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Example–conclusion map in teaching simple interest: A lesson study

Fleur De Cory Apasen Ngiwas[1,5], Daisy Lyn F. Mariano[2,5], Jayson G. Barsana[3,5], Michelle P. Cruz[4,5], Levi Elipane[5]

[1]Mathematics Department, College of Numeracy and Applied Sciences, Benguet State University, Benguet, Philippines
[2]Mathematics Department, Senior High School, Parada National High School, Valenzuela City, Philippines
[3]Mathematics Department, Senior High School, Tagbacan National High School, Catanauan, Philippines
[4]Mathematics Department, Senior High School, San Jose Del Monte National High School, San Jose del Monte City, Philippines
[5]Mathematics and Science Cluster, College of Graduate Studies and Teacher Education Research Faculty, Philippine Normal University, Manila, Philippines

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ABSTRACT

This study investigated the utilization of example-conclusion map (ECM), a tool in teaching simple interest to senior high school in a university in the Philippines. With the purpose of presenting the topic in a more relevant way to learners under the Accountancy and Business Management strand, the researchers engaged in a lesson study. The following issues emerged: i) Contextualizing ECM links the topic to real life problems; and ii) Strategizing with ECM provides opportunities to engage in deep and meaningful thinking given an otherwise technical/mechanical topic. Students were able to deduce conclusions and create their own examples. The learners were given the opportunities to discover the formula and establish how simple interest is computed through the collaboration. Through the facilitation of the teacher using ECM as a pedagogy, substantive conversations and clear understanding of the topic were evident. Contextualized examples in teaching simple interest still needed to be improved. It is concluded that teaching simple interest through ECM is effective. It also facilitates a transformative topic that will not just underpin concepts on computations and algorithms, but utilize critical thinking skills to analyze profound issues the community deals with like issues on social justice, loaning, and investing.

Corresponding Author:

Fleur De Cory Apasen Ngiwas
Mathematics Department, College of Numeracy and Applied Sciences, Benguet State University
Benguet, Philippines
Email: mademoisellefleurdecoryngiwas@gmail.com

1. INTRODUCTION

Mathematics is an interesting and valuable subject, however challenging in its nature [1]. This positive students' point of view about the subject is every mathematics educator's goal to achieve in every content and skill introduced. Other factors lead to the success or failure of this aim. One of which is the pedagogy employed [2]. Mathematics teachers are challenged to look for tools or strategies that will improve the quality of mathematics learning among students. That is the reason why the evaluation of past and new practices is needed. This enables improved student performance and eliminates the stigma that mathematics is only for the exceptional ones.

Mathematics teachers' change in pedagogy is said to positively influence students' interest in the subject and its [2]. As a result, reformation of classroom practices using any possible productive pedagogy is

essential. Productive pedagogy is said to address issues on: i) The role of problem solving in achieving intellectual quality classrooms; ii) Making mathematics classroom activities relevant to the world around the students; iii) Developing an atmosphere of friendship and support; and iv) Recognizing students' differences in mathematics classrooms [3].

The Philippine curriculum shifted the focus of the mathematics framework to problem solving and critical thinking [4]. The development of these twin goals would mean strengthening the conceptualization and application of the content delivered. Designing the lesson with the incorporation of the right pedagogy is teacher's accountability. From the student's end, application of concepts, whether solving various problems in school or their social life is anticipated [4]–[6]. These goals are set to be realized through organized and rigorous curriculum content, a well-defined set of high-level skills and processes, desirable values and attitudes, and appropriate tools, taking into account the different contexts of the Filipino learners [4].

Several years ago, problem solving maps (PSM) was developed and introduced. This method used visual elements to the traditional way of teaching math equations. Trainings were also conducted to K-12 teachers in different countries and they reported positive results when the approach was applied in their own classrooms [5]. PSM are graphical representations of the mathematical thinking skills and are crucial in developing critical thinking and problem-solving skills among students. PSM is a simple but flexible tool that can be utilized in any topic that targets three major skills: inductive thinking, deductive thinking, and analysis. This is designed for the learners not to focus on the product but the process, too. One of these maps is the example–conclusion map (ECM) which was designed for the students to find patterns from examples provided and verify their conclusions using their own examples. This teaching-learning tool is utilized for the students to learn basic rules on their own. Few researches have studied the effectiveness of PSM and ECM as thinking map in teaching mathematics content, thus, the rise of the study.

Since the present framework of the Philippine Mathematics curriculum emphasizes on critical thinking and problem solving; exposing students to such maps may help improve their understanding of various mathematical concepts. It is believed that the thinking processes depicted on these maps are precisely the same set of skills that they need to become successful problem solvers. Hence, utilizing these maps, specifically the ECM, may bring a positive impact on students' mathematics learning [6]. Benefits of PSM is for students to learn mathematics in its application to real-world challenges that they are facing every day.

Previous researchers stated that there is a link between thinking maps on discovery learning with the problem solving skills of the students [7]. Problem solving as a very important skills set needed to be cultivated among the 21st century learners were emphasized by organization for economic cooperation and development (OEDC), new skills agenda for Europe and European skills, competencies, and occupations (ESCO) [8]. In most countries, like in the United States, the goal of teaching is for all age groups to have understanding of mathematical structures and they will develop mathematical thinking that will serve as their foundation when solving problems which are real-life challenges. It is not enough then that the educators practice mechanical skills but mathematical thinking [8], [9].

Agreeing with mathematics being practical and not just theoretical is critical mathematics [9]. Views of critical mathematics education include social justice, mathemacy, dialogue, pedagogical imagination, and uncertainty. With social justice as its primary aim, social issues on inclusion and exclusion are addressed and incorporated in the discussion of critical mathematics. The mathematical agency is also encouraged that is, developing the capacity to act due to ones' understanding and reflection. Anyone can develop a mathematics education which makes it possible for the students to interpret the world filled with numbers, diagrams, figures, and values it that it becomes possible to make a change [10].

On this premise, improving the teaching of mathematics through lesson study can be a vital aspect of creating better outcomes among students [11]. Lesson study is a collaborative practice among the teachers of a school that aims to enhance teaching and learning through the methodology of professional sharing of practice [12]. This idea is rooted in Japan where they characterize the conduct of lesson study as a process in which teachers jointly plan, observe, analyze, and refine actual classroom lessons [13]. It is believed to refine teaching practices that contribute to their growth as professional teachers by reflecting on the effectiveness of the pedagogy implemented in the classroom [14]. In the improvement of the instruction, quality students will be produced [11]. This study investigated the utilization of ECM as a tool in teaching simple interest using lesson study.

2. RESEARCH METHOD

In this study, the researchers used a qualitative approach towards investigating how ECM can maximize students' engagement in learning simple interest through lesson study. The qualitative approach is deemed appropriate for this research. The reason is this study seeks to explore and understand emerging data collected in the participant setting [15], specifically the basic qualitative research.

2.1. Lesson study cycle

In agreement to the message of critical mathematics, where lessons may be built from actual practice and not to be constrained by general theories, a lesson study was conducted [16]. The researchers were guided by the following steps: goal-setting, writing the lesson plan, delivering the lesson plan, and lesson debriefing [17].

For the goal-setting, the proponents considered simple interest as the topic. Simple interest is an application of integral exponent which was the topic said to be leased mastered by junior high school students in a mathematics achievement test (MAT) [18]. Because of that, discovery teaching was decided as the approach to use which would facilitate inductive reasoning among the learners as they discover the formula of simple interest and create their own example using ECM.

The objective was that at the end of the period, 100% of the students with at least 80% proficiency should be able to: i) discover the formula for interest using ECM; ii) compute simple interest, maturity value, and present value in simple interest environment; and iii) solve problems involving simple interest.

In the presentation phase, terms like lender (the creditor), the borrower (the debtor), time (t), principal (P), rate (r), interest (I), simple interest (Is), and maturity value or future value (F) were discussed by giving real life problems related to the topic. The teacher then used the ECM worksheet for the learners to discover as a group the formula for simple interest and construct their own examples to be shared with the class. The concept acquisition was strengthened through the presentation of solved examples on solving simple interest formula. Quiz bee was utilized for both the application and evaluation phases and in the reflection phase; students watched a video clip as they reflect on how the lesson applies to them.

After the demonstration, a post-lesson debriefing or discussion led by the professor, who acted as moderator, was conducted. Firstly, the moderator asked the demonstration teacher about the experience and her own impression regarding the lesson and demonstration it. This was followed by the reflections of the other members of the group about the preparation, the group's collaboration, and the demonstration proper. Lastly, the other observers gave comments on the demonstration teacher, students' participation, and suggested how to improve the lesson.

2.2. Participants and locale of the study

The lesson study was conducted among 36 accountancy and business management (ABM) students of a university in the Philippines. The group involved in conducting this lesson study is composed of five members with one of them as the demonstration teacher. In the critiquing of the conducted research lesson, eight Ph.D. students in mathematics education and their professor took part in sharing their insights, observations, and suggestions on the demonstration.

The study was pursued upon the approval of the school administration that the students-participants be subjected to a lesson study. The participants voluntarily participated and were not forced nor coerced. The anonymity of the participants was preserved as agreed.

2.3. Analysis of the data

Data sources were from observations, recorded post-lesson debriefing, transcripts, student's outputs, ECM worksheets, and field notes/observations. The student-participants were observed during the lesson study process: i) How they participate with the teacher and with their classmates were noted; ii) How they process the lesson as evident in their ECM worksheets, individual and group involvement was carefully noted. The post-lesson debriefing from the teacher-observer was recorded and transcribed. The transcripts were themed and were compared with the students' written and observed responses. The analysis was based on the common theme and patterns in the data were generated.

3. RESULTS AND DISCUSSION

The post-lesson discussion was conducted where the demonstration teacher and observers shared their insights, feedback, and observations. The following issues were raised: i) Contextualizing ECM links the topic to real life problems; and ii) Strategizing with ECM provides opportunities to engage in deep and meaningful thinking given an otherwise technical/mechanical topic.

3.1 Contextualizing ECM links the topic to real life problems

In the ECM, students gave their own examples. This strengthened the connection of the topic to a real-life problem. Therefore, the contextualization of the examples used was requisite. Indeed, contextualizing a mathematical topic must use examples related to student's experiences and using local information that would make the class livelier and engaging [19]. The country's educational system aimed for the mathematics education to go beyond school and classroom with comprehension and depth [4].

In the ECM worksheets, depositing money in the bank was used as an example. However, the suitability of the examples used and the focus of the lesson were questioned by the observers. The teacher asked the students, "What is the purpose of a bank?" This is where some observers opposed the examples used by the teacher. Since the focus of the lesson was on simple interest, it was more relevant to relate it to micro-financing like loaning to friends, or cooperatives since what banks use are compound interest or bank method. Careful planning was needed when aiming to connect the topic being discussed to the student's level of understanding [19].

Group 1: Barbie invested P 60,000 in LPU Bank with a rate of 6% annual interest. It yields an interest of P360 after a year.
Group 2: A businessman wanted to start his own business and decided to loan from CBA bank with the principal amount of P 500,000. The bank gives 10% interest after three years. After three years, the businessman paid an interest of P 150,000.
Group 3: CBA bank lent an amount of P 50,000 to Riza with an annual rate of 10%. After three years, Riza paid P 65.000 to the bank.
Group 4: Maria borrowed P 20,000 from EJ Bank at a rate of 5% annual interest. In the span of six years, he paid P 6,000 as interest.
Group 5: An amount of P 10,000 was invested in BDO at the rate of 3% annual interest. After one year, it yields an interest of 300.
Group 6: Julie borrowed P 14,000 from HIJ Bank at a rate of 6% annual interest. At the end of the year, she paid an interest of P 840.
Group 7: Bea loaned P 70,000 from LPU Bank at a rate of 4% annual interest. After two years, she paid P 5,600.
Group 8: Josh borrowed P 15,000 from East West Bank at a rate of 5% annual interest. After five years, he paid the interest of P 3,750.

Evidently, the students were able to compute for the simple interest applying the formula they generated. On the other hand, they patterned their examples in the examples presented by the teacher which relates to borrowing money in the bank. From the observers, remarks were raised regarding localization and contextualization of the topic transliterated as:

> *"Simple interest in banks is not realistic. Banks do not use simple interest anyway. In reality, they do compound."*
> *"There are others who use simple interests like, borrowing from friends, some cooperatives, too… why not give examples more on micro-finance*."
> *"The approach to the lesson had been too technical, too mechanical, like deriving for the formula…they can engage in deeper discussion. They can be critical. An example was given by the learners during the ECM where they gave an example on borrowing at 10% interest. From there, it would have been a very good opportunity to discuss, is 10% reasonable? When you borrow, usually, it is 10% interest but when you save in the bank, why is it just 2% money growth? There is something wrong with that system."*
> *"We teachers contribute to this existing system that we have. The rich become richer. It is because we teach the topic of interest without questioning. We contribute to poverty in the world.*"

The observers reiterated the integration of critical mathematics in the presentation of simple interest where social issues can be dealt upon more than teaching students mere calculation skills as agreed by some researchers [9], [20]. One of the observers mentioned:

> *"These students can engage in deeper discussions. There is a lot you can inject in the different parts of this lesson, like social justice…. Loan sharks… 10% interest rate if you borrowed money in a bank while if you save it is just 2% interest…. Why many Filipinos are taking a risk in borrowing money on an unauthorized lending group like five-six which offers a 20% interest rate? Perhaps they want easy money."*

With topics that are taught mostly using the traditional procedural approach, introducing this topic in this manner would allow the students to see that mathematics is practical and not merely theoretical. Analyzing the responses of the observers, teaching simple interest is an avenue to discuss social issues like loaning, poverty, and oppression due to social classes, thus, making the topic a transformative one. Besides,

teaching mathematics may be technical or mechanical but it can still be linked to social issues for the reason that it is a social construct. Consequently, the equipping of teachings in areas of contextualization is needed. With the reformation in the presentation of the topic, mathematics can empower students to make better choices [21], [22]. Teaching and learning mathematics for social justice targets civic responsibility reducing events for oppression among them or in their community [23]. Reinventing and redesigning the lesson in this way can be anathematic to some educators who had been banking on traditional conceptualization [24].

An attempt was done in the study of implementing realistic mathematics education by not separating the topic from the everyday lives of the students. It was discovered that the approach increased the performance of the students in the subject and that the students have developed a positive attitude towards the subject [25]. Similarly, it increased the concept of understanding better than the other traditional approaches [26]. Mathematics teachers can teach students to learn beyond numbers and calculations. It was suggested that the use of ECM could have been maximized if real-world appreciation and values integration were given focus. Furthermore, it was observed that this issue could have been addressed only if the students' self – created examples were examined based on its real essence and appreciation of the values that could have been emphasized in the discussion like the importance of having savings, disadvantages of loaning, and mismanagement of finances. It is said that financial literacy and cognitive capabilities have a relationship with the quality of financial decision-making. While other researchers would say that there is little evidence that education's intent to improve financial decision-making succeeded more studies still show that financial literacy increases mathematics engagement leading to increased life opportunities [27].

Using lesson study, the pedagogy involving ECM is deemed effective if examples used in the map and discussion of the mathematical topic were contextualized, thus, leading to the exchange of ideas on social issues and social justice. Also, researches affirm that using mathematics in context with financial management increases student's interest in learning [27]. As an effect of their changed perception of the subject, they tend to perform better because of the unconventional pedagogy implemented [2]. Having a strong pedagogical content knowledge would allow educators to design a contextualized discussion in presenting mechanical topics such as simple interest [27].

3.2 Strategizing with ECM provides opportunities to engage in deep and meaningful thinking given an otherwise technical/mechanical topic

The use of ECM in presenting the topic allowed active participation among the students. The group carried out the plan of using the discovery approach in teaching simple interest. The teacher utilized the ECM to involve the students in inductive thinking and concept acquisition.

In the ECM part of the lesson presentation, the learners were given worksheets that contain three examples. The learners analyzed the examples and created their own conclusion leading them to derive the formula for the simple interest. They also have to provide their own example after. The teacher was quite apprehensive that the students might not be able to derive the formula of annual simple interest using the provided ECM worksheet. As said by the teacher:

> *"I was actually worried in the ECM part because the students might not be able to come up with a conclusion, but they were able to come up with the correct conclusion and their own examples, too, just except for one group who may have spent more time in concluding."*

The observers agreed that the ECM worked effectively since most of the groups were able to arrive at the expected answer and were able to create their own example, as one observer said:

> *"When you used the ECM, I think this is good because they were the one who discovered the formula."*

It was observed that while the students were working with the ECM worksheets, they were striving to think inductively to come up with a conclusion that explains how simple interest is computed and apply this self – established knowledge which allows students to create or come up with their own example is more of the factor that allowed students to be able to cement their derivation of the formula. When the discovery of formula is included in the teaching-learning process, it increased a student's grasp of the topic [28].

In the ECM pedagogy, the students are expected to study the examples carefully for them to draw a certain conclusion. From their deduction, they will create their own examples. The inductive and deductive approach is mostly employed in mathematics education. Because PSM (including ECM) is a powerful tool in enhancing students' performance, utilizing them correctly and appropriately in teaching a specific lesson can even make it more powerful in addressing students' difficulties in problem-solving [6]. The following were the conclusion derived by the learners as written in their ECM group worksheet:

Group 1: "By multiplying the principal to the rate per year."
Group 2: "Interest is computed by multiplying the percent of interest or rate to the principal and multiply it to the time/term."
Group 3: "SI=Prt (Simple interest is equal to the product of principal amount, interest rate and time the amount was borrowed)."
Group 4: "F=(PR)T (Simple interest is equal to the product of principal amount, interest rate and time the amount was borrowed)."
Group 5: "Interest=(Principal times rate)."
Group 6: "Multiplying the principal amount by the rate then if the time is given, multiply it as well."
Group 7: "The interest is computed by the year/s it took to complete the amount loan."

While the observers agreed that utilizing such an ECM method was effective, it was suggested that in presenting the group output, each of the groups must show their synthesis to the class so that the teacher can validate the students' understanding and can clear students' misconceptions especially that there is a group who had a hard time concluding. With the teacher as facilitator, guided discovery learning would allow students to express themselves not just orally but they will be equipped in written mathematical communication [29].

Also, it was suggested that another ECM worksheet has to be provided where the unknown is either the principal amount (P), the rate (r), or the time (t). As stated by another observer that they can engage in a deeper discussion instead of giving away the other derived formula since it is stipulated in the benefits of ECM that the formula must be concluded by the learners [6].

The teacher strengthened the knowledge acquired through the ECM using a quiz bee with three categories, easy, average, and difficult. It was observed that students who were able to quickly complete the ECM worksheets were also the ones who obtained high scores. While some of the observers appreciate the participation of the class, and collaboration among the group members, a point was raised regarding the danger of these types of activities as a form of application of concept learned.

> *"This became a competition... you gave a quiz bee and instead of emphasizing understanding, winning the game became the center. In winning, you can say that they have understood, but not everybody understands… only the winner takes all… Sometimes, competitions can be harmful … what are we really aiming to achieve for our students?"*

The group who had difficulty in accomplishing the ECM worksheet also had low scores during the quiz bee. This was clearly noticed by the observers with one of them saying:

> *"They were striving… but it is not enough for the high score."*
> *"You used questions which the students are the ones telling whether the answers were correct or not. The step-by-step computation was not the focus upon."*

As suggested by the observers, alternative application activities must be carried out to establish the construct among the learners and guarantee a clear understanding of the lesson content. Numeracy is more than algebra and arithmetic. It is further suggested by studies that developing the ability to work with mathematics in context and with multiple approaches, students must first achieve numeracy [30].

This paper is believed to be contributory to the existing body of knowledge since ECM is a new strategy in discovery learning which is deemed appropriate in teaching simple interest where planning and preparation are needed. To improve the delivery of the topic, the observer's suggestions are summarized as: i) allow the learners to discover the formula; ii) establish how simple interest is computed through the collaboration of the teachers with the learners; iii) strategize the use of games and technology and evaluate if its inclusion is essential. Having a strong technological pedagogical content knowledge is essential would allow educators to effectively teach a topic however mechanical it is [31].

4. CONCLUSION

ECM as a pedagogy in teaching simple interest is an effective approach if the examples used in the problem-solving map is contextualized. It is concluded that in teaching the content, the teacher must strategize the conceptualization process. The teacher must design a contextualized and localized ECM material in a way that the learners would relate to the topic. This would make the convention used effective in teaching simple interest. Teaching simple interest can be a transformative topic and must be contextualized and taught using critical mathematics.

Critical mathematics presents not just the underpinning concepts on computations and algorithms but uses critical thinking skills to analyze profound issues the community deals with like issues on social justice, loaning, and investing. Thus, contextualizing and localizing the examples is suggested. Taking a broad view of the topic would create lesson valuing or appreciation among the learners as they change their perception that learning simple interest is not just learning the computational formula but also, its application is greatly experienced in the world. Thus, the teacher plays a great role by making mathematics concepts experienced more than it being a mere calculation subject.

Lastly, in building the mathematics construct among the learners, conceptualization, and presentation of the lesson is very important. If the inductive process is the appropriate strategy for the learners to acquire the concept, then using ECM is an effective convention. Contextualization and localization of the topic must be observed for the learners to gain interest in developing the skills learned as they do not just compute in school but also apply these concepts are made real in their daily lives.

REFERENCES

[1] N. Akhter and N. Akhter, "Learning in Mathematics: Difficulties and Perceptions of Students," *Journal of Educational Research*, vol. 21, no. 1, 2018.

[2] L. C. Anigbo, "Factors Affecting Students' Interest in Mathematics in Secondary Schools in Enugu State," *International Journal of Education and Evaluation*, vol. 2, no. 1, 2016.

[3] I. J. Bature and B. Atweh, "Achieving Quality Mathematics Classroom Instruction through Productive Pedagogies," *International Journal of Educational Methodology*, vol. 2, no. 1, pp. 1–18, Nov. 2016, doi: 10.12973/ijem.2.1.1.

[4] Philippines Department of Education, *K to 12 Mathematics Curriculum*. Department of Education, 2016.

[5] D. Sirias, "College of Business & Management retains accreditation, receives funding from state for new home," The Interior, Saginaw Valley State University, 2018.

[6] D. Sirias, "A proposed model to improve quantitative reasoning: The problem solving maps," in *NEDSI 2018 Annual Conference* - Providence, Rhode Island, USA, 2018.

[7] L. Yuliati and N. Munfaridah, "The Influence of Thinking Maps on Discovery Learning toward Physics Problem Solving Skills," in *Proceedings of the 2nd International Conference on Education and Multimedia Technology*, Jul. 2018, pp. 59–63, doi: 10.1145/3206129.3239423.

[8] Z. K. Szabo, P. Körtesi, J. Guncaga, D. Szabo, and R. Neag, "Examples of Problem-Solving Strategies in Mathematics Education Supporting the Sustainability of 21st-Century Skills," *Sustainability*, vol. 12, no. 23, p. 10113, Dec. 2020, doi: 10.3390/su122310113.

[9] P. Ernest, B. Sriraman, and N. Ernest, *Critical Mathematics Education - Theory, Praxis and Reality*. Charlotte, NC, USA: Information Age Publishing, 2016.

[10] P. Ernest *et al.*, *The Philosophy of Mathematics Education*. Cham: Springer International Publishing, 2016.

[11] Z. H. Iksan and M. B. M. Rahim, "Reflections on Teaching and Learning of Mathematics through Lesson Study and Video Critique," *Advances in Social Sciences Research Journal*, vol. 4, no. 1, Jan. 2017, doi: 10.14738/assrj.41.2499.

[12] L. E. Elipane, "Introducing Lesson Study as a Professional Development Model in the Islands of the Philippines," *Advanced Science Letters*, vol. 23, no. 2, pp. 1126–1129, Feb. 2017, doi: 10.1166/asl.2017.7514.

[13] R. Bjuland and R. Mosvold, "Lesson study in teacher education: Learning from a challenging case," *Teaching and Teacher Education*, vol. 52, pp. 83–90, Nov. 2015, doi: 10.1016/j.tate.2015.09.005.

[14] A. N. Shúilleabháin, "Lesson Study as a form of in-School Professional Development: Case studies in two post-primary schools," National Council for Curriculum and Assessement, Dublin, 2015.

[15] J. W. Creswell and J. D. Creswell, *Research Design Qualitative, Quantitative, and Mixed Methods Approaches*, 5th Ed. Thousand Oaks: SAGE Publications, Inc, 2018.

[16] D. G. Aniban, V. C. Chua, J. Garcia, and L. E. Elipane, "From Arithmetic to Algebra: Sequences and Patterns as an Introductory Lesson in Seventh Grade Mathematics," Sydney, New South Wales, Australia, 2014.

[17] L. Elipane, *Integrating the Essential Elements of Lesson Study in Pre-service Mathematics Teacher Education*. Department of Science Education, University of Copenhagen, 2012.

[18] R. N. A. Capate and M. R. C. Lapinid, "Assessing the Mathematics Performance of Grade 8 Students as Basis for Enhancing Instruction and Aligning with K to 12 Curriculum," Presented at *the DLSU Research Congress 2015*, De La Salle University, Manila, Philippines, 2015.

[19] J. D. Reyes, A. O. Insorio, M. L. V Ingreso, F. F. Hilario, and C. R. Gutierrez, "Conception and Application of Contextualization in Mathematics Education," *International Journal of Educational Studies in Mathematics*, vol. 6, no. 1, pp. 1–18, 2019.

[20] O. Skovsmose, "Critical Mathematics Education," in *Encyclopedia of Mathematics Education*, Cham: Springer International Publishing, 2020, pp. 154–159.

[21] F. Peck, "Rejecting Platonism: Recovering Humanity in Mathematics Education," *Education Sciences*, vol. 8, no. 2, p. 43, Mar. 2018, doi: 10.3390/educsci8020043.

[22] F. Firdaus, I. Kailani, M. N. Bin Bakar, and B. Bakry, "Developing Critical Thinking Skills of Students in Mathematics Learning," *Journal of Education and Learning (EduLearn)*, vol. 9, no. 3, pp. 226–236, Aug. 2015, doi: 10.11591/edulearn.v9i3.1830.

[23] G. V. Larnell, E. C. Bullock, and C. C. Jett, "Rethinking Teaching and Learning Mathematics for Social Justice from a Critical Race Perspective," *Journal of Education*, vol. 196, no. 1, pp. 19–29, Jan. 2016, doi: 10.1177/002205741619600104.

[24] G. Bond and E. J. Chernoff, "Mathematics and Social Justice: A Symbiotic Pedagogy," *Journal of Urban Mathematics Education*, vol. 8, no. 1, pp. 24–30, 2015.

[25] E. Zakaria and M. Syamaun, "The Effect of Realistic Mathematics Education Approach on Students' Achievement And Attitudes Towards Mathematics," *Mathematics Education Trends and Research*, vol. 2017, no. 1, pp. 32–40, 2017, doi: 10.5899/2017/metr-00093.

[26] L. Lestari and E. Surya, "The Effectiveness of Realistic Mathematics Education Approach on Ability of Students' Mathematical Concept Understanding," *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, vol. 34, no. 1, pp. 91–100, 2017.

[27] C. Attard, "Mathematics + Money = Engagement: Financial Literacy as a Tool to Increase Opportunity and Engagement with Mathematics for Students from Low Socio-Economic Areas: Final Report," 2016. doi: 10.4225/35/576376814fb8f.
[28] Y. Herdiana, Wahyudin, and R. Sispiyati, "Effectiveness of discovery learning model on mathematical problem solving," *AIP Conference Proceedings*, 2017, p. 50028, doi: 10.1063/1.4995155.
[29] J. Suratno, W. S. Tonra, and Ardiana, "The effect of guided discovery learning on students' mathematical communication skill," in *The 2nd International Conference on Science, Mathematics, Environment, and Education*, 2019, p. 020119, doi: 10.1063/1.5139851.
[30] S. P. Ferrill, "Discovery Learning Plus Direct Instruction Equals Success: Modifying American Math Education in the Algebra Classroom," *Honors Projects*, 2017. [Online]. Available: https://digitalcommons.spu.edu/honorsprojects/63.
[31] M. Heitink, J. Voogt, P. Fisser, L. Verplanken, and J. Van Braak, "Eliciting teachers' technological pedagogical knowledge," *Australasian Journal of Educational Technology*, vol. 33, no. 3, Jul. 2017, doi: 10.14742/ajet.3505.

BIOGRAPHIES OF AUTHORS

Fleur De Cory Apasen Ngiwas is a graduate Master of Arts in Mathematics in Benguet State University, Philippines and is finishing Doctor of Philosophy in Mathematics Education in Philippine Normal University, Manila, Philippines. She is currently a Senior Highschool and College Instructor in the Mathematics Department of College of Numeracy and Applied Sciences, Benguet State University, Benguet, Philippines where she handles Mathematics and Research subjects. She can be contacted in her email: mademoisellefleurdecoryngiwas@gmail.com.

Daisy Lyn F. Mariano finished her Master of Arts in Education with Specialization in Mathematics Education at Philippine Normal University-Manila, Philippines and is currently pursuing Doctor of Philosophy in Mathematics Education in the same university. She presented her researches in national and international conferences and was able to publish her a paper in an international journal. At present, she is a Master Teacher at Parada National High School, Valenzuela, Philippines. She can be contacted in her email: daisylyn.mariano@deped.gov.ph.

Jayson G. Barsana is a Master Teacher at Tagbacan National High School, Catanauan, Quezon, Philippines. He is a senior high school coordinator of the institution promoting the use of ICT in education. He is a research enthusiast and a member of Quezonian Educators Journal. His researches are focused on pedagogy in Mathematics education. He is the proponent of "MATHNERS" or My Mathematics Partners. He is currently finishing Doctor of Philosophy in Mathematics Education in Philippine Normal University, Manila, Philippines. He had his researches presented both in the national and international level. He can be contacted in his email: jayson.barsana@deped.gov.ph.

Michelle P. Cruz is currently a Doctor of Philosophy in Mathematics Education student at Philippine Normal University. She is a Mathematics Senior High School teacher of San Jose Del Monte National High School, Bulacan, Philippines. She can be contacted at email: michelle.cruz016@deped.gov.ph.

Levi Elipane is a senior program manager at the Philippine National Research Center for Teacher Quality (RCTQ) focusing on the development of National Educators Academy of the Philippines (NEAP) Career Advancement Program (CAPRO) and Teachers Induction Program (TIP). He is an associate professor at the College of Graduate Studies and Teacher Education Research (CGSTER) of the Philippine Normal University (PNU). For the past seven years into the academe, Dr. Elipane has collaborated with his students and some colleagues from different schools and universities to embark on Lesson Study as a form of research and professional development initiative. He can be contacted at email: elipane.le@pnu.edu.ph.