Mandalika Mathematics and Education Journal
Volume 8 Nomor 1, Maret 2026
e-ISSN 2715-1190| |p-ISSN 2715-8292
DOI: http://dx.doi.org/10.29303/jm.v8i1.11038

Conflicting Narratives in Student Group Dynamics When Addressing Exponential Material Contextual Problems

Endrayana Putut Laksminto Emanuel[1], Herfa Maulina Dewi Soewardini[1], Meilantifa[1], Radhitya Duta Pradana[2], Sikky El Walida[3*]

[1] *Pendidikan Matematika, FKIP, Universitas Wijaya Kusuma Surabaya*
[2] *Pendidikan Matematika, FKIP, Universitas Bengkulu*
[3] *Pendidikan Matematika, FKIP, Universitas Islam Malang*
sikkywalida@unisma.ac.id

Abstrak
Konflik komognitif sering terjadi pada mahasiswa pada awal masa studi. Penelitian ini bertujuan untuk mendeskripsikan konflik komognitif berdasarkan narasi (substansiasi atau hafalan) yang dialami mahasiswa ketika menyelesaikan soal kontekstual pada materi eksponen. Keberadaan konflik ditunjukkan oleh adanya hasil pekerjaan yang tidak tepat. Penelitian ini merupakan penelitian kualitatif dengan teknik purposive sampling. Sebanyak 20 mahasiswa Program Studi Pendidikan Matematika berpartisipasi dalam penelitian ini. Mereka mengerjakan satu soal secara mandiri selama 30 menit, kemudian hasil pekerjaan dikelompokkan berdasarkan jawaban yang benar dan tidak benar. Jawaban yang tidak benar dibagi ke dalam dua kelompok. Setiap kelompok dipilih satu orang sebagai subjek penelitian. Jawaban subjek kemudian diklarifikasi melalui wawancara mendalam semi-terstruktur untuk memperoleh informasi mengenai penyebab terjadinya konflik. Hasil penelitian menunjukkan bahwa perbedaan pendapat terjadi karena pemahaman terhadap pengetahuan yang diperoleh di jenjang SMA belum dikuasai dengan baik, sehingga menimbulkan konflik komognitif berupa hafalan. Ketika konflik ini terjadi, mahasiswa menjadi bingung dan tidak yakin terhadap kebenaran jawaban serta pengetahuan yang dimilikinya. Namun demikian, pada akhirnya penerimaan terhadap pengetahuan baru yang disampaikan oleh para ahli menjadi salah satu solusi. Konflik ini dapat diminimalkan dengan mengulang kembali materi dari jenjang SMA, yang dapat dilakukan melalui lembar kerja atau penugasan, sehingga konflik komognitif diharapkan tidak terulang kembali.

Keywords: commognitive; commognitive conflict; narratives; memorization; contextual problem

Abstract
Commognitive conflict often occurs in students at the beginning of their. This study aims to describe commognitive conflict, based on narratives experienced by students when solving contextual problems on exponential material. This study is a qualitative study with purposive sampling. A total of 20 undergraduate students of the Mathematics Education as a participant. They worked on one problem independently for 30 minutes, then their work was grouped based on correct and incorrect results. The incorrect results were divided into two groups. Each group selected one person as a research subject. Their answers were clarified through in-depth semi-structured interviews to obtain information about the causes of the conflict. The results showed that the conflict caused by their understanding of the knowledge they gained in high school was not mastered properly. Students become confused and unsure of the accuracy of their answers and knowledge. However, ultimately, accepting the new knowledge conveyed by experts is one solution.

This conflict can be minimized by repeating the material from high school, which can be in the form of worksheets or assignments, so that commognitive conflict is expected to prevent recurrence.

Kata Kunci: komognitif; konflik komognitif; menghafal; masalah kontekstual; narasi

1. PENDAHULUAN

High school mathematics instruction differs from university mathematics instruction (De Clercq, Galand, & Frenay, 2017; Krasilnikov & Smirnova, 2017; Thoma & Nardi, 2017; van Rooij, Jansen, & van de Grift, 2018a). To solve mathematical issues at the university level, students need to be able to think critically and creatively as well as discuss and expound on the subject (De Clercq, Roland, Brunelle, Galand, & Frenay, 2018; Hassel & Ridout, 2018; Meehan & Howells, 2019). Strong communication skills are required for students to comprehend mathematical concepts. Students communicate with their groups and with themselves through thinking (Thoma & Nardi, 2017, 2018). Communication and thought are inextricably linked. The term commognitive refers to the combination of cognitive thinking and communication (Sfard, 2008, 2018, 2020).

Word use, visual mediators, narratives, and routines are all components of commognitive processes (Meilantifa & Emanuel, 2024; Putut, Emanuel, & Anam, 2022; Putut, Emanuel, Nusantara, Rahman, & Rahardi, 2023; Putut, Emanuel, Maulina, & Soewardini, 2024; Putut, Emanuel, Nusantara, & Rahardi, 2024). Words Use (WU) includes words, sentences, characters, symbols, and signs that are used in daily speech, such as the Y-axis, six, and volume. WU can also be mathematical, such as indefinite integrals, area, and exponents. mediators that are visual (VM). VM can be diagrams, tables, graphs, or pictures. Rules and theorems, like the Pythagorean theorem, can be narratives (N). When it comes to solving mathematical issues, routines (R) are recurring patterns of steps. Using a commognitive framework, these four elements can be used to study student work.

The findings of student work have been analyzed using the commognitive framework (Ioannou, 2018; Kim et al., 2019; Nardi, Ryve, Stadler, & Viirman, 2014). Several anomalies in the problem-solving process were discovered based on observations and earlier studies on student work utilizing commognitive analysis. It is believed that these discrepancies in the students' work or in the group talks they had while working through the topic are signs of cognitive conflict, which in turn causes commognitive conflict (Putut, Emanuel, Nusantara, et al., 2024; Putut et al., 2023). Conflict between what is believed and what is communicated can lead to commognitive conflict. Within a learning group, communication might take place between or within individuals (Sternberg & Zhang, 2014). When the justifications or arguments offered for resolving an issue diverge from the guidelines that ought to be adhered to, commognitive conflict arises in the narrative component (Mpofu & Pournara, 2018). Even though commognitive conflict has been studied in detail, there are concerns that it still occurs based on the viewpoint of narrative elements, especially in exponential material with contextual questions. It is possible to detect signs of commognitive conflict by asking contextual questions.

Communication and thinking are inseparable (Sfard, 2008). The combination of the two terms, communication and cognitive, gives rise to a new word, commognitive (Sfard, 2008).

Commognitive consists of four components: word use, visual mediators, narratives, and routines (Tabach & Nachlieli, 2016). Different student abilities with diverse knowledge backgrounds are suspected to be the cause of varying commognitive (Fernández-León, Gavilán-Izquierdo, González-Regaña, Martín-Molina, & Toscano, 2019). Narratives are a sequence of explanations, oral or written, contained in mathematical discourse regarding solving mathematical problems, which can be in the form of memorization, definitions, theorems, and axioms (Presmeg, 2016). Narratives are divided into two, namely substantiation and memorization (Presmeg, 2016). Substantiation is the justification or reason for an action, for example, mathematical theory, definitions, theorems, axioms, lemmas, and theorems of consequence. Memorization is already known as prior knowledge; for example, when calculating the area of a circle, students use the value of π as 3.14 or $\frac{22}{7}$, without understanding where the value comes from and simply memorizing it. Students' prior knowledge can lead to diverse narratives in their work or in the discussions they have when solving problems, especially contextual types of problems.

These diverse narratives can indicate students' commognitive abilities in solving contextual problems (Ioannou, 2016). This is evident in how they use words or sentences to solve problems, both verbally and in writing. Student narratives can also demonstrate why they use illustrations or tables in solving problems (Viirman, 2015). Reasons or arguments also indicate the rules students use in completing their work, including the steps to solve the problem. Narratives presented by students in their work have two truth values: true or false. True values are based on the actual rules for solving the problem, and false values are based on the existing rules. This conflict with the rules for solving the problem is evident in the narratives expressed. This triggers or indicates commognitive conflict in narrative analysis, known as narrative conflict commognitive. The following is Table 1, which lists the narrative components with descriptions and examples.

Table 1. Components of Narratives

Commognitive Components	Subcomponents	Descriptions	Examples
Narratives	Substantiation	Using justification and reasoning to solve problems	$Area = \int_1^3 x\,dx$ because it is reasoned that the area being calculated is in the interval [1,3] and under the graph of $f(x) = x$
	Memorisation	Using formulas or rules to solve problems based on memorization or memory	Using the definite integral formula to determine the area under the curve f(x) on the interval [a,b] without first examining the details of the area $Area = \int_a^b f(x)\,dx$

Oddities in students' work or group discussions when solving problems are suspected to be indications of cognitive conflict, leading to commognitive conflict. Commognitive conflict can occur when there is a conflict between what is thought and what is communicated. The communication can be intra- or inter-individual within a study group. Commognitive conflict in the narrative component occurs when the arguments or reasons expressed when solving problems differ from the established rules. Although commognitive conflict has been extensively researched, suspicions arise that commognitive conflict still exists from the perspective of the narrative component, especially in exponential material with contextual problems. Contextual problems allow for indications of commognitive conflict.

Narrative conflict occurs when the arguments or reasons presented by students in their group discussions differ from one another. The students' work also indicates the occurrence of conflict. Table 2 below illustrates the commognitive conflict that may occur from the perspective of narrative components.

Table 2. Narratives Conflict Commognitive

Commognitive Components	Subcomponents	Descriptions	Examples
Narratives	Substantiation (NS)	Using justifications and reasons to solve problems that differ from the actual rules.	The student stated that ln 1 = 0, arguing that ln and log are equal. This contradicts the rule that ln is the logarithm with base e, while log is the logarithm with base 10.
	Memorisation (NM)	Using formulas or rules to solve problems based on memorization or memory, but contrary to the actual rules.	The student stated that ln 100 = 2, arguing that, according to his memory, log 100 = 2, which is incorrect.

Researchers studied exponential mathematics for pupils because of this phenomenon. Additionally, researchers believed that pupils were still moving from mathematics in school to mathematics in college. This study sets out to characterize the commognitive conflict narratives that emerge in students as they work through contextual difficulties in exponential mathematics. Researchers have previously studied commognitive conflict among students in several ways, but no study has yet characterized commognitive conflict narratives in students' work in exponential mathematics. It is anticipated that this study will help instructors and students better understand the conflict-commognitive narratives that arise in student group dynamics when tackling contextual challenges with exponential content. The anticipated benefit is that prospective students in the mathematics education study program will be able to anticipate and comprehend the origins of conflict commognitive narratives that arise in the dynamics of student groups

when solving contextual problems on exponential material, improving their learning and preparing them for university study.

2. RESEARCH METHODS

This research was qualitative with purposive sampling. The instruments used were the researcher as the primary instrument, a written test sheet, and an interview sheet, all validated by an expert. The researcher designed, prepared, implemented, observed, analyzed, and drew conclusions (Kelly, 2014). The written test was used to determine how students wrote down problem-solving steps. This test was developed based on the study program syllabus and consisted of one descriptive question as follows:

> *"Adi saves Rp 1,000,000.00 in a bank with 10% compound interest per year. After several years, his money has become Rp 2,500,000.00. How long will Adi save in the bank?"*

The interview form was used to clarify the collected student answers and explore the sources of commognitive conflict narratives. The research data collected included student work, interview transcripts, photographs, audio recordings, and videos. The data were analyzed commognitive using the narratives component based on the research problem to be studied. Based on the data analysis, the researcher concluded the research problem. Conclusions were drawn from the triangulation of research findings, data analysis, and interviews.

This research was conducted in the Mathematics Education study program at Wijaya Kusuma University, Surabaya. The population in this study consisted of all active students in the program. The sample was taken from 20 students from the Class of 2022 to 2024, totaling 20. Data were collected by giving students a contextual problem related to exponential functions and asking them to solve it independently for 30 minutes. The students' work was then sorted by error status, with a focus on the number of work groups. Then, one person from each group who made errors was selected as a research subject. During the problem-solving and discussion, observations were made and recorded. This was done as a basis for selecting research subjects for further in-depth information exploration through interviews. In-depth semi-structured interviews with research subjects were conducted to describe the sources of narrative conflict commognitive. The reason for choosing a semi-structured interview model was to ensure that research subjects would not feel directly involved in the research project.

3. RESULTS AND DISCUSSION

Among the 20 students who participated in the study, two categories of incorrect responses were identified and grouped by work. One student from each group was selected as the research subject: S1 represented the first group, and S2 represented the second. Both subjects, S1 and S2, then had their answers clarified through in-depth semi-structured interviews. S1's work results are shown in Figure 1 below. Initially, S1 was able to identify the problem and understand it well. The next step S1 was to convert the problem statement into a mathematical statement. In the initial part of the solution, S1 wrote the formula to be used to solve the problem. In this part, there was an error, namely the choice

of formula to be used. S1 used the formula to solve problems about single interest. This contradicts what is known in the problem, namely about compound interest.

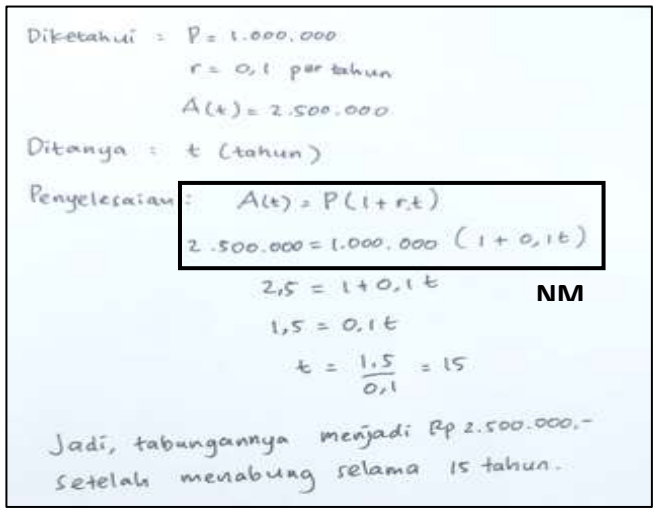

Figure 1. S1's Work Results

S1's choice of formula was based on prior knowledge acquired in high school. S1 argued that the formula could be used to solve problems about compound interest. This argument was evident in the semi-structured interview excerpt. S1 initially rejected the fact that his work was incorrect, as he believed it was correct based on his prior knowledge (NM). This indicates a commognitive conflict in the narrative review, namely memorization. However, he ultimately accepted it because the argument presented contradicted the supposed rule about compound interest, as seen in the interview excerpt.

The results of S1's work were clarified through semi-structured interviews to uncover information on the causes of commognitive conflict in the narrative component. The following is an excerpt from the interview conducted by the researcher with S1.

R : Could you please explain the steps you took to solve the problem? (pointing to S1's worksheet)
S1 : Okay, sir. First, I read and understood the problem. Then, I wrote down what was known and what was asked about the given problem.
R : And what about this part? (pointing to the solution)
S1 : Yes, sir. I recalled what I learned in high school about compound interest (NM). Then, I wrote the formula on the worksheet.
R : Is that it? Are you sure about the formula you chose to use?
S1 : Yes, sir. It's compound interest, right? I used that formula and found that the result was 15 years.
R : Is that formula for compound interest? I don't know how it works.
S1 : Oh, yes, sir. As far as I remember, that's it. If compound interest is like that, um... I'm a bit unsure about the formula.

R : The formula you used should be...$A(t) = P(1 + r)^t$.
S1 : Oops, that means I was wrong. It's different from the formula I used. Okay then, sir.

Meanwhile, the results of the S2 work can be seen in Figure 2 below.

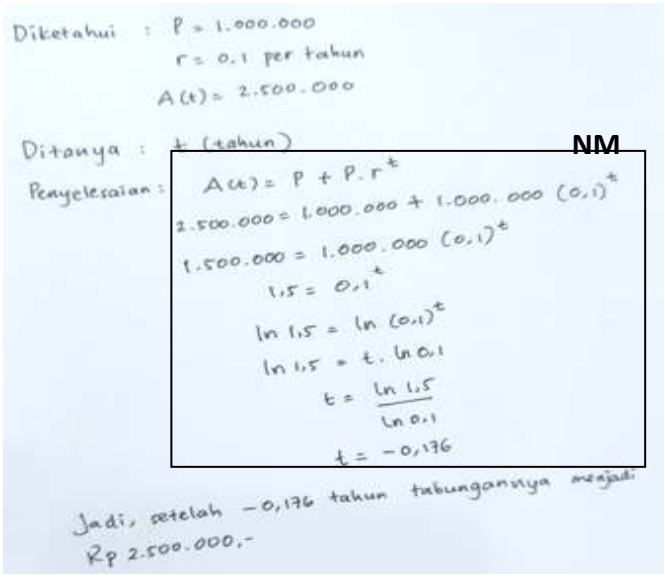

Figure 2. S2's Work Results

Clarification of answers to S2 was carried out to dig up in-depth information on the causes of commognitive conflict in the narrative's component, as seen in the following interview excerpt.

Commognitive conflict is often found in students, especially first-year students. This opinion aligns with Gunnell et al. (2017); Kahu, Nelson, & Picton (2017); and Lee, Ang, & Dipolog-Ubanan (2019), who state that first-year students still need to adapt to the university environment, which differs from high school. In addition, they still have to adapt to university mathematics, which differs from high school mathematics. This opinion aligns with Geng & Midford (2015) and Trautwein & Bosse (2017), who state that university mathematics differs from high school mathematics. Commognitive conflict can occur when students understand the problem, namely when they interpret the problem and turn it into a mathematical statement. This is supported by the opinion of van Rooij, Jansen, & van de Grift (2018b) that misinterpretation of the problem can trigger commognitive conflict. Another opinion by Putut, Emanuel, Nusantara, et al. (2024) also states that a lack of conceptual understanding can cause commognitive conflict in their thinking.

Commognitive conflict can also occur when students solve problems related to the steps involved in solving the problem. A lack of understanding of the mathematical formulas related to the material in the problem can lead to conflict. The narratives or arguments presented regarding the choice of formulas or steps for solving the problem contradict the established rules. This triggers commognitive conflict in the narrative's component, which can be substantiation (NS) or memorization (NM). Substantiation is using justifications

and reasons in solving problems that differ from the actual rules. Meanwhile, memorization is using formulas or rules to solve problems based on memory, rather than following established rules. The opinion of Emanuel & Meilantifa (2022) emphasizes that this memorization originates from the knowledge they gained in high school and is applied in university.

Based on prior knowledge and memory, this triggers conflict (NM). Generally, students remember formulas from their previous knowledge but incorrectly, resulting in errors in solving problems and indicating a commognitive conflict in the narrative component. This commognitive conflict can be anticipated by identifying the source of the conflict. Students' lack of understanding of the previous material is the source of commognitive conflict in the narrative component (NM).

4. CONCLUSION

School mathematics differs from university mathematics. Students must thoroughly understand the knowledge they have acquired in high school. A lack of understanding of the material they learned in high school can trigger commognitive conflict. When faced with a math problem to solve, students should thoroughly understand the use of words, the use of illustrations in the form of graphs or images, the selection of steps to solve the problem, and the arguments or narratives presented. Differences of opinion or arguments trigger commognitive conflict in the narrative component. Conflicts that arise from differing arguments based on prior knowledge and the rules that should apply are commognitive memorization conflicts. When this conflict occurs, students become confused, hesitant, and unsure of the accuracy of their answers and knowledge. However, ultimately, accepting the new knowledge conveyed by experts is one solution. This conflict can be minimized by repeating the material from high school, which can be in the form of worksheets or assignments, so that commognitive conflict is expected to prevent recurrence. This step can be a great opportunity for further research on commognitive conflict.

6. RECOMMENDATION

Based on the findings of this study, future research is recommended to further investigate effective instructional strategies for minimizing commognitive conflict, particularly memorization conflict, by reinforcing high school mathematics content. Such studies may focus on the development and testing of instructional interventions, such as the use of worksheets, diagnostic tasks, or transitional learning approaches from school to university, as well as analyzing their effects on conceptual understanding, the quality of mathematical argumentation, and the reduction of commognitive conflict among university students.

7. REFFERENCES

De Clercq, M., Galand, B., & Frenay, M. (2017). Transition from high school to university: a person-centered approach to academic achievement. *European Journal of Psychology of Education*, *32*(1), 39–59. https://doi.org/10.1007/s10212-016-0298-5

De Clercq, M., Roland, N., Brunelle, M., Galand, B., & Frenay, M. (2018). The delicate balance to adjustment: A qualitative approach of student's transition to the first year at university. *Psychologica Belgica*, *58*(1), 67–90. https://doi.org/10.5334/pb.409

Fernández-León, A., Gavilán-Izquierdo, J. M., González-Regaña, A. J., Martín-Molina, V., & Toscano, R. (2019). Identifying routines in the discourse of undergraduate students when defining. *Mathematics Education Research Journal*. https://doi.org/10.1007/s13394-019-00301-1

Geng, G., & Midford, R. (2015). Investigating first-year education students' stress level. *Australian Journal of Teacher Education*. https://doi.org/10.14221/ajte.2015v40n6.1

Gunnell, K. E., Mosewich, A. D., McEwen, C. E., Eklund, R. C., & Crocker, P. R. E. (2017). Don't be so hard on yourself! Changes in self-compassion during the first year of university are associated with changes in well-being. *Personality and Individual Differences*. https://doi.org/10.1016/j.paid.2016.11.032

Hassel, S., & Ridout, N. (2018). An investigation of first-year students' and lecturers' expectations of university education. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2017.02218

Ioannou, M. (2018). Commognitive analysis of undergraduate mathematics students' first encounter with the subgroup test. *Mathematics Education Research Journal*. https://doi.org/10.1007/s13394-017-0222-6

Kahu, E., Nelson, K., & Picton, C. (2017). Student interest as a key driver of engagement for first year students. *Student Success*. https://doi.org/10.5204/ssj.v8i2.379

Kelly, A. E. (2014). Handbook of Design Research Methods in Education. In *Handbook of Design Research Methods in Education*. https://doi.org/10.4324/9781315759593

Kim, D.-J., Choi, S., Lim, W., Thoma, A., Nardi, E., Viirman, O., … Sfard, A. (2019). Discourses of Functions – University Mathematics Teaching Through a Commognitive Lens. *Educational Studies in Mathematics*, *8*(2), 423–430. https://doi.org/10.1007/s10649-015-9676-1

Krasilnikov, A., & Smirnova, A. (2017). Online social adaptation of first-year students and their academic performance. *Computers and Education*. https://doi.org/10.1016/j.compedu.2017.05.012

Lee, K.-F., Ang, C.-S., & Dipolog-Ubanan, G. (2019). "My First Year in The University": Students' Expectations, Perceptions and Experiences. *Journal of Social Science Research*, *14*, 3134–3145. https://doi.org/10.24297/jssr.v14i0.8006

Meehan, C., & Howells, K. (2019). In search of the feeling of 'belonging' in higher education: undergraduate students transition into higher education. *Journal of Further and Higher Education*, *43*(10), 1376–1390. https://doi.org/10.1080/0309877X.2018.1490702

Meilantifa, M., & Emanuel, E. P. L. (2024). Commognitive Mahasiswa Dalam Menyelesaikan Soal Kontekstual Pemodelan Matematika. *Briliant: Jurnal Riset Dan Konseptual*, *9*(2), 299–305. https://doi.org/10.28926/briliant.v9i2.1683

Mpofu, S., & Pournara, C. (2018). Learner Participation in the Functions Discourse: A Focus on Asymptotes of the Hyperbola. *African Journal of Research in Mathematics, Science and Technology Education*, *22*(1), 2–13. https://doi.org/10.1080/18117295.2017.1409170

Nardi, E., Ryve, A., Stadler, E., & Viirman, O. (2014). Commognitive analyses of the learning and teaching of mathematics at university level: The case of discursive shifts

in the study of Calculus. *Research in Mathematics Education*. https://doi.org/10.1080/14794802.2014.918338

Presmeg, N. (2016). Commognition as a lens for research. *Educational Studies in Mathematics*. https://doi.org/10.1007/s10649-015-9676-1

Putut, E., Emanuel, L., & Anam, F. (2022). Sebuah Tinjauan Commognitive : Apakah Matriks Singular ? *BRILIANT Jurnal Riset Dan Konseptual*, *7*(54), 922–930. https://doi.org/http://dx.doi.org/10.28926/briliant.v7i4.1073

Putut, E., Emanuel, L., Nusantara, T., & Rahardi, R. (2024). Does Domain of Absolute Value Function Always Positive ? Commognitive-Conflict Analysis of Students of First Semester. *Qalamuna: Jurnal Pendidikan, Agama, Dan Sosial*, *16*(2), 795–806. https://doi.org/10.37680/qalamuna.v16i2.5169

Putut, E., Emanuel, L., Nusantara, T., Rahman, A., & Rahardi, R. (2023). Why am I confused ? Commognitive Conflict in Non-ordinary Question About Number Division. *Journal for ReAttach Therapy and Developmental Diversities*, *6*(5s), 891–901. Retrieved from https://jrtdd.com/index.php/journal/article/view/644

Sfard, A. (2008). Thinking as Communicating. In *Thinking as Communicating*. https://doi.org/10.1017/cbo9780511499944

Sfard, A. (2018). Commognition. In *Encyclopedia of Mathematics Education*. https://doi.org/10.1007/978-3-319-77487-9_100031-1

Sfard, A. (2020). Commognition. In *Encyclopedia of Mathematics Education*. https://doi.org/10.1007/978-3-030-15789-0_100031

Sternberg, R. J., & Zhang, L. F. (2014). Perspectives on thinking, learning, and cognitive styles. In *Perspectives on Thinking, Learning, and Cognitive Styles*. https://doi.org/10.4324/9781410605986

Tabach, M., & Nachlieli, T. (2016). Communicational perspectives on learning and teaching mathematics: prologue. *Educational Studies in Mathematics*. https://doi.org/10.1007/s10649-015-9638-7

Thoma, A., & Nardi, E. (2018). Transition from School to University Mathematics: Manifestations of Unresolved Commognitive Conflict in First Year Students' Examination Scripts. *International Journal of Research in Undergraduate Mathematics Education*. https://doi.org/10.1007/s40753-017-0064-3

Trautwein, C., & Bosse, E. (2017). The first year in higher education—critical requirements from the student perspective. *Higher Education*. https://doi.org/10.1007/s10734-016-0098-5

van Rooij, E. C. M., Jansen, E. P. W. A., & van de Grift, W. J. C. M. (2018a). First-year university students' academic success: the importance of academic adjustment. *European Journal of Psychology of Education*. https://doi.org/10.1007/s10212-017-0347-8

van Rooij, E. C. M., Jansen, E. P. W. A., & van de Grift, W. J. C. M. (2018b). First-year university students' academic success: the importance of academic adjustment. *European Journal of Psychology of Education*, *33*(4), 749–767. https://doi.org/10.1007/s10212-017-0347-8

Viirman, O. (2015). Explanation, motivation and question posing routines in university mathematics teachers' pedagogical discourse: a commognitive analysis. *International Journal of Mathematical Education in Science and Technology*. https://doi.org/10.1080/0020739X.2015.1034206