Seeing Without Thinking: The Role of Partial Metacognitive Blindness in Mathematics Problem-Solving

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The urgency of this research is to complement the theory of metacognitive failure to reveal the barriers to face-to-face mathematics learning. This research used a qualitative approach with a case study design. The subjects of this research have passed the Linear Program course, called S1 and S2. S1 who was at level 3 (strategic use) and S2 who was at level 1 (tacit use) both experience ED at the final stage of problem-solving. This ED causes partial metacognitive blindness. Metacognitive blindness only occurs when interpreting the results of the graph where the subject does not realize that the solution to the linear inequality that he does is infinite. The subject incorrectly identified the area that intersects the system of linear inequalities. Therefore, this phenomenon is referred to as partial metacognitive blindness. Partial metacognitive blindness is a special form of metacognitive blindness caused by the appearance of red flags in the verification stage. ED that occurs in S1 and S2 is caused by a lack of cognitive involvement during online learning. In this study, the use of technology, namely GeoGebra, cannot solve the problem. Therefore, further studies are needed especially regarding what prerequisites must be met by students before they use GeoGebra in learning.

Keywords: metacognitive, metacognitive blindness, partial metacognitive blindness

INTRODUCTION

During the pandemic, the teaching and learning process must be carried out online (Salem M. Alqahtani et al., 2018). This is to comply with the procedures for handling COVID-19, namely implementing social distancing. In online learning, one of the important aspects that students must have is the ability to study independently (Esterhuysen & Stanz, 2004). This online learning requires students to carry out learning activities such as, looking for information, doing assignments, and discussing independently because those activities are done from each home. But this online learning causes some problems. In the Indonesian context, for example, most students in Indonesia are not ready to study independently, including at the tertiary level (Abidah et al., 2020). Most students still depend on their lecturers when learning. This is supported by the research of Tyaningsih et al. (2020) reporting that the implementation of student-centered learning is difficult to implement considering that students' critical thinking skills in Indonesia are still very low. It can be noted that students' metacognitive abilities play an important role. Students who have good metacognitive skills have better performance in completing assignments (Lingel et al., 2019).

In this study, metacognition is thinking about how other people think, and the component of metacognition consists of metacognitive knowledge and metacognitive regulation (Radmehr & Drake, 2019). Metacognition refers to students' awareness of their cognitive processes and the regulation of these processes to achieve certain goals (Veenman & van Cleef, 2019). In other words, metacognition is students' ability to understand and monitor their learning and how to use specific learning strategies in problem-solving or decision-making (Desoete & De Craene, 2019).

Although metacognition is an important aspect of problem-solving, many students who have metacognitive activities in solving mathematical problems still fail to perform metacognition. According to (Goos, 2002), there are three metacognitive failures (mirage, vandalism and blindness). Mirage occurs when students see no difficulty, mistakenly ignore useful strategies, alter incorrect calculations, and reject correct answers. Vandalism occurs when a student overcomes a deadlock by taking a destructive action with which the student can change the problem by applying the conceptual structure incorrectly. Blindness occurs when a student fails to notice something is wrong. For example, a student survives a strategy error or ignores a calculation error. As a result of the three metacognitive failures, a student experiences an error in problem-solving. Metacognitive failure can be observed from three metacognitive activities, such as metacognitive awareness, metacognitive evaluation and metacognitive regulation (Magiera & Zawojewski, 2011; Rozak et al., 2018). Metacognitive awareness relates to self-made statements or other people's mathematical thinking and shows thoughts about several things, such as: what is known, where one is present in the problem-solving process, what needs to be done, what has been done, or what one can do. Metacognitive evaluation relates to self-made thinking or other people's mathematical thinking that shows: the effectiveness and limitations of one's thinking, the effectiveness of the chosen strategy, results from assessment, progress assessment, and people's abilities and understanding. Metacognitive regulation is concerned with self-made or other people's mathematical statements of thought that suggest problem-solving planning strategies, goal setting, and the selection of problem-solving strategies.

Some studies have examined metacognitive thinking skills. As cited in (Pratiwi, 2019) one's metacognitive ability is often seen in people who have a *slow accurate* thinking style (Jabusch, 2016; Smyers et al., 2018). In addition, (Morsanyi et al., 2019), the ability to learn metacognition is needed to train students think a problem more deeply and critically. According to psychologist Swartz & Perkins (Efklides, 2014), metacognition has several different levels and it is different for everyone. This is because experiences and information that enter the human brain are different. Therefore, each human has different levels of metacognition (Cera et al., 2014). During the current pandemic, the sudden and drastic changes of the learning process is likely to cause changes in the student's metacognition process.

In addition, students need metacognitive skills in learning to think critically, take various actions to understand a concept and reflect on themselves. However, not all students have good metacognitive skills. In the process of thinking, students often experience metacognitive failure. Maulyda et al. (2020) the implementation of student-centered learning is still very difficult to implement considering that students' critical thinking skills in Indonesia are also still very low. In this period, it can be said that students' metacognitive abilities play an important role. Students who have good metacognitive skills will have better performance in completing assignments (Dindar et al., 2020; Shilo & Kramarski, 2019; Young & Worrell, 2018). In addition, students need metacognitive skills in learning to think critically, take various actions to understand a concept, and reflect on themselves (Lestari et al., 2019). However, unfortunately, not all students have this skill. In the process, students often experience metacognitive failure.

So far, there is no metacognitive failure theory that explains failure in online learning. In addition, research on learning barriers is still limited in non-pandemic situations (Huda et al., 2016; Ortega et al., 2018; Shekhar & Rahnev, 2021) while research during the pandemic has not been widely carried out. The urgency of this research is to complement the theory of metacognitive failure to reveal the barriers to online mathematics learning.

Several studies related to metacognitive failure have been carried out to identify various forms of metacognitive failure by highlighting how verbal interactions can directly affect the thinking of each student (Goos, 2002). But so far, there has been limited research that specifically discusses metacognitive blindness in online learning. Online mathematics learning has existed since at least the early 2000s (Borba et al., 2016; Kim & Lim, 2019). Many empirical studies focus on the implementation of online learning designed to improve mathematics achievement (Hidayah et al., 2021; Zheng et al., 2019). Previous research reports that online learning can be as effective as face-to-face learning and has a positive effect on students' self-concept and attitudes toward learning mathematics(Engelbrecht et al., 2020). At the university level, research shows that online learning is helpful and plays an important role in student learning success (Hidayah et al., 2021). However, online learning during a pandemic is certainly different. Synchronous and asynchronous learning is not new in the world of education but is mostly seen as a complement to traditional face-to-face learning. The current learning, of course, is no longer a compliment, but the main learning method, and maybe even the only one during the pandemic. Therefore, a study on metacognitive blindness in online learning needs to be done to extend the theory of metacognitive failure.

MATERIAL AND METHODS

This research used a qualitative approach with a case study design. The subjects of this research have passed the Linear Program course. This consideration is important to ensure that subjects have sufficient cognitive knowledge to solve the mathematical problems investigated in this study. In the process of collecting data, the researcher used a metacognition test instrument which was converted into a Google Form format. The conversion of this instrument is one form of adaptation of the learning process that must be carried out online during the COVID-19 pandemic. The mathematical problems used in this study are as follows:

> Find the value of x and y that satisfy $2x + y \geq 4$, (2) $x + 2y \geq 4$, (3) $x \geq 0$, (4) $y \geq 0$ by (a) maximizing $f = -x + y$ and (b) minimizing $f = -x + y$.

Furthermore, by considering their communication skills, two students were selected as research subjects. They were then labeled as S1 and S2. The researcher gave metacognition test questions as lecture evaluation material. S1 solved the problem directly using the graphical method, while S2 solved the problem using GeoGebra. The results of the student's work were then classified using the level of metacognition indicators (Ray & Ray, 2012) as follows:

TABLE 1
COMPARISON OF CHARACTERISTIC VALUES OBTAINED BY PCA AND THRESHOLD VALUES OBTAINED BY THE PARALLEL ANALYSIS

Level	Indicator	Indicator Description
Level 1	Tacit Use	This type of thinking is concerned with making decisions without thinking about those decisions. In this case, the subject applies a strategy or skill without special awareness or through trial and error and just answers in solving problems
Level 2	Aware Use	This type of thinking is related to the subject's awareness of what and why the subject does that thought. In this case, the subject realizes that he/she must use a problem-solving step by explaining the reasons for choosing this step.
Level 3	Strategic Use	This type of thinking is related to the arrangement of individuals in their conscious thinking processes by using special strategies that can increase the accuracy of their thinking. In this case, the subject is aware and able to select specific strategies or skills to solve problems.

Level	Indicator	Indicator Description
Level 4	Reflective Use	This type of thinking is related to individual reflection on their thought processes before and after or even during the process by considering the continuation and improvement of the results of their thoughts. In this case, the subject is aware of and corrects the mistakes made in the problem-solving steps.

Next, an analysis was conducted based on the students' works to determine whether the subjects had the potential to experience red flags and metacognitive blindness during the problem-solving process. The analysis was based on indicators of metacognitive blindness in each phase of problem-solving including understanding problems, analyzing problems, exploring problems, planning, implementing, and verifying (Faradiba et al., 2019).

RESULTS

The results show that S1 was at level 3 (Strategic Use). In this study, S1 was consciously able to select problem-solving strategies. S1 also seems to have special skills to solve the problems shown in dialogues (3) and (4). Furthermore, S1 also had a sufficient understanding of the concept of SPLDV which was shown in dialogues (2) and (6). However, S1 did not realize that he was wrong in determining the solution area for the problem at hand. S1 did not check the graph but only checked the counts shown in the dialog (8).

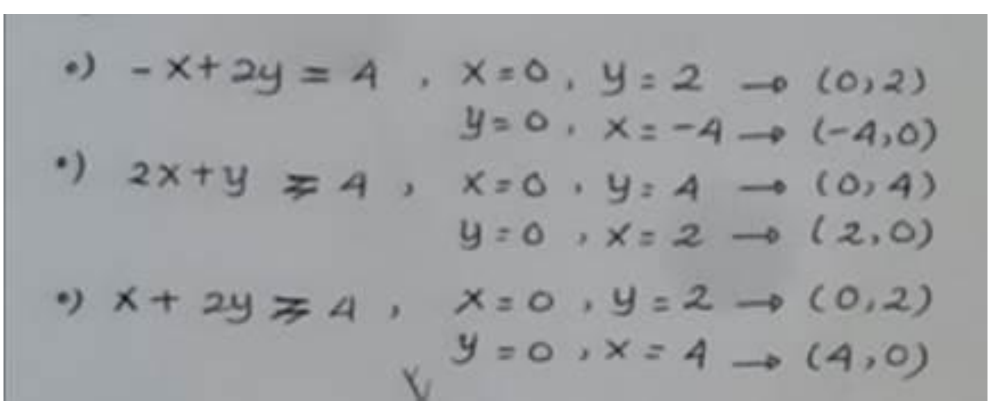
(1) R : "What do you know about the Two-variable Linear Inequality System?"

(2) S1 : "First, there are two variables, namely x and y. Second, there is an inequality symbol which is indicated by the sign less than, more than, less than equal to, more than equal to. Third, there is a linear word which means an algebraic form with the highest power of one. If the graph is drawn in the form of a straight line, there is no square 2, 3, etc. Fourth, there is the word system which means more than one inequality that is solved simultaneously.

(3) R : "What are the steps to determine the SPLDV settlement area?"

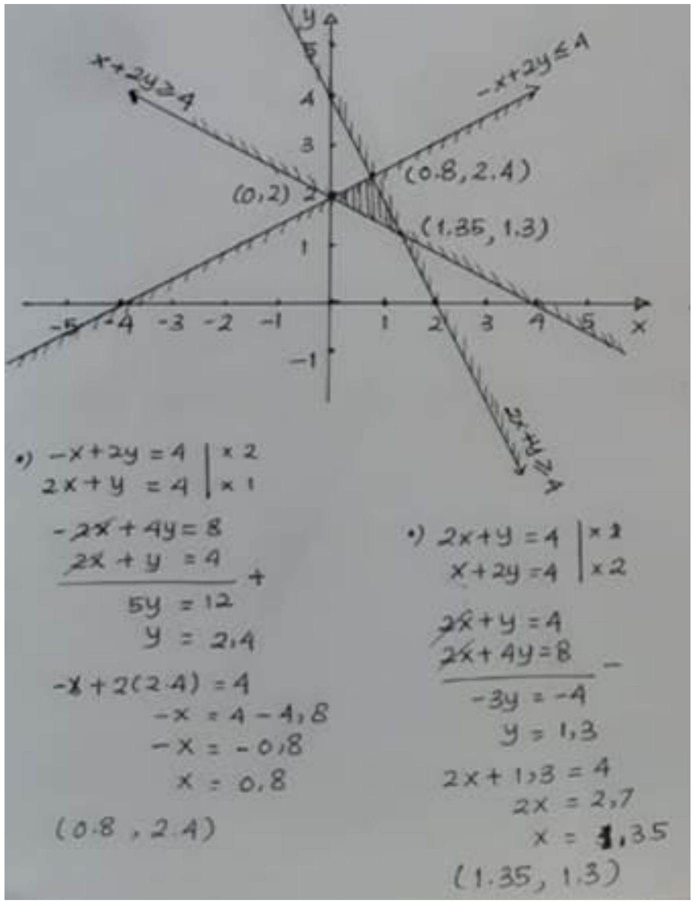
(4) S1 : "First, move the variables to the left and the constants to the right. Second, change the sign of the inequality to be equal to. Third, determine the points. If you use the x –axis, it means y=0. Otherwise, if you use the y –axis, it means x=0;

FIGURE 1
CALCULATIONS BY S1



The four cut-off points. Fifth, do a point test to get the solution area. We take a point that is inside the line (left of the line). If the result of the point test is wrong, it means that the area is outside the line (right), while the result of the point test is correct, then the area is inside the line (left)"

FIGURE 2
GRAPHS CREATED BY S1



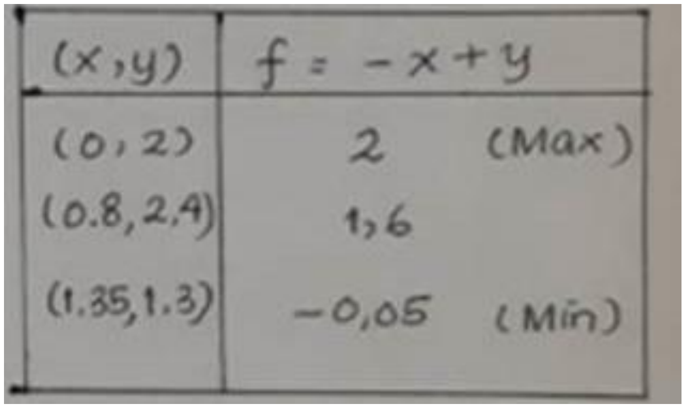
(5) R : "Then, what is the difference between the notation and > or and <?"

(6) S1 : "The difference lies in the line. For the notation that has equal to (=), for example it is greater than equal to (≥) and less than equal to (≤), the line is continuous, unbroken as in the example of regional settlement above. Meanwhile, for the notation that is more than (>) and less than (<), the line is dotted.

(7) R : "Are you sure and have you double-checked your answer?"

(8) S1 : "Yes, I've double-checked my calculations and believe in my answer. The maximum f-score is 2 and the minimum f-score is -0.05"

FIGURE 3
SOLUTION BY S1



(x,y)	f = -x + y	
(0,2)	2	(Max)
(0.8,2.4)	1,6	
(1.35,1.3)	-0,05	(Min)

Meanwhile, S2 solved the problem using GeoGebra. S2 was at level 1 (Tacit Use). S2 applied strategies or skills without special awareness or through trial and error in solving problems. S2 input each inequality sequentially starting with the first equation and saw a graph that is automatically degenerated by GeoGebra. This can be seen in the dialog (12). S2 still lacked of conceptual understanding as can be seen in dialogues (10) and (14), because the order in which the inequalities are represented in graphical form does not affect the solution area.

(9) *R : "What do you know about the Two-variable Linear Inequality System?"*

(10) *S2: "Inequality involving more than one inequality is solved together"*

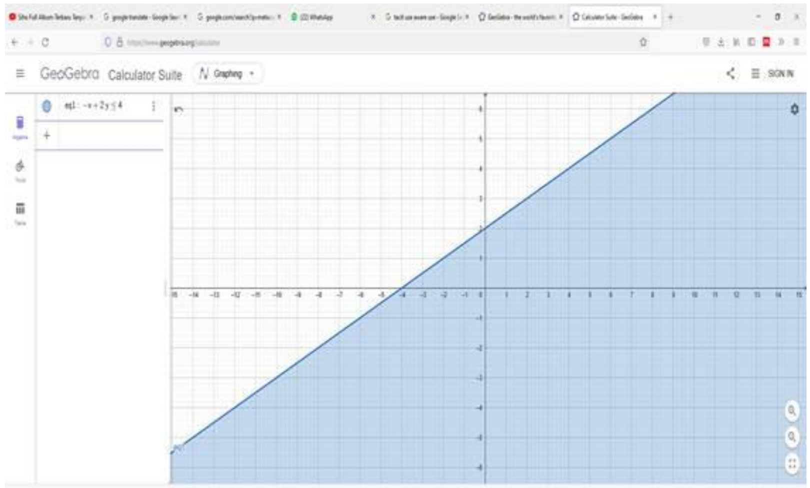
(11) *R: "What are the steps to determine the SPLDV settlement area?"*

(12) *S2: "I directly input the inequality one by one sequentially starting from the first inequality. Second, and so on then observing the intersecting area"*

(13) *R: "Does it have to be in the order in which the problem is presented?"*

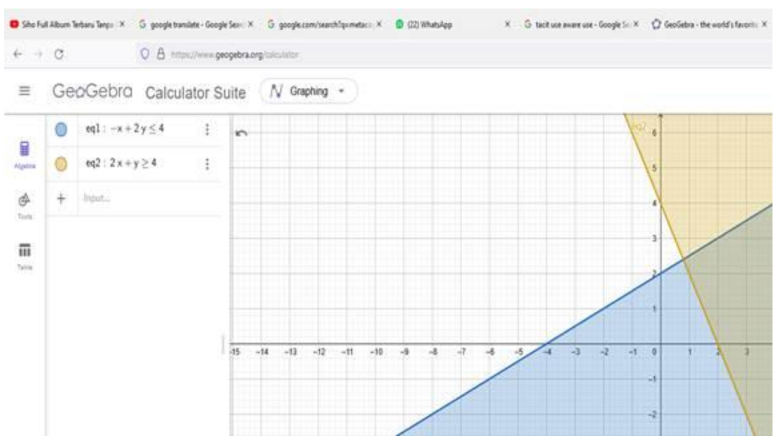
(14) *S2: "Yes, ma'am, if you don't order the results, the results will be different. First, I input the inequality of the solution area that meets the blue one.* $-x + 2y \leq 4$ (1)

FIGURE 4
FIRST STEP DRAWING GRAPHICS BY S2



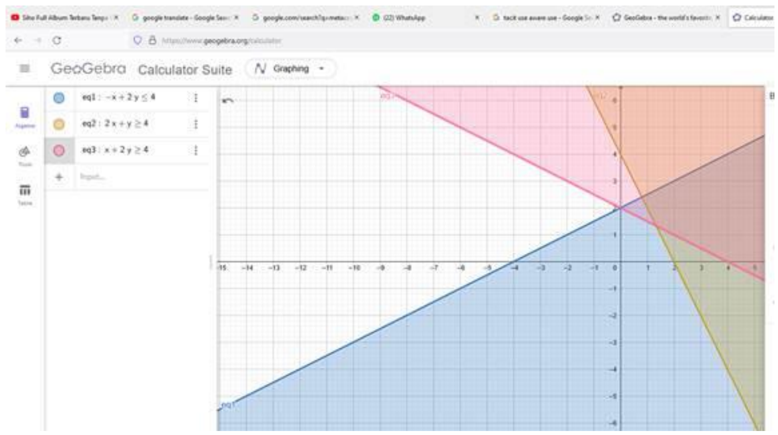
"Second, I input the solution area inequality that satisfies the yellow one $2x + y \geq 4$ (2)"

FIGURE 5
SECOND STEP DRAWING GRAPHICS BY S2



"My third input is the solution area inequality that meets the red one $x + 2y \geq 4$ (3)*"*

FIGURE 6
THE LAST STEP DRAWING GRAPHICS BY S2



> *"From this, it can be seen that the solution area is the one that is shaded by the three colors, namely forming a triangle in the middle"*

Furthermore, the Red flags that occurred in S1 and S2 at each stage of problem-solving can be seen in Table 4.

TABLE 4
RESULTS OF INTERVIEW WITH S1

	S1 (Level 3: Strategic Use)	**S2 (Level 1: Tacit Use)**
Phase 1: Understanding the problem	*none*	*none*
Phase 2: Analyzing problem	*none*	*none*
Phase 3: Exploring Problem	*none*	*none*
Phase 4: Planning	*none*	*none*
Phase 5: Implementing	*none*	*none*
Phase 6: Verification	**ED**	**ED**

DISCUSSIONS

The first type of "Red flag" namely *Lack of Progress* (LP) directs the subject to re-analyze the problem to reassess the fit between the chosen strategy and decide whether to stick with it, consider any information that is found to be useful, or abandon the existing strategy to switch to a new strategy. In this phase, the subject may need to reassess their understanding of the problem at hand and look for new information or new strategies that may be used in the problem-solving process. In this study, LP was not found by either S1 or S2. S1 did not experience LP because the subject was already at level 3, which meant he had a fairly good understanding of the concept. This is under the opinion of Fahmi et al., (2020) which states that LP is usually caused by procedural difficulties, namely difficulties in presenting steps in solving problems, as well as difficulties in formulating strategies to solve problems effectively and efficiently. Meanwhile, S2 also did not experience LP. Although S2 is still at level 1 (tacit use) but S2 had no difficulty in solving math problems because S2 used GeoGebra assistance. Learning using GeoGebra media has been widely implemented from school to university levels. This media is also developed and adapted to the cognitive development of students and offers convenience and high flexibility (Hoerunnisa et al., 2019). However, this convenience also needs to be watched out for, because after all, GeoGebra is a tool. Before using it, students need to be equipped with a strong understanding of concepts, so that they can be responsible for every stage of problem-solving that they do use GeoGebra. This is per Hidayah's opinion.

When technology is used flexibly, students and faculty must engage and collaborate well (Patricia Aguilera-Hermida, 2020). Thus, in online learning, lecturers must arrange learning strategies so that students stay involved in learning well (Hidayah, et al., 2021). Furthermore, they revealed that in online learning, student engagement is classified into three dimensions: behavioral, emotional, and cognitive engagement. Behavioral involvement refers to regularity in following class standards or solving problems in learning. Behavioral engagement is characterized by concentration and actively contributing to class discussions, as well as timely attendance at online classes. Meanwhile, emotional involvement refers to the emotional response of students in the classroom. While cognitive engagement can be interpreted as an integration between students' thinking and strategies in learning (Richardson & Newby, 2006). Cognitive engagement can be demonstrated in the form of striving to face challenges or problems and utilizing more and more in-depth self-study strategies. Cognitive engagement is a prerequisite for meaningful learning (Shukor , Tasir ,Van der Meijden, & Harun, 2014). Research also shows that cognitively engaged students can form new knowledge and achieve a deeper understanding in online learning. In addition, cognitive engagement is an indicator of student learning outcomes. In online learning, cognitive engagement can be evaluated by observing student behavior in written assignments (Shukor et al., 2014) .

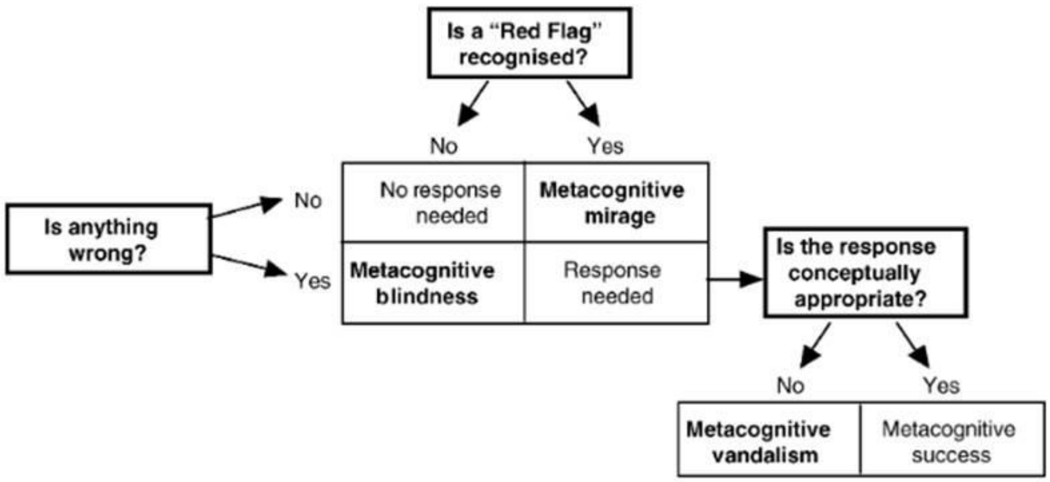
Cognitive engagement plays an important role in the problem-solving process and influences mathematics learning. This problem-solving ability is the main goal of learning mathematics and realizing this goal is the concern of the teacher by considering various factors and strategies (Lester, 2013). By mastering problem-solving skills, students can apply their mathematical abilities with a better approach; they create a deeper understanding of mathematical concepts and feel the involvement of being a mathematician through problem-solving (Son, Darhim , & Fatimah, 2020). Li et al. (2021) considers the relationship between cognitive involvement in solving a problem. Additionally, Hidayah et al. (2021) indicate that the self-regulated learning component is considered highly relevant to students' cognitive engagement because both their research is concerned with students' processes and performance in solving math problems.

The second type of Red-flag, namely ED. In this case, the subject must immediately check and correct the calculations made. If an attempt to verify a solution reveals that the answer doesn't meet the conditions of the problem, or doesn't make sense, then the third Red-flag is AR. In this study, both S1 and S2 experienced ED in the last phase of problem-solving. This is indicated by S1 and S2 errors in identifying the settlement area on the resulting graph although the previous completion steps did not find any errors.

Figure 1 shows the characteristics of each metacognitive failure based on the occurrence of red flags. Metacognitive success will occur if students recognize "red flags" and take appropriate action to overcome difficulties (or admit that nothing is wrong and continue on the same solution path). The first metacognitive failure is metacognitive blindness. Metacognitive blindness occurs if they fail to realize that something is wrong, for example, by sticking with the wrong strategy or ignoring miscalculations. The second metacognitive failure is vandalism. Vandalism occurs when the subject takes destructive action to overcome the impasse. It means that subjects change problems by imposing inappropriate conceptual structures to enable them to apply knowledge already available to them. Finally, the presence of false red flags causes the third metacognitive failure, namely mirage. Metacognitive mirage occurs when the subject "sees" a non-existent difficulty, and mistakenly abandons a useful strategy, alters an incorrect calculation, or rejects the correct answer.

Figure 7 shows a schematic of the original metacognitive failure. Metacognitive failure can be divided into three forms, namely metacognitive blindness, metacognitive mirage, and metacognitive vandalism. In this scheme, the metacognitive blindness has not been identified in detail in which phase of problem-solving. Metacognitive blindness is characterized by the presence of red flags, which can be in the form of a lack of progress (LP), error detection (ED), or anomaly result (AR).

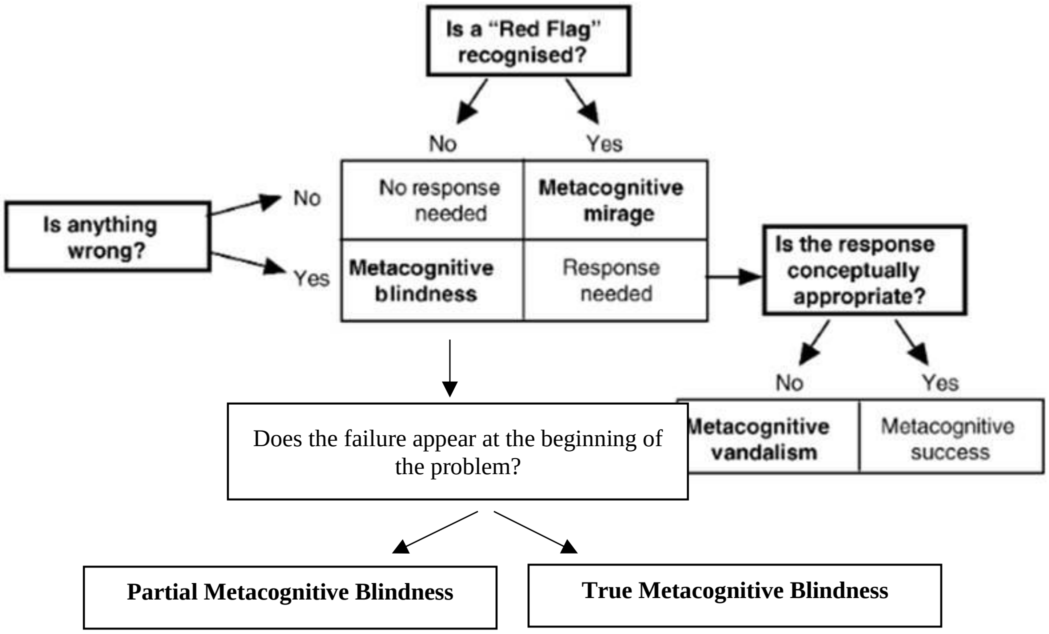
FIGURE 7
ORIGINAL SCHEMA



In this study, the subject experienced metacognitive blindness even though the problem-solving steps were correct. Metacognitive blindness only occurs when interpreting the results of the graph where the subject does not realize that the solution to the linear inequality that he does is infinite. The subject incorrectly identified the area that intersects the system of linear inequalities. Therefore, this phenomenon is referred to as partial metacognitive blindness. Goos (1997, 2002) find that partial metacognitive blindness emerged in the collaborative problem-solving process of groups. Partial metacognitive blindness occurs when a red flag situation is detected and may be present by at least one member of the group. This phenomenon is compared to total metacognitive blindness where a red flag situation occurs in all group members. Interestingly, both positive and negative problem-solving outcomes can arise from the effects of partial metacognitive blindness. This is following the results of this study, where the subject solves the problem individually. The presence of partial metacognitive blindness also resulted in a negative (wrong) problem-solving in S1 and S2. To accommodate these findings, the metacognitive failure scheme was modified to produce a new scheme in Figure 2. The presence of partial metacognitive blindness also resulted in a negative (wrong) problem-solving in S1 and S2. To accommodate these findings, the metacognitive failure scheme was modified to produce a new scheme in Figure 2. The presence of partial metacognitive blindness also resulted in a negative (wrong) problem-solving in S1 and S2. To accommodate these findings, the metacognitive failure scheme was modified to produce a new scheme in Figure 8.

Figure 8 shows that metacognitive blindness can be identified into two types. First, True Metacognitive Blindness, occurs when students have experienced metacognitive blindness since the early phase of problem-solving. The red flags that appear at the beginning of the troubleshooting phase are permanent and persist until the final phase of troubleshooting. This is not surprising, considering that the initial red flag resulted in the next red flag. Second, partial metacognitive blindness, namely metacognitive blindness occurs in some stages of problem-solving. In this research, the new red flag appears in the final stage of troubleshooting. This is experienced by S1 and S2.

FIGURE 8
MODIFIED SCHEMA



Problem-solving is very important in learning mathematics because it can improve students' ability to choose the right solution strategy and apply it appropriately to get the right solution (Callan & Cleary, 2019; Goos & Kaya, 2020). The metacognitive aspect is a very important aspect of solving mathematical problems because it plays an important role in decision-making (Wilson & Conyers, 2016). When students have high metacognitive ability, they know how to apply it and in turn, it supports the problem-solving process (Abdelrahman, 2020; Lingel et al., 2019; Morsanyi et al., 2019). Some researchers concluded that metacognitive processes can improve problem-solving outcomes and students who use metacognition in problem-solving often produce correct responses than those who do not use it (S. S. Faradiba et al., 2019; Lucangeli et al., 2019; Vorhölter, 2019).

CONCLUSIONS

S1 who was at level 3 (strategic use) and S2 who was at level 1 (tacit use) both experience ED at the final stage of problem-solving. This ED causes partial metacognitive blindness. Partial metacognitive blindness is a special form of metacognitive blindness caused by the appearance of red flags in the verification stage. ED that occurs in S1 and S2 is caused by a lack of cognitive involvement during online learning. In this study, the use of technology, namely GeoGebra, cannot solve the problem. Therefore, further studies are needed especially regarding what prerequisites must be met by students before they use GeoGebra in learning. The phenomenon found in the two subjects in this study is a red flag that appears only at the final stage of problem-solving, we call it partial metacognitive blindness. This phenomenon occurs when the subject is too dependent on the use of technology (GeoGebra) so it weakens his own thought process because he thinks that problem-solving assisted by GeoGebra must be correct. Subjects forget that GeoGebra is just a tool, and its operation still requires thought and precision. Specifically, in this study, both subjects verified the answers without deep thought, only looking at the output results of the graphs displayed by GeoGebra without re-validating whether the shaded area was indeed appropriate (seeing without thinking).

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REFERENCES

Abdelrahman, R.M. (2020). Metacognitive awareness and academic motivation and their impact on academic achievement of Ajman University students. *Heliyon*, *6*(9), e04192. https://doi.org/10.1016/j.heliyon.2020.e04192

Abidah, A., Hidaayatullaah, H.N., Simamora, R.M., Fehabutar, D., & Mutakinati, L. (2020). The Impact of Covid-19 to Indonesian Education and Its Relation to the Philosophy of "Merdeka Belajar." *Studies in Philosophy of Science and Education*, *1*(1), 38–49. https://doi.org/10.46627/sipose.v1i1.9

Borba, M.C., Askar, P., Engelbrecht, J., Gadanidis, G., Llinares, S., & Aguilar, M.S. (2016). Blended learning, e-learning and mobile learning in mathematics education. *ZDM - Mathematics Education*, *48*(5), 589–610. https://doi.org/10.1007/s11858-016-0798-4

Callan, G.L., & Cleary, T.J. (2019). Examining cyclical phase relations and predictive influences of self-regulated learning processes on mathematics task performance. *Metacognition and Learning*, *14*(1), 43–63. https://doi.org/10.1007/s11409-019-09191-x

Cera, R., Mancini, M., & Antonietti, A. (2014). Relationships between Metacognition, Self-efficacy and Self-regulation in Learning. *ECPS - Educational, Cultural and Psychological Studies*, *7*, 115–141. https://doi.org/10.7358/ecps-2013-007-cera

Desoete, A., & De Craene, B. (2019). Metacognition and mathematics education: an overview. *ZDM - Mathematics Education*, *51*(4), 565–575. https://doi.org/10.1007/s11858-019-01060-w

Dindar, M., Järvelä, S., & Järvenoja, H. (2020). Interplay of metacognitive experiences and performance in collaborative problem-solving. *Computers and Education*, *154*. https://doi.org/10.1016/j.compedu.2020.103922

Efklides, A. (2014). How does metacognition contribute to the regulation of learning? An integrative approach. *Psihologijske Teme*, *23*(1), 1–30.

Engelbrecht, J., Borba, M.C., Llinares, S., & Kaiser, G. (2020). Will 2020 be remembered as the year in which education was changed? *ZDM - Mathematics Education*, *52*(5), 821–824. https://doi.org/10.1007/s11858-020-01185-3

Esterhuysen, S., & Stanz, K.J. (2004). Locus of control and online learning. *SA Journal of Industrial Psychology*, *30*(1), 63–71. https://doi.org/10.4102/sajip.v30i1.139

Faradiba, S.S., Sa'dijah, C., Parta, I.N., & Rahardjo, S. (2019). Looking without seeing: The role of metacognitive blindness of student with high math anxiety. *International Journal of Cognitive Research in Science*, *Engineering and Education*, *7*(2), 53–65. https://doi.org/10.5937/IJCRSEE1902053F

Faradiba, S.S., Sadijah, C., Parta, I.N., & Rahardjo, S. (2019). Metacognitive therapy for mathematics disorder. *Journal of Physics: Conference Series*, *1157*(4). https://doi.org/10.1088/1742-6596/1157/4/042079

Goos, M. (2002). Understanding metacognitive failure. *Journal of Mathematical Behavior*, *21*(3), 283–302. https://doi.org/10.1016/S0732-3123(02)00130-X

Goos, M., & Kaya, S. (2020). Understanding and promoting students' mathematical thinking: A review of research published in ESM. *Educational Studies in Mathematics*, *103*(1), 7–25. https://doi.org/10.1007/s10649-019-09921-7

Hidayah, I.N., Sa'dijah, C., Subanji, & Sudirman. (2021, March). The students' cognitive engagement in online mathematics learning in the pandemic Covid-19 era. *AIP Conference Proceedings*, *2330*. https://doi.org/10.1063/5.0043567
Huda, N., Subanji, Nusantara, T., Susiswo, Sutawidjaja, A., & Rahardjo, S. (2016). University students metacognitive failures in mathematical proving investigated based on the framework of assimilation and accommodation. *Educational Research and Reviews*, *11*(12), 1119–1128. https://doi.org/10.5897/err2016.2721
Jabusch, H.C. (2016, August). Setting the stage for self-regulated learning instruction and metacognition instruction in musical practice. *Frontiers in Psychology*, *7*, 1–4. https://doi.org/10.3389/fpsyg.2016.01319
Kim, J.Y., & Lim, K.Y. (2019). Promoting learning in online, ill-structured problem-solving: The effects of scaffolding type and metacognition level. *Computers and Education*, *138*, 116–129. https://doi.org/10.1016/j.compedu.2019.05.001
Lestari, W., Pratama, L.D., & Jailani, J. (2019). Metacognitive Skills in Mathematics Problem-solving. *Jurnal Daya Matematis*, *6*(3), 286. https://doi.org/10.26858/jds.v6i3.8537
Lester, F.K. (2013). Thoughts About Research On Mathematical Problem- Solving Instruction. *The Mathematics Enthusiast*, *10*(1), 245–278.
Lingel, K., Lenhart, J., & Schneider, W. (2019). Metacognition in mathematics: do different metacognitive monitoring measures make a difference? *ZDM - Mathematics Education*, *51*(4), 587–600. https://doi.org/10.1007/s11858-019-01062-8
Lucangeli, D., Fastame, M.C., Pedron, M., Porru, A., Duca, V., Hitchcott, P.K., & Penna, M.P. (2019). Metacognition and errors: The impact of self-regulatory trainings in children with specific learning disabilities. *ZDM - Mathematics Education*, *51*(4), 577–585. https://doi.org/10.1007/s11858-019-01044-w
Magiera, M.T., & Zawojewski, J.S. (2011). Characterizations of social-based and self-based contexts associated with students'awareness, evaluation,and regulation of their thinking during small-group mathematical modeling. *Journal for Research in Mathematics Education*, *42*(5), 486–520. https://doi.org/10.5951/jresematheduc.42.5.0486
Maulyda, M.A., Annizar, A.M., Hidayati, V.R., & Mukhlis, M. (2020). Analysis of students' verbal and written mathematical communication error in solving word problem. *Journal of Physics: Conference Series*, *1538*(1). https://doi.org/10.1088/1742-6596/1538/1/012083
Morsanyi, K., Cheallaigh, N.N., & Ackerman, R. (2019). Mathematics anxiety and metacognitive processes: Proposal for a new line of inquiry. *Psihologijske Teme*, *28*(1), 147–169. https://doi.org/10.31820/pt.28.1.8
Ortega, J., Montañes, P., Barnhart, A., & Kuhn, G. (2018, April). Exploiting failures in metacognition through magic: Visual awareness as a source of visual metacognition bias. *Consciousness and Cognition*, *65*, 152–168. https://doi.org/10.1016/j.concog.2018.08.008
Pratiwi, M. (2019). Student Tutoring, Facilitator and Explaining Models: A Problem-solving Metacognition towards Learning Achievements of Informatics Students. *Journal of Educational Sciences*, *3*(2), 145–154.
Radmehr, F., & Drake, M. (2019). Students' mathematical performance, metacognitive experiences and metacognitive skills in relation to integral-area relationships. *Teaching Mathematics and Its Applications*, *38*(2), 85–106. https://doi.org/10.1093/teamat/hry006
Ray, S., & Ray, M. (2012). Incorporation of peer learning in first MBBS curriculum to enhance metacognition skills. *Al Ameen J Med Sci*, *5*(4), 339–342.
Richardson, J.C., & Newby, T. (2006). The Role of Students' Cognitive Engagement in Online Learning. *International Journal of Phytoremediation*, *21*(1), 23–37. https://doi.org/10.1207/s15389286ajde2001_3
Rozak, A., Subanji, Nusantara, T., & Sulandra, I.M. (2018). Identification Metacognitive Failure on Mathematics Problem-solving. *Proceedings of the University of Muhammadiyah Malang's 1st*

International Conference of Mathematics Education (INCOMED 2017), *160*, 108–113. https://doi.org/10.2991/incomed-17.2018.23

Salem M. Alqahtani, M., Bhaskar, C.V., Vadakalur Elumalai, K., & Abumelha, M. (2018). WhatsApp: An Online Platform for University-Level English Language Education. *Arab World English Journal*, *9*(4), 108–121. https://doi.org/10.24093/awej/vol9no4.7

Shekhar, M., & Rahnev, D. (2021). Sources of Metacognitive Inefficiency. *Trends in Cognitive Sciences*, *25*(1), 12–23. https://doi.org/10.1016/j.tics.2020.10.007

Shilo, A., & Kramarski, B. (2019). Mathematical-metacognitive discourse: How can it be developed among teachers and their students? Empirical evidence from a videotaped lesson and two case studies. *ZDM - Mathematics Education*, *51*(4), 625–640. https://doi.org/10.1007/s11858-018-01016-6

Shukor, N.A., Tasir, Z., Van der Meijden, H., & Harun, J. (2014). A Predictive Model to Evaluate Students' Cognitive Engagement in Online Learning. *Procedia - Social and Behavioral Sciences*, *116*(2006), 4844–4853. https://doi.org/10.1016/j.sbspro.2014.01.1036

Smyers, M., Friberg, J., & Vinney, L.A. (2018). Visions of the Possible: Reflections on the Faculty/Student CoInquirer Relationship. *Teaching and Learning in Communication Sciences & Disorders*, *2*(1).

Tyaningsih, R.Y., Baidowi, B., & Maulyda, M.A. (2020). Integration of Character Education in Basic Mathematics Learning in the Digital Age. *Proceedings of the 1st Annual Conference on Education and Social Sciences (ACCESS 2019)*, *465*, 156–160. https://doi.org/10.2991/assehr.k.200827.040

Veenman, M.V.J., & van Cleef, D. (2019). Measuring metacognitive skills for mathematics: Students' self-reports versus on-line assessment methods. *ZDM - Mathematics Education*, *51*(4), 691–701. https://doi.org/10.1007/s11858-018-1006-5

Vorhölter, K. (2019). Enhancing metacognitive group strategies for modelling. *ZDM - Mathematics Education*, *51*(4), 703–716. https://doi.org/10.1007/s11858-019-01055-7

Wilson, D., & Conyers, M. (2016). Teaching students to drive their brains: Metacognitive strategies, activities, and lesson ideas. In *Ascd*.

Young, A.E., & Worrell, F.C. (2018). Comparing Metacognition Assessments of Mathematics in Academically Talented Students. *Gifted Child Quarterly*, *62*(3), 259–275. https://doi.org/10.1177/0016986218755915

Zheng, L., Li, X., Zhang, X., & Sun, W. (2019). The effects of group metacognitive scaffolding on group metacognitive behaviors, group performance, and cognitive load in computer-supported collaborative learning. *Internet and Higher Education*, *42*(19), 13–24. https://doi.org/10.1016/j.iheduc.2019.03.002