The Analogical Reasoning Thinking Process Viewed from Self-Efficacy

Fitrianto Eko Subekti[1]*, Y.L. Sukestiyarno[2], Wardono Wardono[2], Isnaini Rosyida[2]

[1]Doctoral Students of Graduate School, Universitas Negeri Semarang, Indonesia
[2]Mathematics Department Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Indonesia
*Corresponding Author: efitrians@students.unnes.ac.id

Abstract. This study aims to describe the analogical reasoning thinking process in terms of self-efficacy on set material. Student self-efficacy data were obtained through questionnaires, while analogical reasoning deemed process data received from tests and in-depth interviews. The sampling method was using the purposive sampling technique. Data analysis used the stages of data reduction, data presentation, and concluding. The study results show that: Respondents with moderate self-efficacy tended not to understand the concept of a combination of sets, which resulted in an inability to solve problems related to intersection and combination questions in the three sets. Respondents with high self-efficacy tend to determine the pattern of the relationship between a slice and a combination of two sets with a piece and a variety of three sets. And 3) respondents with moderate and high self-efficacy tend to solve set problems using Venn sets' help.

Key words: analogical reasoning; self-efficacy; set material.

How to Cite: Subekti, F. E., Sukestiyarno, Y. L., Wardono, W., Rosyida, I. (2021). The Analogical Reasoning Thinking Process Viewed from Self-Efficacy. *ISET: International Conference on Science, Education and Technology,7*(1), 197-203.

INTRODUCTION

Each individual has different self-efficacy. Self-efficacy is important for every individual because it can help solve problems and tasks that have been planned (Doğru, 2017). Students' mathematical anxiety can reduce by the presence of self-efficacy (Rozgonjuk et al., 2020). Experience, verbal perception, and emotions can shape and strengthen self-efficacy (Bartley & Ingram, 2017; Sultan, 2020). Self-efficacy is related to individual perceptions or judgments to achieve goals (Rakoczy et al., 2019; Taylor & Wilson, 2019; Wang & Sun, 2020). If the individual's perceptions are positive, the decision-making process in problem-solving will be more comfortable. However, if the individual's perception is negative, it will result in the problem-solving process constrained due to doubts. A person's behavior, both positively and negatively, can be influenced by self-efficacy (Wang & Sun, 2020). Situation analysis and abilities possessed are sources to develop self-efficacy (Bakar et al., 2020).

Reasoning abilities need to cultivate to make the right decisions in life (Bunge & Leib, 2020; Mehraj A. Bhat, 2016). Reasoning plays an essential role in mathematics (Morsanyi et al., 2018). The problem-solving process will help individuals have good reasoning skills (Beatty & Thompson, 2012). Solving mathematical problems requires reasoning while developing mathematical reasoning through learning mathematics (Hasanah et al., 2019).

Increasing reasoning skills is not only by giving math assignments but the need for collaboration and communication (Olteanu & Olteanu, 2020). Motivational factors can improve the development of mathematical reasoning skills (Tee et al., 2018). Failure to apply reasoning schemes related to everyday problems sometimes weakens students' confidence in solving problems or vice versa, encourages an increase in guesswork (Datsogianni et al., 2020).

Reasoning defines using reasons to get conclusions (Fyfe & Brown, 2017; Hasanah et al., 2019; Jäder et al., 2016). The reasoning process sometimes uses an analogy. Analogy serves as scaffolding and identifies those aspects of a known item or an essential domain similar to the unknown or target element (Ramdani, M R; Husodo, B; & Subanti, 2017). Problem-solving between the source of the problem and the target problem is common, where conceptual and procedural problem solving can be used to solve the target problem (Kristayulita et al., 2018). The analogy sought similarities of two different things and concluded based on similarities (Angraini et al., 2018).

Analogical reasoning affects cognition and decision making (Vecchiato, 2020). The main characteristic of analogical reasoning is the flexibility to view and map similar relationships (Kao, 2020; Silliman & Kurtz, 2019). Analogical reasoning is the ability to distinguish meaningful

patterns in various relationships (Meguro, 2020).

Analogical thinking is recognizing the similarity of relational structures between known problems and target problems (Stevenson et al., 2014). Several steps in analogical reasoning, namely: a) finding similarities between the source problem and the target problem, b) formulating conjectures based on similarities; and c) conducting tests (Supratman et al., 2016).

The analogical thinking process in reasoning is a person's way of thinking in providing possible solutions based on their knowledge, choosing specific methods to solve problems, and giving evidence or reasons for concluding by paying attention to the source problem's similarities to the target problem. Researchers' indicators are as follows: 1) determine the relationship or pattern; 2) choosing a settlement strategy, and 3) provide evidence or reasons for concluding.

Based on these problems, how can an overview of the analogical reasoning thinking process regarding student self-efficacy on set material? The purpose of this study was to find out more about how the thinking process of students' analogical reasoning in terms of self-efficacy.

METHODS

This type of research is a qualitative descriptive study. The study conducted an overview of the analogical reasoning thought process in terms of self-efficacy on set material. The research subjects were students of the Mathematics Education Study Program Universitas Muhammadiyah Purwokerto. Research time odd semester for the academic year 2020/2021. Data collection techniques used, questionnaires, tests, interviews, and documentation. Questionnaires use to obtain self-efficacy data, while tests and interviews use to get data on analogical reasoning. Data analysis was carried out in the following stages: data reduction, data presentation, and conclusion. The data reduction stage is carried out by selecting, concentrating attention, and simplifying the data obtained. Data presentation does compile the information obtained based on the results of data reduction. The final stage of inference is to get an in-depth picture of the analogy reasoning thought process. The triangulation test technique uses to test the credibility of the data.

RESULT AND DISCUSSION

Self-Efficacy Questionnaire Analysis

The study begins with self-efficacy data collection using a questionnaire consisting of 3 dimensions: level, general, and strength (Bandura, 1997). From these three dimensions, it is developed into 30 statements to measure student self-efficacy. The results of the questionnaire data analysis can present in Table 1 below.

Table 1. Self-Efficacy Questionnaire Analysis Results

Average	Category	Respondents
$30 < \bar{x} \leq 70$	Moderate	A 01, A 02, A 05, A 09, A 11, A 14, A 17, A 29, A 32
$\bar{x} > 70$	High	A 03, A 04, A 06, A 07, A 08, A 10, A 12, A 14, A 15, A 16, A 18, A 19, A 20, A 22, A 23, A 24, A 25, A 26, A 27, A 30, A 31

Table 1 above shows that student self-efficacy results are quite encouraging because more than half of students fall into the high category. Took two students in the medium (A01 and A17) were taken to find out more intensely, and two students from the high (A14, A31). Respondents considered that the sample is easy to communicate to get more in-depth data about students' analogical reasoning abilities.

Analyze test and interview results

Respondents give three items related to set material. Items 1a, 1b, and number 2 are used as source questions, while items 1c, 1d, and 3 are the target questions. In the source question, respondents ask to recall about the slice, the combination of two sets, and problem-solving using a Venn diagram involving two sets. Whereas in the target questions related to the development of slices and varieties of two sets, as well as solving problems with a Venn diagram involving three sets.

Description of the analogical reasoning thinking process in the moderate category

Respondent A17 already understands the meaning of the slice of two sets but does not understand the combination of two sets. Apart from that, the respondents did not understand the meaning of the sum of two sets. The combination of two sets written as $A+B-(A\cap B)$. In item c, the respondent writes $(A+U)\cup(A\cap B)$. This understanding results in an inability to solve the target problem, namely questions c and d. Respondents who filled in sentences , while in item d, the respondent writes A + (B∩C) - (A∩B∩C), which should be $(A\cup C)\cap B$ and

$A \cup (B \cap C)$.

Regarding the relationship between questions a and b with c and d, the respondent only said that the Venn diagram is a set of slices, c is a combination of two slices of two sets, and d is one set and a slice of the other two sets.

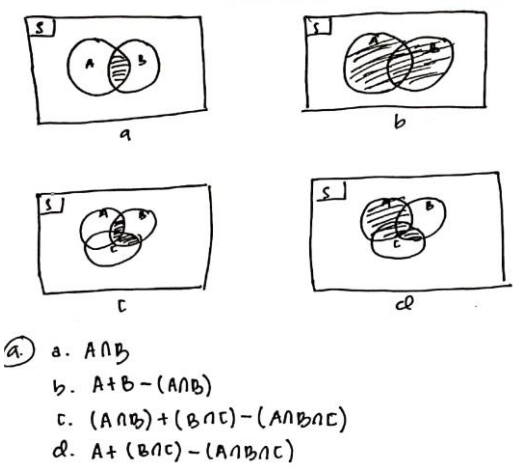

Figure 1. Test results of respondent A17 at number 1.

The interview results show that the respondent thinks that picture b in the questions shows the operation of the $A + B - (A \cap B)$ set. Respondents argued that because the shading at $(A \cap B)$ is thinner than the shading at sets A and B, $A + B$ should be reduced $(A \cap B)$. The respondent then uses this understanding to solve the problem in question c, as in Figure 1 above. Respondents wrote that the Venn diagram in figure c shows the set operation $(A \cap B) + (B \cap C) - (A \cap B \cap C)$. Understanding the Venn diagram in figure b is also used to work on the Venn diagram in figure. The occurs because respondents misunderstood definitions of $A \cup B$ and $A + B$. Respondents have made a conceptual error regarding $A \cup B$ and $A + B$. Respondents realized that the Venn diagram a and b has a relationship with the Venn diagram c and d. Respondents recognized that when they were wrong in completing picture b, it would wrong in completing the Venn diagrams c and d. Diagrams a and b are the basis for solving the Venn diagrams in figures c and d.

Likewise, respondent A01 showed that he understood the meaning of the slices of two sets but did not understand the importance of combining two sets. Respondent's answer A17 and A01 (Figure 2) tend to be similar. It this indeed interesting to dig deeper. Is this error related to a mistake in understanding the meaning of the combination of two sets or because other factors cause these two errors to be almost similar? This misunderstanding affects the process of working on questions c and d. The wrong answer to question b makes it unsuitable to do questions c and d. The interviews indicated that the respondents had misunderstood the definitions of $A \cup B$ and $A + B$. Respondents use this understanding to work on problems c and d. Thus the respondent has made a conceptual error regarding the definition of $A \cup B$ and $A + B$.

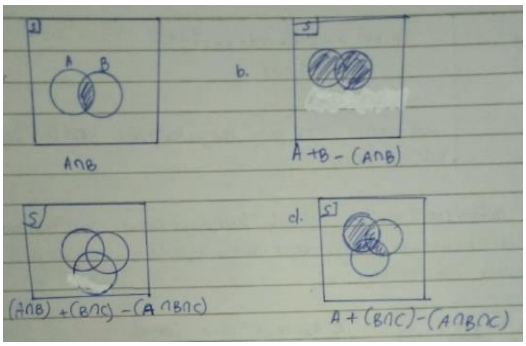

Figure 2. Test results of respondent A01 at number 1.

Description of the analogical reasoning thinking process in the high category

Figure 3 below shows that respondent A31 has understood the slice of two sets and the combined meaning of two sets. This understanding makes the respondent have no difficulty in solving questions c and d. To solve problems c and d, the respondent first understands the slice's meaning and combination of two sets. Just that in answer c, the respondent still writes in the form $(A \cap B) \cup (B \cap C)$, which can simplify into the form $(A \cup C) \cap B$. Respondents state that between a and b with c has a relationship, where the pattern used to solve problem c is to use operations on problems a and b. Whereas for question d, it has the connection of all set A and members of the set B slice C. The interview results show that the respondent uses their understanding of the combination and the slice of two sets to solve problems c and d. Because shaded on the slice of sets A with B and slices of sets B and C, the respondent writes $(A \cup B) \cap (B \cap C)$. Respondents looked confused when asked, "Can it be simplified?". Through several trigger questions, the respondent finally simplifies the form.

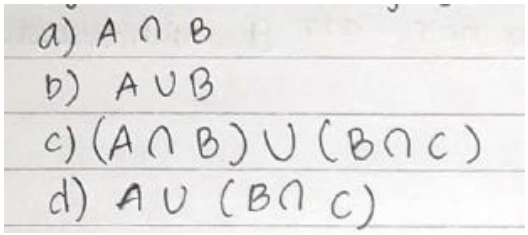

Figure 3. Test results of respondent A31 at number 1.

Like respondent A31, respondent A14 as in Figure 4 below, shows that he has understood the meaning of slices and combinations of two sets. This understanding affects the work of questions c and d. Respondents can write answers to set operations in questions c and d correctly. Respondents stated that questions a and b have a relationship where c and d the pattern of work uses the concept of slices and a combination of two sets. In contrast to respondent A31, the respondent explained that $(A \cap B) \cup (C \cap B) \cong (A \cup C) \cap B$. These results indicate that the respondents have understood the concepts related to combinations and set slices well.

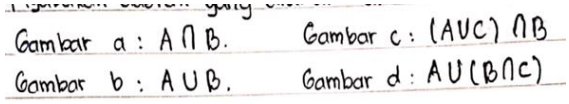

Figure 4. Test results of respondent A14 at number 1.

Figure 5 below shows that the respondent has solved the problems associated with the intersection and combination of two sets. This ability is the found basis for solving the problem of slices and varieties of 3 sets. The results of work number 2 have a pattern that is almost the same as that of question number 3. Respondents use the help of a Venn diagram to solve these two problems.Respondents write n (B) = 30 - 21 and in question number n (C) = 45 - 33. S2 respondents also showed that they had solved these two problems using the Venn diagram as done by S1 respondents. Respondents have also a relationship between question number 2 and number 3. These results are strengthened based on interviews, where respondents have no difficulty solving problems related to the Venn diagram application. Respondents felt that it was much helped by the question in question number 2 regarding the Venn set for two sets, making it easier to solve the problem in question number 3 related to the Venn diagram application for three sets.

Respondent A14 as in Figure 6 below shows that in solving problems using the Venn diagram's help with the same design as respondent A17. Respondents have no difficulty in solving problems number 2 and 3. Likewise, respondent A31 does not have trouble solving problems related to set questions.

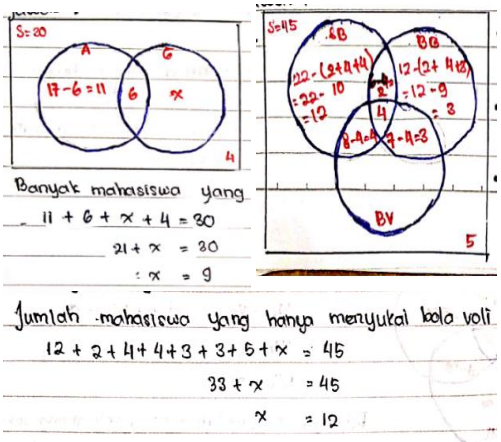

Figure 5. Respondent A14's work results in questions 2 and 3

These results are strengthened based on interviews with respondent A14, where respondents did not experience difficulties and believed that the solutions given could provide the right answers. A person's belief in the results is formed based on the experience he has (Pawlak et al., 2020). Respondents said that question number two has a relationship with question number three. Respondents noted that questions number two and three are related. The depiction in the form of a Venn diagram makes it easy to solve these two problems. The initial step is to enter A∩B scores for question number 2 and A∩B∩C for question number 3. Analogy encourages the relationship of existing knowledge to solve new problems (Devecioglu-Kaymakci, 2016). While reasoning provides conclusions to users about what to do (Baumtrog, 2017).

Based on these results, the source questions with the same concept, structure, and pattern as the target problem make it easy for the respondent to solve all problems. Understanding the source problem's ideas, designs, and patterns adds confidence and helps respondents solve the target problem. The weakness that occurs is when there

is a misunderstanding of the concept of the source problem, it will result in a misunderstanding of the idea on the target problem. Respondents in the high category have understood the concept of slices and combinations of two sets. This understanding use to complete the development of the slices and joins of two or more sets. Meanwhile, in the medium category respondents, doubts about the combination, and some of the two sets make the target Respondents appear confident and confident in the answers given. The results above indicate that the better the self-efficacy possessed by individuals, the more likely students will be able to solve the problems given with high confidence. Respondents appear confident and confident in the answers given. Students with high mathematical self-efficacy have a more positive view of mathematics (Chen et al., 2015; Koyuncu & Dönmez, 2018). Have feelings of pleasure, pride, satisfaction, and persistence with their mathematical activities (Duchatelet et al., 2021; Gao, 2020), as well as related to its achievements (Schöber et al., 2018; Trautner & Schwinger, 2020). Meanwhile, respondents in the medium category tend to hesitate in solving problems and experience several misconceptions. The analogy has a significant effect on reducing mathematical concepts' misunderstandings (Ugur et al., 2012). Students who have low self-efficacy tend to avoid assignments, give up quickly, and not complete tasks (Li et al., 2020).

CONCLUSION

Respondents with moderate self-efficacy tended not to understand the concept of a combination of sets, which resulted in an inability to solve problems related to slice and combination questions in 3 sets. And respondents with high self-efficacy tend to determine the pattern of the relationship between a slice and a combination. Respondents with moderate and high self-efficacy tend to solve set problems using the help of the Venn set. And source questions with the same concept, structure, and pattern need to solve the target problem. This research is only limited to the material set and foremost in terms of student self-efficacy. It is necessary to deepen whether there are other factors besides self-efficacy that contribute to analogical reasoning abilities.

REFERENCES

Angraini, L. M., Kusumah, Y. S., & Dahlan, J. A. (2018). The enhancement of mathematical analogical reasoning ability of university students through concept attainment model. *Journal of Physics: Conference Series*, *1013*(1). https://doi.org/10.1088/1742-6596/1013/1/012111

Bakar, N. S. A., Maat, S. M., & Rosli, R. (2020). Mathematics teacher's self-efficacy of technology integration and technological pedagogical content knowledge. *Journal on Mathematics Education*, *11*(2), 256–276. https://doi.org/10.22342/jme.11.2.10818.259-276

Bandura, A. (1997). Self-efficacy: The exercise of control. In *W.H. Freeman and Company*. https://b-ok.asia/book/2708361/d4ef2e

Bartley, S. R., & Ingram, N. (2017). Parental modelling of mathematical affect: self-efficacy and emotional arousal. *Mathematics Education Research Journal*. https://doi.org/10.1007/s13394-017-0233-3

Baumtrog, M. D. (2017). Others and imagination in reasoning and argumentation: Improving our critical creative capacity. *Informal Logic*, *37*(2), 129–151. https://doi.org/10.22329/il.v37i2.4769

Beatty, E. L., & Thompson, V. A. (2012). Effects of perspective and belief on analytic reasoning in a scientific reasoning task. *Thinking and Reasoning*, *18*(4), 441–460. https://doi.org/10.1080/13546783.2012.687892

Bunge, S. A., & Leib, E. R. (2020). How Does Education Hone Reasoning Ability? *Current Directions in Psychological Science*, 1–7. https://doi.org/10.1177/0963721419898818

Chen, M. J., Lee, C. Y., & Hsu, W. C. (2015). Influence of mathematical representation and mathematics self-efficacy on the learning effectiveness of fifth graders in pattern reasoning. *International Journal of Learning, Teaching and Educational Research*, *13*(1), 1–16. https://www.ijlter.org/index.php/ijlter/article/view/277/184

Datsogianni, A., Sodian, B., Markovits, H., & Ufer, S. (2020). Reasoning With Conditionals About Everyday and Mathematical Concepts in Primary School. *Frontiers in Psychology*, *11*, 1–16.

Devecioglu-Kaymakci, Y. (2016). Embedding analogical reasoning into 5E learning model: A study of the solar system. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(4), 881–911. https://doi.org/10.12973/eurasia.2016.1266a

Doğru, M. (2017). Development of a self-efficacy

scale of technology usage in education. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(6), 1785–1798. https://doi.org/10.12973/eurasia.2014.1204a

Duchatelet, D., Spooren, P., Bursens, P., Gijbels, D., & Donche, V. (2021). Explaining self-efficacy development in an authentic higher education learning context of role-play simulations. *Studies in Educational Evaluation*, *68*. https://doi.org/10.1016/j.stueduc.2020.100940

Fyfe, E. R., & Brown, S. A. (2017). Feedback influences children's reasoning about math equivalence: A meta-analytic review. *Thinking and Reasoning*, 1–21. https://doi.org/10.1080/13546783.2017.1359208

Gao, J. (2020). Sources of Mathematics Self-Efficacy in Chinese Students: a Mixed-Method Study with Q-Sorting Procedure. *International Journal of Science and Mathematics Education*, *18*, 713–732. https://doi.org/10.1007/s10763-019-09984-1

Hasanah, S. I., Tafrilyanto, C. F., & Aini, Y. (2019). Mathematical Reasoning: The characteristics of students' mathematical abilities in problem solving. *Journal of Physics: Conference Series*, *1188*(1). https://doi.org/10.1088/1742-6596/1188/1/012057

Jäder, J., Sidenvall, J., & Sumpter, L. (2016). Students' Mathematical Reasoning and Beliefs in Non-routine Task Solving. *International Journal of Science and Mathematics Education*. https://doi.org/10.1007/s10763-016-9712-3

Kao, C. Y. (2020). How Figurativity of Analogy Affects Creativity: The Application of Four-Term Analogies to Teaching for Creativity. *Thinking Skills and Creativity*, *36*. https://doi.org/10.1016/j.tsc.2020.100653

Koyuncu, B., & Dönmez, P. (2018). Predictive value of sense of self-efficacy and attitudes of high school students for their resistance to mathematics. *Universal Journal of Educational Research*, *6*(8), 1629–1636. https://doi.org/10.13189/ujer.2018.060801

Kristayulita, K., Nusantara, T., As'Ari, A. R., & Sa'Dijah, C. (2018). Identification of Students Errors in Solving Indirect Analogical Problems Based on Analogical Reasoning Components. *Journal of Physics: Conference Series*, *1028*(1). https://doi.org/10.1088/1742-6596/1028/1/012154

Li, L., Peng, Z., Lu, L., Liao, H., & Li, H. (2020). Peer relationships, self-efficacy, academic motivation, and mathematics achievement in Zhuang adolescents: A moderated mediation model. *Children and Youth Services Review*, *118*. https://doi.org/10.1016/j.childyouth.2020.105358

Meguro, Y. (2020). The effects of individual differences in field dependence/independence and analogical reasoning for L2 instruction. *System*, *94*, 1–13. https://doi.org/10.1016/j.system.2020.102296

Mehraj A. Bhat. (2016). The Predictive Power of Reasoning Ability on Academic Achievement. *International Journal of Learning, Teaching and Educational Research*, *15*(1), 79–88.

Morsanyi, K., Prado, J., & Richland, L. E. (2018). Editorial: The role of reasoning in mathematical thinking. *Thinking and Reasoning*. https://doi.org/10.1080/13546783.2018.1435425

Olteanu, C., & Olteanu, C. (2020). Programming , mathematical reasoning and sense-making. *International Journal of Mathematical Education in Science and Technology*, 1–19. https://doi.org/10.1080/0020739X.2020.1858199

Pawlak, M., Csizér, K., & Soto, A. (2020). Interrelationships of motivation, self-efficacy and self-regulatory strategy use: An investigation into study abroad experiences. *System*, *93*, 1–11. https://doi.org/10.1016/j.system.2020.102300

Rakoczy, K., Pinger, P., Hochweber, J., Klieme, E., Schütze, B., & Besser, M. (2019). Formative assessment in mathematics: Mediated by feedback's perceived usefulness and students' self-efficacy. *Learning and Instruction*, *60*, 154–165. https://doi.org/10.1016/j.learninstruc.2018.01.004

Ramdani, M R; Husodo, B; & Subanti, S. (2017). Student's mathematical understanding ability based on self-efficacy. *IOP Conf. Series: Journal of Physics: Conf. Series*, *909*(012065). https://doi.org/10.1088/1742-6596/909/1/012065

Rozgonjuk, D., Kraav, T., Mikkor, K., Orav-Puurand, K., & Täht, K. (2020). Mathematics anxiety among STEM and social sciences students: the roles of mathematics self-efficacy, and deep and surface approach to learning. *International Journal of STEM Education*. https://doi.org/10.1186/s40594-020-00246-z

Schöber, C., Schütte, K., Köller, O., McElvany, N., & Gebauer, M. M. (2018). Reciprocal effects between self-efficacy and achievement in mathematics and reading. *Learning and Individual Differences*, *63*, 1–11. https://doi.org/10.1016/j.lindif.2018.01.008

Silliman, D. C., & Kurtz, K. J. (2019). Evidence of analogical re-representation from a change detection task. *Cognition*, *190*, 128–136. https://doi.org/10.1016/j.cognition.2019.04.031

Stevenson, C. E., Alberto, R. A., van den Boom, M. A., & de Boeck, P. A. L. (2014). Visual relations children find easy and difficult to process in figural analogies. *Frontiers in Psychology*, *5*(AUG), 1–9. https://doi.org/10.3389/fpsyg.2014.00827

Sultan, A. A. Al. (2020). Investigating preservice elementary teachers' subject-specific self-efficacy in teaching science. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(5). https://doi.org/10.29333/ejmste/7801

Supratman, Ryane, S., & Rustina, R. (2016). Conjecturing via Analogical Reasoning in Developing Scientific Approach in Junior High School Students. *Journal of Physics: Conference Series*, *693*(1). https://doi.org/10.1088/1742-6596/693/1/012017

Taylor, J., & Wilson, J. C. (2019). Using our understanding of time to increase self-efficacy towards goal achievement. *Heliyon*, *5*, 1–8. https://doi.org/10.1016/j.heliyon.2019.e02116

Tee, K. N., Leong, K. E., & Abdul Rahim, S. S. (2018). The Mediating Effects of Critical Thinking Skills on Motivation Factors for Mathematical Reasoning Ability. *Asia-Pacific Education Researcher*. https://doi.org/10.1007/s40299-018-0396-z

Trautner, M., & Schwinger, M. (2020). Integrating the concepts self-efficacy and motivation regulation: How do self-efficacy beliefs for motivation regulation influence self-regulatory success? *Learning and Individual Differences*, *80*, 1–13. https://doi.org/10.1016/j.lindif.2020.101890

Ugur, G., Dilber, R., Senpolat, Y., & Duzgun, B. (2012). The effects of analogy on students' understanding of direct current circuits and attitudes towards physics lessons. *European Journal of Educational Research*, *1*(3), 211–223. https://doi.org/10.12973/eu-jer.1.3.211

Vecchiato, R. (2020). Analogical reasoning, cognition, and the response to technological change: Lessons from mobile communication. *Research Policy*, *49*. https://doi.org/10.1016/j.respol.2020.103958

Wang, C., & Sun, T. (2020). Relationship between self-efficacy and language proficiency: A meta-analysis. *System*, *95*, 1–11. https://doi.org/10.1016/j.system.2020.102366