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Using context of local environment maps to develop lesson plan which foster mathematical literacy

[1, 3*]Vita Istihapsari, [1]Afit Istiandaru, [2]Rachmat Satrio Wahyudi, [3]Sukestiyarno, [3]Hardi Suyitno, [3]Rochmad
[1]Universitas Ahmad Dahlan, Jl. Jend. Ahmad Yani, Tamanan, Banguntapan, Bantul, DIY 55191 Indonesia
[2]SMP N 2 Cimerak, Jl. Raya Ciparanti No. 351 Cimerak, Pangandaran, Jawa Barat, Indonesia
[3]Universitas Negeri Semarang (Postgraduate), Jl. Kelud Utara III No.15, Kota Semarang, Jawa Tengah 50237
*Corresponding e-mail: vita.istihapsari@pmat.uad.ac.id

Abstract

Mathematical litreracy is defined as individual capacity to reason mathematically, to formulate, to employ, and to interpret mathematics, and to solve problems in the various real-life contexts. These skills are important for students but PISA – an OECD program to assess these skills – reported that the Indonesian students' performance in mathematical literacy remains low for decades mostly due to instructional factor. It also happened in SMP N 2 Cimerak – a junior high school in Pangandaran, Indonesia, that the students still need a lot of improvement in mathematical literacy skills and their teachers also needs to develop capacity to teach the skills. This research aims to develop a valid and practical lesson plans which could be used to foster mathematical literacy. The lesson plans also include powerpoint presentation slides, students' worksheet, teaching materials, and assessment instrument. It was a modified version of R&D introduced by Plomp which consist of stages: initial investigation, design, construction, evaluation, and final product. In the evaluation stage, we involved four experts to validate the lesson plans and 26 junior high school students to test the lesson plans, and revised them accordingly. The results suggest that the lesson plans are valid with the score of 4.46 (lesson plan), 3.96 (PPT slides), 4.38 (worksheet), 4.00 (teaching materials), dan 4.39 (assessment). The validity could be explained from the accommodation of mathematical literacy domains such as contexts (job and society, local environment maps), content (change and relationship, Cartesian coordinate), process (manifested in the problem-based learning), and the skills (communication, mathematization, representation, reasoning, devising strategies, using symbols, and using mathematics tools). The testing also resulted in 84.19 score of students' positive responses and 3.92 (good) score of practicality. Moreover, the lessons also have potential effects in fostering students' mathematical literacy viewed from the observation of mathematical literacy process, which suggest that 3.8% students in low performance, 53.8% students in intermediate performance, and 42.3% students in high performance. Therefore, the lesson plans were valid, practical, and having potential effect in fostering students' mathematical literacy.

Keywords: lesson plan, local environment, mathematical literacy, PISA

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INTRODUCTION

In 2018, Programme for International Students Assessment (PISA) released a report that Indonesian students aged 14-15 scored 379 in mathematical literacy, which makes them ranked 71 from 78 participating countries (OECD, 2020). The PISA results have made a shock moment to the Indonesian mathematics education as it always put Indonesia in the lowest place in decades. This shock moment makes the Indonesian Ministry of Education takes a look to its curriculum and makes various changes (Pratiwi, 2019). One of which is the implementation of 2013 Curriculum and

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Emancipated Curriculum. Both curriculums emphasize on the fostering of higher order thinking skills such as mathematical literacy.

Mathematical literacy is an individual capacity to reason mathematically, to formulate, to employ, and to interpret mathematical situations, and to solve problems in various contexts (OECD, 2021). According to PISA framework, mathematical literacy could be seen in the process of formulation of real situations into mathematics problem, application of mathematics to solve it, and interpreting the solutions in the related context. Furthermore, mathematics literacy also includes the capacity of reasoning and problem-solving. Therefore, teaching materials should be developed by accommodating these skills. The content of mathematical literacy mostly about quantity, change and relationships, space and shape, as well as uncertainty and data. Meanwhile, the contexts mostly used in developing mathematical literacy teaching materials are personal, occupation, society, and science.

Various studies found that the causes of the Indonesian students' low performance in PISA come from several factors, such as instructional factor and student factor (Kusumawardani et al., 2018; Hapsari, 2019; Hidayati et al., 2020). Instructional factor may come from the lack capacity of teachers in teaching and fostering mathematics literacy (Hidayati et al., 2020), and the lack availability of teaching materials teachers could use to foster mathematics literacy (Kusumawardani et al., 2018). Moreover, the students mostly do not used to engage with contextual problems. It was reflected on their difficulty to formulate the real situations into mathematical problems (Hapsari, 2019).

This situation also happened at SMP N 2 Cimerak, a junior high school in Pangandaran, West Java. The 8^{th} grade students still need improvement in mathematical literacy skills. They were not used to engage in mathematical literacy activities because generally teachers do not have teaching materials specifically designed to foster mathematical literacy.

Various studies also have tried to develop teaching materials with particular objective to foster mathematical literacy using various contexts, such as sailing context (Efriani & Putri), Covid-19 context (Nusantara & Putri, 2021), cultural heritage context (Oktiningrum & Zulkardi, 2016), Asian Games context (Yansen et al., 2019), and so on. These studies suggest that problems which foster mathematical literacy should start from students' surrounding.

One of the contexts which is close to students is a local map. A local map shows places surround the school or house. The map could be transformed into Cartesian coordinate which shows locations and, then, developed to make the students learn about change and relationships between two variables. Therefore, this research aims to develop lesson plans (teaching materials) which foster mathematical literacy using the context of local environment map.

RESEARCH METHOD

This research is an R&D using a modified Plomp development model. The development stages are: (1) initial investigation, (2) design stage, (3) realization (construction) stage, (4) test, evaluation, and revision stage, and (5) final product stage. At the initial investigation stage, we analyzed the needs of lesson plans that can foster students' mathematical literacy, including students' abilities and the competence of mathematics teachers. Furthermore, at the design stage, we designed the format and concept of the lesson plans to be developed. In the construction stage, we made the lesson plans from the design stage so as to produce a prototype of the lesson plans that claimed to foster mathematical literacy. At the test, evaluation, and revision stages, we submitted the lesson plans for validation to experts, made improvements based on experts' input, tried out the use of lesson plans in a learning, and analyzed their practicality. The results of these improvements are used to prepare a final product that is ready to be implemented in the field.

The lesson plan validation involved three experts in mathematics education and a junior high school teacher, while the participants of testing the lesson plan involve 26 students of 8^{th} grade of junior high school. We used questionnaires to get quantitative feedback from experts. We also had them provided qualitative feedback using a walk-through method. Based on the feedback, we could find out the validity of the lesson plans.

On the practicality, we used questionnaire to get students' response. We also observed the teacher on how they implement the lesson plan. Based on the questionnaire and observation results, we could find out the practicality.

Furthermore, we also found out the lesson plans' potential effect by observing the students' skills of mathematical literacy process, namely formulating mathematical problems, employing mathematical procedures, and interpreting the results, as presented in Table 1.

Table 1. The process of mathematical literacy skills

	Formulating	Employing	Interpreting
Communicating	Read, parse a statement, question, or assignment to form a model of the given situation.	Proposing a solution, showing how to reach the solution.	Build and explain the context of the problem.
Mathematizing	Identify variables and structures in the problem and make assumptions about the use of variables.	Using an understanding of the context to carry out the solving process.	Understand the expansion and limitations of the solutions obtained from the results of the applied model.
Representation	Make a representation of a real problem.	Make logical, connect and use representations in solving problems.	Interpret the results of problem solving, evaluate two or more representations.
Reasoning and argument	Explain or defend the representations that have been made.	Explain or defend the procedures applied.	Reflect on the results of problem solving.
Devising strategies	Choose the right strategy to solve the problem.	Control the problem-solving mechanism.	Plan validation and attempt to interpret results.
Using math symbols	Use appropriate symbols or variables to create representations.	Understand and use formal structures based on definitions and algorithms.	Understand the relationship between the context of the problem and the representation of the problem.

Table 1 shows the relationships between the process and the skills of mathematical literacy which could be fostered in students. When a teacher develops lesson plans, they need to think about how to put some of them in their learning activities such that their students would learn to foster the skills.

RESULTS AND DISCUSSION

The results of this study are divided into the following sections.

Investigation stage

The results of the initial investigation of student abilities and teacher competence related to efforts to foster students' mathematical literacy, especially at SMP N 2 Cimerak, are presented in Table 2.

Table 2. Initial investigation results

No	Problems	Analysis of identified problems
1	Lack of students' mathematical literacy skills	- Students' skills to find important information in word problems and the application of problem-solving algorithms was still challenging. - Students found difficulty in understanding instructions in the existing worksheet. - Students could not fluently apply number operation. - Students did not understand the mathematics symbols. - Students could not think in abstract way. - Students forgot the use of formulas, definitions, or theorems.
2	Lack of teachers' pedagogical capacity	- Teachers were careless to the students' initial ability. - Teachers did not apply diagnostic assessment so that their learning would be suitable for students' needs. - Teachers failed to select the most appropriate learning model/method. - Teachers did not understand the application of several innovative learning models, thus, their learning tends to be conventional.

These results are in line with previous studies, such as Argina et al. (2017) confirmed that Indonesian teachers still have a mindset of delivering knowledge in mathematics learning instead of creating meaningful learning. Fenanlampir (2019) argues about the gap of teachers' capacity in teaching between Indonesian urban and rural areas also affects the students' mathematical literacy. These conditions did not only happen in Indonesia. Ozgen (2019) revealed that many mathematics teachers in Turkiye still focused on "employing" procedures but lack of facilitating students in "formulating" and "interpreting" procedures. That was why their students faced challenges in mathematical literacy. Genc and Erbas (2020) also found out that many mathematics teachers in Turkiye sees mathematics literacy only as a skill for students with unsatisfactory results, as it probably still connected mathematics with reality, while the advanced students are more ready with the abstract mathematics.

Design stage

To follow up on the results of the initial investigation, we designed a lesson plan. At the design stage, we have determined the design of lesson plan including PPT media, worksheets, teaching materials, and assessment instruments. We planned to use the Problem-Based Learning (PBL) model with the SQRQCQ strategy (survey, question, read, question, compute/construct, question). The details of the device design developed are presented in Table 3.

Table 3. Design of lesson plan

Learning process	Tools	Domains of mathematical literacy based on PISA framework: Process	Content	Context	Skills
Model: PBL Method: SQRQCQ	- Lesson plan - PPT media - Students' worksheet - Teaching material - Test of mathematical literacy	Formulating (SQ, RQ) - Problem orientation - Student organization Employing (CQ) - Doing investigation - Developing presentation Interpreting - Evaluating the problem-solving	Change and relationship - Cartesian coordinate	Occupation - Farmer Society - Position of public places - Local environ-ment map	- Communicating - Mathematising - Representation - Reasoning and argument - Devising strategies - Using symbol - Using math tools

Construction stage

At this stage, we and the teachers collaborate in compiling learning tools to obtain drafts/prototypes of learning devices as the excerpts are presented in Figure 1, Figure 2, Figure 3, Figure 4, and Figure 5.

Mengorientasikan Siswa pada Masalah

- ✓ Guru menyajikan permasalahan nyata yang berkaitan dengan letak tempat pada denah *powerpoint*. (TPACK-TPK)
- ✓ Peserta didik membaca permasalahan dengan cara *survey*, yaitu membaca dengan cepat masalah yang disajikan. (*Survey*)
- ✓ Peserta didik diberikan kesempatan untuk menceritakan kembali dengan bahasanya sendiri terkait masalah yang disajikan. (TPACK-CK, 4C-*Communication*)
- ✓ Guru mengajukan pertanyaan kepada peserta didik mengenai apa yang ditanyakan atau diminta dalam permasalahan yang disajikan. (*Question I*)

Mengorganisasikan Siswa untuk Belajar

- ✓ Peserta didik dibagi menjadi beberapa kelompok yang terdiri dari 4 orang sesuai dengan kemampuan disposisi matematis. (TPACK-PA, 4C-*Collaboration*)
- ✓ Guru mengorganisasikan setiap kelompok untuk siap belajar dan bekerja.
- ✓ Setiap kelompok dapat mengakses Lembar Kerja Peserta Didik (LKPD) menggunakan tablet melalui *liveworksheet*. (TPACK-

Mengembangkan dan Menyajikan Hasil Karya

- ✓ Setiap kelompok mempresentasikan hasil pekerjaannya di depan kelas dan guru memberikan *reward* serta penguatan di setiap presentasi. **(TPACK-PCK)**
- ✓ Guru mendorong kelompok lain untuk mengajukan pertanyaan dan menyampaikan pendapat terkait hasil pekerjaan kelompok yang presentasi.

Membimbing Penyelidikan Individu dan Kelompok

- ✓ Peserta didik diminta untuk menceritakan kembali masalah tentang dengan menuliskannya pada kolom jawaban langkah *survey* yang telah tersedia dalam e-LKPD. **(TPACK-TCK)**
- ✓ Peserta didik diminta untuk menuliskan pertanyaan yang telah dibuat berdasarkan apa yang ditanyakan dalam permasalahan di dalam e-LKPD. **(TPACK-TCK, 4C-*Communication*)**
- ✓ Peserta didik diminta untuk membaca kembali permasalahan dengan seksama pada langkah *Read* yang telah tersedia dalam e-LKPD. **(*Read*) (TPACK-TCK)**
- ✓ Guru memberikan pertanyaan kepada peserta didik tentang proses matematis atau konsep matematika apa yang akan digunakan untuk memecahkan masalah dengan tepat. **(*Question II*) (TPACK-CK, 4C-*Critcal Thinking*)**
- ✓ Peserta didik diminta untuk mulai melakukan perhitungan matematis. **(*Compute*) (TPACK-CK, 4C-*Critical Thinking*)**
- ✓ Guru mengajukan pertanyaan kepada peserta didik terkait jawaban yang telah diperoleh dan meminta peserta didik untuk melihat kembali dengan teliti proses perhitungan dan jawaban yang dibuatnya. **(*Question III*) (TPACK-CK, 4C-*Creativity and Innovation*)**
- ✓ Selama peserta didik berdiskusi dan mengisi LKPD, guru memberikan bimbingan pendampingan kepada peserta didik secara individu ataupun kelompok. **(TPACK-PK, 4C-*Communication*)**
- ✓ Guru memberikan *ice breaking*.

Menganalisis dan Mengevaluasi Proses Pemecahan Masalah

- ✓ Guru membuka forum diskusi kelas untuk memberikan tanggapan secara umum.
- ✓ Peserta didik mendapat penguatan terkait kesimpulan yang telah dibuat secara bersama-sama.
- ✓ Guru memberikan motivasi tentang

Figure 1. Sample of lesson plan

Figure 1 presents an excerpt of the Learning Implementation Plan designed using the problem-based learning (PBL) learning model and the survey, question, read, question, compute/construct, question (SQRQCQ) strategy. In Figure 1, it can be seen that the SQRQCQ strategy is embedded in the PBL steps. In addition, the process of mathematical literacy namely formulating problems, implementing problem solving steps and interpreting them is also accommodated in PBL steps.

The sample of PPT media is presented in Figure 2.

Figure 2. Sample of PPT media

In Figure 2, the slide begins with an explanation of learning patterns, which are important for students to understand. In addition, the main function of this PPT slide is to better visualize the activities listed on the LKPD. On the PPT slides, it appears that students are invited to understand the context used in learning where the context is useful in the process of formulating problems and interpreting mathematical situations.

Furthermore, Figure 3 presents an excerpt from the students' worksheet.

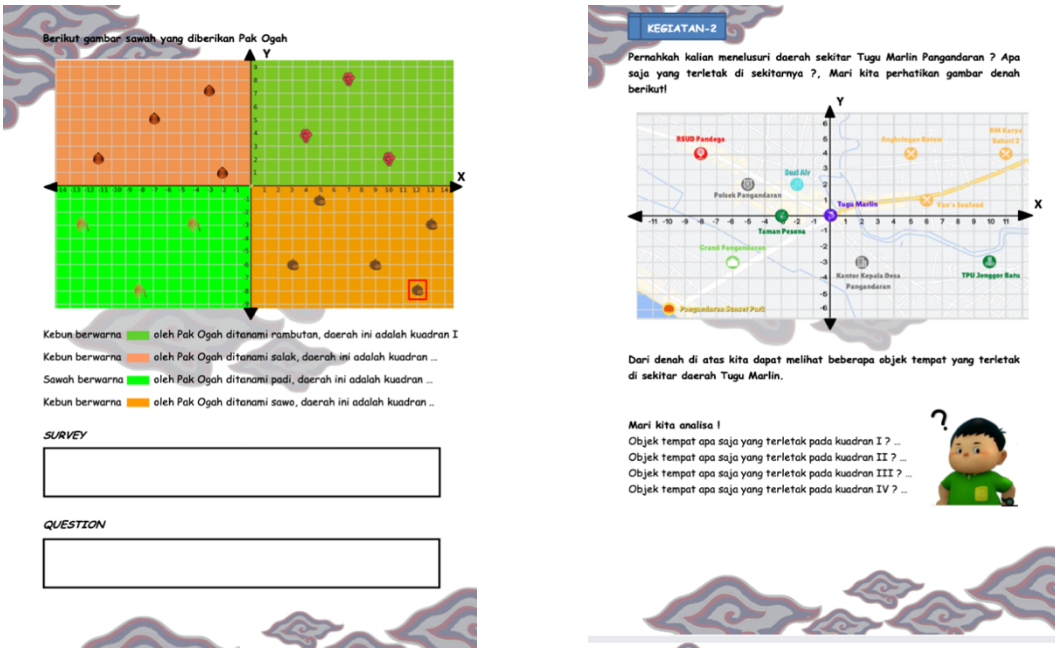


Figure 3. Sample of students' worksheet

Figure 3 shows the integration of the SQRQCQ strategy used in the LKPD and also the process of formulating a mathematical situation, implementing and interpreting it in the provided fields.

The next product is the teaching material (See Figure 4).

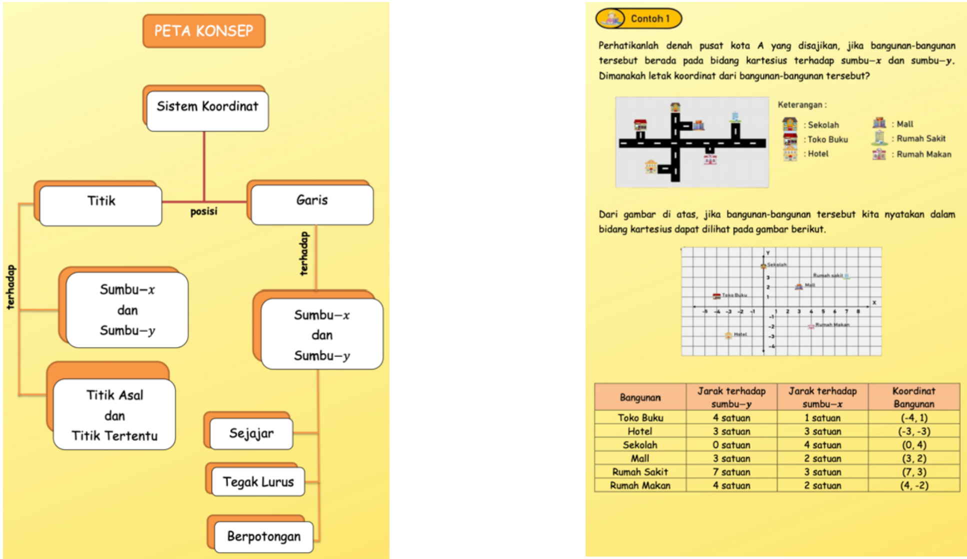


Figure 4. Sample of teaching materials

The difference with students' worksheet lies in the completeness of sample questions that are accompanied by answers, not just filling in blanks like in students' worksheet. The use of this teaching material as material to confirm and provide reinforcement after students learn to use students' worksheet.

The 5th tool developed is an assessment instrument in the form of a mathematical literacy test, as presented in Figure 5.

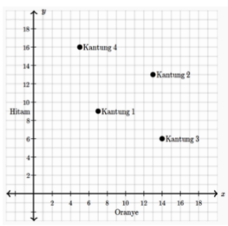
Kompetensi Dasar	Nomor Soal	Buku Sumber Belajar
Menjelaskan kedudukan titik dalam bidang koordinat kartesius yang dihubungkan dengan masalah kontekstual.	2	Buku Guru (Kemendikbud RI Revisi 2018) Buku Siswa (Kemendikbud RI Revisi 2018)
Indikator Pencapaian Kompetensi	**Rumusan Soal**	
Menganalisis (C4) posisi titik terhadap sumbu−x, sumbu−y, titik pusat $(0, 0)$, dan titik tertentu (a, b).	Untuk hari Raya Lebaran, Fitri membuat beberapa kantung yang diisi permen warna oranye dan hitam untuk 5 orang cucunya. Titik-titik berikut menggambarkan jumlah permen oranye dan hitam dalam 4 kantung yang ada.	
Indikator Soal		
Disajikan sebuah permasalahan dan koordinat kartesius, peserta didik dapat memecahkan permasalahan tersebut dengan tepat.	Kantung kelima memiliki 4 permen oranye lebih banyak dari kantung 1 dan 1 permen hitam lebih sedikit dari kantung 2. Tentukanlah titik koordinat kantung kelima tersebut!	

Figure 5. Sample of test item

In Figure 5, it appears that the context of Cartesian coordinates as a relationship between variables does not only use the situation of the object's location, but also shows a quantity relationship. This is important to enrich students' understanding.

Test, evaluation, and revision stage

At this stage, researchers and teachers collaborate to evaluate learning tools to determine the validity, practicality, and potential effects of the tools developed on students' mathematical literacy. The results of the learning device validation are presented in Table 4.

Table 4. Validation results

No	Materials	Validator 1	Validator 2	Validator 3	Validator 4	Average	Category
1	Lesson plan	4.38	4.38	4.46	4.62	4.46	Very good
2	PPT media	3.83	4.17	3.83	4.00	3.96	Good
3	Students' worksheet	4.42	4.50	4.17	4.42	4.38	Very good
4	Teaching materials	4.00	4.17	3.83	4.00	4.00	Very good
5	Test	4.71	4.29	4.29	4.29	4.39	Very good

In this study, the learning device is said to be valid if the validation results show the minimum criteria are Good. The device validation criteria include the suitability of the device with the expected competencies (mathematical literacy), the PISA mathematical literacy framework (content, context and process domains), as well as elements of the legibility of learning tools. In Table 3, it appears that the learning tools produced are in the Good and Very Good categories, so the devices are declared valid.

Furthermore, the results of the device trials consisted of student responses and the implementation of the following learning. Student responses to 18 questionnaire items regarding student responses to applied learning models, learning tools (LKPD and teaching materials), materials, and student interests resulted in a score of 84.19 (Very Good). In addition, the results of observations on the implementation of learning (preliminary activities, core activities, and closing activities) are presented in Table 5.

Table 5. Learning implementation

Score of Observer 1	Score of Observer 2	Average	Category
3.69	4.15	3.92	Very good

By looking at the results of student responses and learning implementation scores, the learning tools that are applied are practical.

Finally, researchers also look at the potential effects of learning tools on the growth of students' mathematical literacy. One of the benchmarks used by researchers is the result of observing the mathematical literacy process skills carried out during learning. The researcher describes the 6 components of mathematical literacy into aspects of formulating, applying, and interpreting mathematical situations and compiling a scoring scale of 4, the results are as presented in Table 6.

Table 6. Students' mathematical literacy skills

Category	Number	Percentage
Low	1	3.8
Intermediate	14	53.8
High	11	42.3
Total	26	100

By applying the learning that has been developed, it is obtained data that 3.8% of students process low mathematical literacy, 53.8% of students process moderate mathematical literacy, and 42.3% of students process high literacy when participating in learning using the developed tools. This means that there is a potential effect of implementing learning with the tools developed on the growth of students' mathematical literacy.

CONCLUSION

Based on the data analysis, we could find out that we have successfully developed lesson plan along with the PPT media, students' worksheet, teaching materials, and test instrument to foster mathematical literacy. All the components of lesson plan are valid based on the experts' judgement, and practical based on positive students' responses and learning implementation. The validity could be explained from the accommodation of mathematical literacy domains such as contexts (job and society, local environment maps), content (change and relationship, Cartesian coordinate), process (manifested in the problem-based learning), and the skills (communication, mathematization, representation, reasoning, devising strategies, using symbols, and using mathematics tools). Furthermore, the lesson plan also had potential effect in fostering the students' mathematical literacy based on the observation of process skills.

DECLARATION

Author Contribution

All authors contribute in the research process, such as collecting the data, analyzing the data, and writing the manuscript. All authors approved the final manuscript.

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This research did not receive any funding.

Conflict of Interest

Both authors declare that they have no competing interests.

Ethics Declaration

We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Emerging Mathematics Education (IJEME) in maintaining high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

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