students (28%) from various universities in Lampung province, Indonesia. In this study, most participants came from the first semester, with as many as 157 students (34%). The following highest number came from semester 3, with as many as 116 students (25%), followed by 102 students (22%) in semester five, and the remaining students in semester seven as many as 90 students (19%) (see Table 2).

This research is quantitative research with multivariate analysis. Multivariate analysis is used to look for the effect of various variables on one object simultaneously. These variables are interrelated, with at least one dependent variable and more than one independent variable. SEM – PLS (Structural Equation Modeling – Partial Least Square) analysis measures the impact of self-disclosure, infrastructure support, and communication in mathematics learning on the ease of online learning. SEM is a multivariate analysis technique that combines factor analysis and regression (correlation) analysis to examine the relationship between variables in a model, both between indicators and their constructs and relationships between constructs. PLS (Partial Least Square) is a variant-based SEM structural equation model. PLS is an alternative approach that shifts from a covariance-based SEM approach to a variance-based one.

The data is then recapitulated in MS Excel and Smart PLS 3 for analysis. The use of PLS-SEM in this study was divided into two analysis steps. The first step, the analysis, focuses on the measurement model, determining validity and reliability. The validity and reliability criteria refer to CR, Cronbach's alpha value, loading factor, and AVE. The validity of each indicator is determined using standardized factor loading (SFL). If the SFL is higher than 0.4, the item is said to be valid (Wawan, 2020). According to Mehrens and Lehmann, determining a reliability coefficient above 0.85 is a good criterion (Retnawati, 2016). In the second step, evaluate the structural model to test the hypothesis. In this study, the analysis used the bootstrap method with 5000 subsamples in Smart PLS to calculate path coefficients, t-values, and p-values. In SEM, model fit is determined by four criteria R square, SRMR, RMS Thea, and NFI (Hair et al., 2019).

## 3. RESULT AND DISCUSSION

The analysis results using Confirmatory Factor Analysis (CFA). The CFA test results show that this instrument's development can be accepted as a fit model (see Table 3).

**Table 3**. Validity and reliability test based CFA

| Variabel Laten | Manifest Variabel | ELF | dlta | note | CR | AVE | Decision |
|---|---|---|---|---|---|---|---|
| Self-disclosure | Items 1 | 0.834 | 0.305 | Valid | 0.870 | 0.721 | Reliable |
| | Items 2 | 0.877 | 0.292 | Valid | | | |
| | Items 3 | 0.890 | 0.298 | Valid | | | |
| | Items 4 | 0.793 | 0.283 | Valid | | | |
| Communicating mathematics | Items 5 | 0.715 | 0.165 | Valid | 0.848 | 0.617 | Reliable |
| | Items 6 | 0.729 | 0.155 | Valid | | | |
| | Items 7 | 0.850 | 0.321 | Valid | | | |
| | Items 8 | 0.864 | 0.328 | Valid | | | |
| | Items 9 | 0.758 | 0.280 | Valid | | | |
| Ease of online learning | Items 10 | 0.785 | 0.265 | Valid | 0.885 | 0.746 | Reliable |
| | Items 11 | 0.870 | 0.290 | Valid | | | |
| | Items 12 | 0.907 | 0.299 | Valid | | | |
| | Items 13 | 0.887 | 0.302 | Valid | | | |
| Infrastructure support | Items 14 | 0.826 | 0.261 | Valid | 0.866 | 0.651 | Reliable |
| | Items 15 | 0.708 | 0.207 | Valid | | | |
| | Items 16 | 0.842 | 0.226 | Valid | | | |
| | Items 17 | 0.795 | 0.232 | Valid | | | |
| | Items 18 | 0.857 | 0.308 | Valid | | | |

The analysis results show that all indicators contribute significantly to measuring the latent variable (see Figure 1). The standardized factor loading (SFL) value for each hand determines validity. If the EFL is higher than 0.7, the item is said to be valid (Wawan, 2020). The minor loading factor is 0.715 (item 5), while the largest is 0.907 (item 17). All of the 18 items have a loading factor higher than 0.7 (see Table 3).

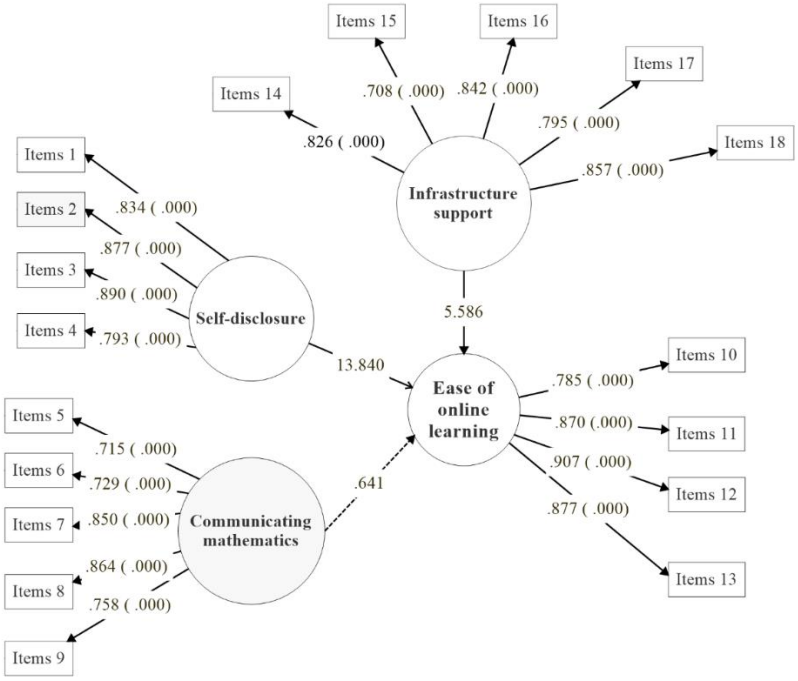


**Figure 1**. T value and outer loading factor

The results of the path analysis show that the ease of online learning is influenced by self-disclosure, communicating mathematics, and infrastructure support. The R square results show that these factors influence 47%. Each path analysis shows that self-disclosure (r = 0.556 and p= 0.000) and infrastructure support (r = 0.243 and p = 0.000) has a positive and significant relationship to the ease of online learning. Meanwhile, mathematical communication (r = -0.025 and p =0.507) has an insignificant negative connection to the ease of online learning (see Figure 2).

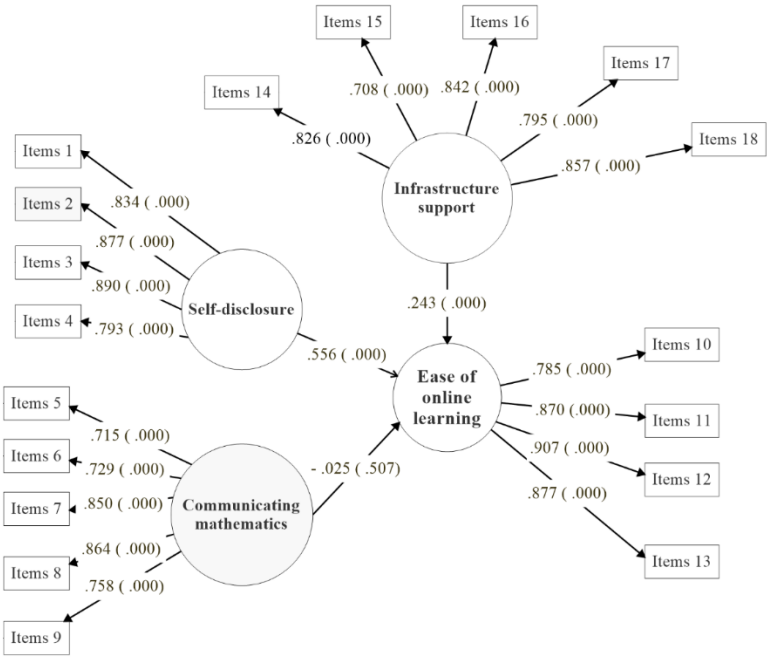


**Figure 2**. Path coeficient and P value

The SRMR value or Standardized Root Mean Square model fit criteria must be smaller than 0.08 (Hair et al., 2019). RMS Theta or Root Mean Square Theta value 0.102; and NFI value > 0.90 are the model fit requirements. Based on the model criteria, the NFI 0.865 < 0.90 does not match the fit model criteria. However, based on the SRMR or Standardized Root Mean Square Value, the value is 0.056 < 0.08 and RMS Theta or Root Mean Square Theta 0.158 > 0.102, the model is fit based on these two criteria. Based on the model criteria, the value of RMS Theta or Root Mean Square Theta 0.158 > 0.102 matches the fit model criteria.

### 3.1. The relationship between self-disclosure and ease of online learning

Accessibility, which includes the facilities that are available and their adaptability. Students are welcome to come in at any time of day or night. Interaction (Chorrojprasert, 2020) in online learning occurs in virtual classrooms, eliminating the need for teachers and students to sit together in the school to communicate. Virtual classrooms necessarily require a teacher's ability to facilitate active discussion interaction between students. The disadvantage is that there is no direct interaction, as there is in face-to-face learning. However, this allows students to enjoy themselves more because it removes the rigidity of implementing learning. Strong self-confidence (McSporran & Young, 1969; Ramírez-Correa et al., 2015) in learning mathematics leads to high achievement in online learning

(Lee et al., 2021; Ramírez-Correa et al., 2015). The comfort and confidence in speaking, debating, and sharing information are recognized as indicators of self-disclosure.

Ease of access is part of the advantages of online learning. Learning that is held in a virtual space allows every student to take part in learning from anywhere without having to come to campus (López Meneses et al., 2020; Okoye et al., 2022). The study results a show that implementing online learning can attract students from various countries to meet in one virtual space (Ma & Lee, 2019). Online learning makes it easy for students to express their ideas (Joo et al., 2011). Learning that finds students online provides confidence for students to engage in online communication. Learners can be more open when communicating online. Students not used to appearing directly in front of the class get the opportunity to express ideas through virtual space.

Self-disclosure is an act of sharing information with others. The online learning environment provides a space that allows students to connect with one another. Students can share and utilize learning resources together. For today's young generation, online communication has become a common thing to do. They are barely separated from the gadgets that connect them to online social networks. This makes students feel comfortable carrying out discussions online. Learners do not hesitate to disclose personal information in the online environment. Online social media allows one person to share personal information with others. The survey results show that 66% of adults use social networks. In addition, schools also use social networking sites to support educational goals. Self-disclosure in online social networks helps convenience when participating in online learning (Chen & Sharma, 2015). When participating in online learning, students consciously choose profile information to display to teachers and friends. The convenience of sharing information online affects students' interest in participating in online learning.

Students enjoy online learning because of its flexibility which does not require them to be present in class. The online discussion provides convenience for students to comment and provide feedback. In contrast to face-to-face learning, sometimes students withdraw to provide responses and wait for the teacher to choose them. Students who are not used to appearing directly in front of the class get the opportunity to express ideas through virtual space.

### 3.2. The relationship between Infrastructure support and ease of online learning

Infrastructure support has been identified as a factor in online learning readiness. One of the indicators is fund readiness. This is consistent with the belief that financial assistance plays a role in online learning (Muilenburg & Berge, 2005). Technical issues appear to be part of the online learning infrastructure support, including the availability of laptop equipment, cell phones, internet networks, and electricity networks (Taskin & Erzurumlu, 2021). When there is a power outage, some internet service providers have problems. Power grid outages are sometimes caused by bad weather. This confirms that the weather is a part of the infrastructure support in online learning. The need to organize online learning during the pandemic encourages all parties to become involved with technology. Of course, technological mastery is required for online learning readiness (Olayemi et al., 2021).

In contrast to face-to-face learning, laptops, and internet access, although needed, have yet to become a vital part of organizing education. Infrastructure support makes a substantial contribution to the implementation of online learning. However, explicitly learning mathematics requires the support of facilities that are no less important, for example, the application of mathematics (Loch et al., 2011) and video support that links mathematics to life (Engelbrecht et al., 2020). Learners need help that represents the mathematical language presented online. Even with the backing for explaining, a teacher

needs additional equipment to write virtually. Research shows that mathematics learning media were developed online to support online learning tools (Borba, 2012; Hariyono et al., 2021; Hwang et al., 2006).

The limitations of this research infrastructure support online learning still focuses on primary facilities, namely laptops, internet and electricity networks, and funding. Furthermore, especially in learning mathematics requires the support of other means. Learning mathematics about formulas, theorems, and proofs involves mathematical symbols and terms. Mathematical material cannot be discussed abstractly but requires visual presentation. Facilities such as digital whiteboards, digital pens, and math applications are parts that must be prepared during online learning. Further research is needed on how this infrastructure influences the ease of online learning.

### 3.3. The relationship between communicating mathematics and ease of online learning

Interaction in a virtual space using online communication. Of course, providing comfort in touch, including discussions with teachers and other students, is necessary (Hung et al., 2010). According to Ledbetter, one aspect of online communication attitude is the self-disclosure and online social connection (Ledbetter, 2009). Individuals feel fear, anxiety, nervousness, or despair when participating in online communication (Bernhold & Rice, 2020). Indicators of confirmed self-disclosure include discomfort with expressing opinions and pain after online learning.

In the previous results, it was found that online learning provides easy access and communication for students. However, on a more specific aspect of mathematical communication, the ease of online education is relatively minor. The relationship shown tends to be negative, although not significant. This indicates that the online learning system still needs to support students' mathematical communication in learning mathematics. The study results a show that teachers must put extra effort into teaching geometry material online (Diana et al., 2021). Learning mathematics requires clear thinking and direct contact with the teacher/face-to-face. Mathematical anxiety also influences students to express opinions and convey ideas systematically. Education providers need to provide support to facilitate virtual mathematical communication.

Direct learning provides space for students to express their ideas. Writing mathematical symbols and making representations in pictures can be done directly. This convenience cannot be felt now during online learning. However, research shows that learning through Google Meet can improve mathematical communication (Hutajulu, 2022).

During mathematics learning, students are involved in activities to share ideas. On online learning, students express their views by speaking directly online. In addition, opinions are usually conveyed through voice recordings and writing in the comment's column. Problems that can be faced when student express ideas through voice messages, symbols and mathematical terms become more abstract. In addition, writing and drawing shapes related to mathematical concepts is limited when students have online learning tools in the form of gadgets and laptops only. The ease of expressing mathematical ideas is yet to be part of the convenience obtained from online learning.

These results align with research findings Trenholm and Peschke (2020) which show the problems encountered during online learning, namely limitations in communicating mathematical concepts that involve notation and diagrams. In face-to-face learning, the teacher usually writes a mathematical note and mathematical symbols on a large blackboard. In addition, verbal cues, gestures, and facial expressions help cognitive mastery during learning. These resources are less felt during this online learning process, causing difficulties in developing students' conceptual understanding. Johnson recommends using online

whiteboards to communicate mathematical ideas or justify students' reasoning (Johnson & Green, 2007). Support online platforms to use virtual whiteboards that enable interactive learning. It's just that the obstacle for students is not being able to make pictures flexibly and write symbols, especially since there is no additional support for using virtual whiteboards and pens. Mathematics which has abstract characteristics and is full of characters, certainly involves the language of mathematics in providing mathematical explanations and arguments.

## 4. CONCLUSION

The results of this study highlight three aspects related to self-disclosure, infrastructure support, and communicating mathematics as determining factors for ease of online learning. Self-disclosure and infrastructure support strongly influence the ease of online learning. Meanwhile, communicating mathematics does not affect online learning. Teachers need to provide more specific means of support for math content. Virtual mathematical communication requires additional media and applications that support mathematical content. Infrastructure support in this research instrument is limited to facilities in general, while for communicating mathematics, it is not specific to mathematical communication. This is a limitation of this research. Further research is needed to see how the impact of mathematical application support on mathematical communication skills in online learning.

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