



The Effectiveness of Learning Media Exhibitions Through Project-Based Learning (PjBl) to Improve the Creativity Skills of Prospective Mathematics Teachers

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Abstract

Prospective mathematics teachers in the IAIN Kudus mathematics education study program have not demonstrated maximum creative behaviour when developing learning media. Learning media exhibitions through project-based learning (PjBL) enable prospective teachers to interact directly (facilitate discussions)/be engaged authentically, explore critically, be innovative, elaborative, collaborative, and original, and gain challenging cognitive experiences so that their creativity increases. To determine the effectiveness of media exhibitions through PjBL on increasing the creativity of prospective mathematics teachers, a quasi-experimental approach was carried out on students (n=50) in the fifth semester of the 2022/2023 academic year of the IAIN Kudus mathematics education study program taken using cluster random sampling techniques. After applying this model and carrying out a paired t-test, there was a statistically significant difference between the mean of creativity of prospective mathematics teachers before and after implementing the PjBL model and exhibition activity. Meanwhile, the effectiveness of the improvement is 0.48 in the medium category. This means that the learning media exhibition through PjBL is effective in increasing the creativity of prospective teachers. Media exhibition activities through project-based learning can be a valuable and sustainable educational program to foster the creativity of prospective teachers majoring in mathematics education.

Keywords: Creativity; Exhibition; Learning Media; Project-Based Learning; Prospective Math Teacher

Abstrak

Calon guru matematika pada program studi pendidikan matematika IAIN Kudus belum menunjukkan perilaku kreatif yang maksimal dalam mengembangkan media pembelajaran. Pameran media pembelajaran melalui pembelajaran berbasis proyek (PjBL) memungkinkan calon guru berinteraksi langsung (memfasilitasi diskusi)/terlibat secara autentik, bereksplorasi secara kritis, inovatif, elaboratif, kolaboratif dan orisinal, serta memperoleh pengalaman kognitif yang menantang sehingga kreativitasnya meningkat. Untuk mengetahui efektivitas pameran media melalui PjBL terhadap peningkatan kreativitas calon guru matematika, dilakukan pendekatan kuasi eksperimen pada siswa ($n=50$) semester V tahun pelajaran 2022/2023 pendidikan matematika IAIN Kudus program studi yang diambil dengan menggunakan teknik cluster random sampling. Setelah diterapkan model tersebut dan dilakukan uji t berpasangan, terdapat perbedaan yang signifikan secara statistik antara rata-rata kreativitas calon guru matematika sebelum dan sesudah penerapan model PjBL dan kegiatan pameran. Sedangkan efektivitas peningkatannya sebesar 0,48 dengan kategori sedang. Artinya pameran media pembelajaran melalui PjBL efektif meningkatkan kreativitas calon guru. Kegiatan pameran media melalui pembelajaran berbasis proyek dapat menjadi program pendidikan yang bernilai dan berkelanjutan untuk menumbuhkan kreativitas calon guru jurusan pendidikan matematika.

Kata Kunci: Calon Guru Matematika; Kreativitas; Pameran; Pembelajaran Berbasis Proyek; Media Pembelajaran

Introduction

Creative teachers will continue to innovate in organizing meaningful learning activities, adapting to children's needs, taking advantage of technological advances, and making it fun for students. Not only are they able to use innovative and collaborative models, but creative teachers should also be able to develop media and teaching aids that can help and even complement students' learning activities so that they are actively involved and get better learning outcomes (Smeda, Dakich, & Sharda, 2014). Likewise with prospective mathematics teachers.

Mathematics is inherently abstract, requiring the incorporation of abstraction into the classroom learning process. These activities can be facilitated through the use of specific media and props. In other words, when students construct mathematical concepts, this can be done by mathematizing something concrete in nature through the help of media or teaching aids (Çalışkan-Dedeoğlu, 2022; Rosa & Orey, 2016). However, the creativity of prospective mathematics teachers, whether when solving mathematical problems, proposing problems, applying digital media, or when designing learning tools, is not yet optimal (Andrade & Pasia, 2020; Daher & Anabousy, 2018; Mawarsari, Astuti, & Purnomo, 2021; Widiati, Turmudi, & Juandi, 2020). In an interview with a lecturer specializing in learning media at IAIN Kudus, it was revealed that lectures primarily emphasize

theoretical concepts, leaving limited room for students to engage in the development of media and mathematical teaching aids. Conversely, students encounter challenges in generating innovative ideas, as their efforts are not aligned with current trends and the evolving requirements of mathematics education in schools. Their tendency is to expediently create media solely to fulfill course assignments, lacking a comprehensive understanding of the practical utility of the teaching aids they develop for both teachers and students in school. This means that prospective mathematics teachers have not demonstrated creative behavior such as being able to put forward ideas to solve problems (fluency), are less sensitive in capturing and producing solutions in responding to situations (sensitivity) (Silaningsih, 2014), and have not been able to demonstrate the novelty of the media and teaching aids being developed (Siswono, 2007).

Several research results show that efforts are needed to increase teacher creativity directly through professional development programs during pre-service education (Bolden, Harries, & Newton, 2010; Wadaani, 2023), including developing the creativity of prospective teachers in developing learning media (Gunawan, Harjono, Sahidu, & Herayanti, 2019; Wati, Hastuti, & Mustadi, 2021). Glassman & Opengart Glassman & Opengart (2016) stated that teaching creativity is not only determined by genetic aspects but also by parenting factors so that creativity can be taught or trained. Creativity also encourages someone to innovate and think outside the box.

Not only pedagogical and didactic knowledge, but lectures are also expected to provide prospective teachers with a space or platform to express their creativity both individually and in groups when developing relevant and innovative learning media. The form of the forum can be in the form of a media exhibition as an open forum that allows them to interact directly with educational practitioners and other prospective teachers. The exhibition provides an opportunity for prospective teachers to introduce and explain the results of the development of their learning media, as well as get appreciation and feedback from visitors directly. They are also encouraged to record reflections from media exhibition activities creatively. Hauan & Kolstø (2014) state that exhibitions can be linked and used to demonstrate educational results and complement formal education programs. Anderson, Lucas, Ginns, & Dierking (2000) emphasized that interactive exhibitions or expos have the potential to become educational material and support learning. This is because an expo or exhibition provides visitors with the opportunity to provide comments to designers so that they are encouraged to read material regarding the objects on display more deeply and be more careful regarding the objects to be designed (Martin & Hokanson, 2022).

Exhibitions are considered an important aspect because they can encourage discussion activities regarding certain topics (Gilbert & Priest, 1997) and explain each other based on their experiences (Rix & McSorley, 1999). Exhibition design principles that have a significant impact are interactive, exploratory, collaborative, and challenging (Dewitt & Osborne, 2010). Implementation of this learning media expo can be realized if the lecture media is directed at project-based learning. Pre-service teachers are encouraged to produce or develop learning media that is relevant for students in school and socialize it with various related parties through exhibitions. Through PjBL, the various products produced become focused because the media development carried out is based on the urgency of various problems that exist in mathematics learning (Cervantes, Hemmer, & Kouzekanani, 2015).

PjBL is considered a promising learning approach to improve student learning in higher education. Implementing the PjBL model in higher education can facilitate innovative education for prospective teachers so that they are ready to enter the world of work, have high competitiveness, and encourage long-term community development. Through this model, prospective teachers can actively construct knowledge which allows them to test and realize the ideas they want so that they can improve their innovation competence (Guo, Saab, Post, & Admiraal, 2020). It is not surprising that several empirical studies show that this model can improve student learning outcomes in higher education and propose it as a model that needs to be implemented and developed in higher education (Almulla, 2020; De Vivo, 2022). In fact, this model also needs to be further researched in the future (Guo et al., 2020; Maros, Korenkova, Fila, Levicky, & Schoberova, 2023).

Meanwhile, carrying out exhibitions at an expo makes students more creative, confident, communicative, and innovative. Apart from that, creative learning focuses on providing real phenomena that suit the target visitors, campus external environmental factors, and learning media (Mariam, Latianingsih, & Wartiningsih, 2020). For this reason, an exhibition of learning media outside the classroom through project-based learning which allows prospective teachers to interact directly (facilitate discussions)/authentically engage, explore, collaborate, and provide challenging cognitive experiences is expected to be able to foster their creativity effectively (Albritton & Stacks, 2016; Isabekov & Sadyrova, 2018).

On this basis, the PjBL model was applied to lectures on developing mathematics learning media for students/prospective mathematics teachers in the mathematics education study program at IAIN Kudus College. This model has never been applied before in mathematics learning media classes in IAIN Kudus. Even though there are many studies that show the influence of the PjBL model on the student learning outcomes, there is still no comprehensive picture of prospective

teachers creativity in developing secondary school mathematics learning aids and media due to implementation of the PjBL model which is integrated with expo activities based on empirical studies. In other words, prospective teachers are not only encouraged to produce mathematics learning media for middle school students, but are also encouraged to collaborate in planning an expo event that invites several practitioners in schools to see some of the media and teaching aids that they can use. This study is in line with proposal Guo et al., (2020), PjBL model research can be oriented towards the learning process and student performance in higher education through experiment research. In this study we provide research questions such as how effective the expo learning media through the PjBL model is in increasing the creativity of students in the IAIN Kudus mathematics education study program.

Method

This study employed a quasi-experimental design as there was no random assignment to class samples; instead, they were initially selected randomly using the cluster random sampling technique. This is because prospective Mathematics teachers are naturally formed in a class group (intact group). On this basis, the experimental class uses class groups that have been formed naturally. The quasi-experimental design uses a one-group pretest-posttest experiment. A one-group pretest-posttest design is a quasi-experimental research design in which the same dependent variable is measured in one group of participants before (pretest) and after (posttest) a treatment administered (Cambell & Stanley, 1963). Before the class was given treatment in the form of implementing a learning media exhibition through project-based learning, all students were given a creativity pre-test. Students were also given a creativity post-test after being given treatment. The sample for this research was students majoring in mathematics education in the fifth semester of the 2022/2023 academic year in two classes A (n=25) and class B (n=25). Meanwhile, class C (n=26) was used to test the creativity test instruments for prospective students.

Before the creativity test instrument for prospective mathematics teachers was used, the instrument was assessed by three experts to prove its content validity. Content validity is calculated using Aiken's V formula. The results show that each test item has a V Aiken index in the high category, namely $V \geq 0,8$ (Retnawati, 2017). Apart from that, from the results of the validator assessment from both language, material, and construction aspects, the test instrument has a V Aiken index in the high category too. Because every test item and every aspect (material, construction, and language) of the instrument has a high V Aiken index, the instrument has been

proven valid according to expert assessment. Meanwhile, construct validity was carried out using confirmatory factor analysis. Several aspects that are observable variables for developing creativity test instruments are sensitivity, elaboration, fluency, flexibility, and originality (Cropley, 1967). The following Table 1 shows several questions used to measure student creativity in developing learning media.

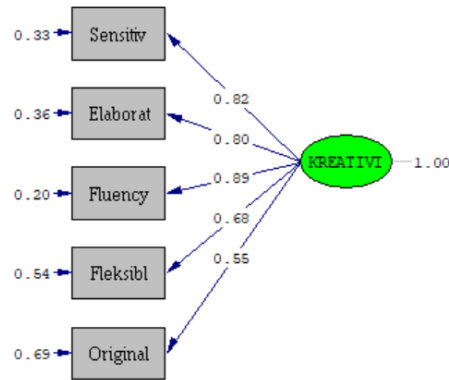
Table 1 Aspect, indicator, and questions for creativity test

Aspect	indicator	Questions
Sensitivity	Students can explain the reasons and urgency for developing teaching aids and learning media	Mention the name of the media product and props that you will develop. Explain the reasons and urgency for the development of media and mathematics teaching aids that you will carry out?
Elaboration	Students can make strategic plans to develop teaching aids and media from the initial stage until they can be used in detail	Make a strategic plan to create/realize the media and teaching aids for mathematics that you will develop!
Fluency	Students can explain how to use teaching aids and mathematics learning media well	How do you operate the media and props that you will create?
Flexible	Students can explain the use of media and teaching aids to solve various mathematical problems	How are the media and teaching aids that you developed useful for solving mathematical problems?
Original	Students can show the novelty of the teaching aids and mathematics learning media that will be developed	Explain the novelty of the media and props that you are developing!

The assessment rubric in this study used a holistic assessment by considering several criteria such as relevance, clarity, accuracy and completeness. Utilizing this rubric, scores ranging from 0 to 4 points were allocated to assess the responses of prospective teachers in each indicator of the creativity test. A minimum score of 0 is obtained by teacher candidates who do not provide any answers at all. This means that the prospective teacher is not able to achieve the abilities according to the indicators that correspond to the questions he did not answer. Meanwhile, a score of 4 is given to prospective teachers who are able to demonstrate abilities

according to the indicators seen from answers that are complete, precise, clear and interrelated.

After getting scores in each aspect of creativity, we proved construct validity through CFA with the help of Lisrel 8.80 as in Figure 1 below.



Chi-Square=4.81, df=5, P-value=0.44010, RMSEA=0.000

Figure 1. Student Creativity Theory Construct (Use First-Order Confirmatory Factor Analysis)

Figure 1 shows a standard model with factor loads (path coefficients from variable to variable) ranging from moderately high to exceptionally high (respectively from 'sensitivity' to 'original' variables), namely 0.82, 0.80, 0.89, 0.68, and 0.55. In line with Retnawati, the path coefficient is meaningful if the factor loading is not less than 0.4 (Retnawati, 2016). This indicates that all observable variables make a significant contribution to measuring the latent variable, namely student creativity. Apart from that, the model in Figure 3 was fit because $p\text{-value}=0.44 > 0.05$ and RMSEA was close to 0 or less than 0.08. This is based on the goodness of fit criteria by Schermelleh-Engel et al., (2003). These findings show that, if students are said to be creative in creating media and mathematical teaching aids, they must be sensitive, elaborative, fluent, flexible, and original.

On the other hand, the test instrument also has good discriminating power and can be used because it has a discriminant index of more than 0.3. Meanwhile, construct reliability (CR) estimates were determined using the formula from (Raykov & Penev, 2006) using factor loadings (l) shown in Figure 1.

$$CR = \frac{\sum \frac{l^2}{(1-l^2)}}{1 + \sum \frac{l^2}{(1-l^2)}} = \frac{8,934096}{9,934096} = 0,899337$$

These calculations show that the construct reliability estimate obtained is 0.899, more than 0.6, so the test instrument used is reliable.

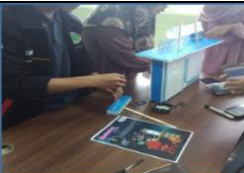


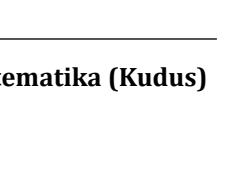
After the creativity test instrument for prospective teachers was declared valid and reliable, we used it to collect data on the creativity of prospective teachers before and after being given the PjBL model treatment which was integrated with mathematics learning media exhibition activities in secondary schools. After obtaining data on the creativity of prospective teachers, we analyzed it using a paired t test assisted by SPSS 26 to find out whether there was a significant difference between the average creativity of prospective teachers before and after being given the PjBL model. Meanwhile, to find out the effectiveness of the learning media exhibition using the PjBL model, we tested the n gain score. The interpretation category for the effectiveness of the n gain score according to Meltzer (2002) is high if the n gain score is more than 0.7. The effectiveness of the model is said to be moderate if the n gain value is between $0,3 \leq g \leq 0,7$. Meanwhile, effectiveness is said to be low if $g < 0,3$.

Result

This research employed a project-based learning model (following the steps outlined by Afriana & Jaka, 2015), which was integrated with media exhibition activities to enhance prospective teacher creativity. A general description of the learning activities that have been carried out can be seen in Table 2.

Table 2. Project-Based Learning Model Learning Steps with Learning Media Exhibition Activities

Activity Steps	Activity Description and creativity dimension
Asking question	At this stage, prospective teachers questioned various problems that arose during mathematics learning at school. Students specifically identified problems experienced by students in certain mathematics materials. This identification was carried out by exploring various previous research results and conducting interviews with several students and teachers. Besides identifying difficulties and problems faced by students and teachers, students in groups thought about various possible solutions through media and teaching aids. This stage was conducted in class, and the results of their identification were presented in front of the class. Meanwhile, other groups responded and asked questions (<i>sensitivity</i>).
Create project designs	Students in groups created media designs and props to realize ideas or solutions obtained from their group discussions. At this stage, students also thought about the various tools, materials, and software needed for

	<p>media design and props. They also considered project work strategies and determined the name of the product, as well as its use and how it worked. During this stage, the lecturer helped direct students to design appropriate media designs and props to overcome the problems that had been identified. The lecturer also directed students to hold a large discussion (across classes) to discuss the design of the place/stand for each group (fluency, originality, flexibility).</p>	
<p>Make schedule</p>	<p>Students together determined a schedule for making products according to the designs they had made. This stage allowed students to work on projects outside the learning media course schedule. Additionally, the schedule was also determined by the lecturer to allocate time for conducting FGD activities and the final activity in the form of an exhibition, as well as the product assessment stage. (elaboration)</p>	
<p>Monitoring students and the progress of projects as well as FGDs</p>	<p>This activity was carried out by lecturers to assess to what extent students and their groups had completed their product designs and to ensure that the products made complied with the designs that had been prepared. Lecturers also provided advice on media development difficulties experienced by students. On the other hand, other groups were allowed to provide constructive suggestions regarding the difficulties experienced by other students. After the groups perfected their products, an FGD was held, concluding with IT experts. This was due to the importance of choosing the right media to accommodate and support the existence of teaching aids that had been designed to make it easier for students to access them. (elaboration, sensitivity, fluency, flexibility, originality)</p>	
<p>Expo and assessment of results and evaluation of experience</p>	<p>This stage provided students with the opportunity to showcase the media products and teaching aids they had created to other students, both from the Mathematics Education study program and other study programs. Not only were students present, but this activity was also attended by several lecturers and practical teaching staff. Some lecturers who attended provided constructive input and suggestions; for example, they mentioned that students' results/products could be patented. The evaluation stage was conducted by asking students to assess their performance in the group (self-assessment) and evaluate the performance of their</p>	

group members (peer assessment). This stage encouraged students to recognize strengths and weaknesses in creating mathematical media and teaching aids and prompted them to propose improvements they could make. (*sensitivity, elaboration, fluency*)

Before testing the hypothesis, a prerequisite test for homogeneity and normality was carried out on student creativity data before and after being given treatment. The results of the homogeneity test with the Lavene test show the $p_{value} = 0,142 \geq \alpha = 0.01$ so that H_0 was accepted. In other words, the pretest and posttest data groups for student creativity were significantly homogeneous. Meanwhile, the results of the normality test using the Shapiro Wilk test on the pretest data showed a value of $p_{value} = 0,013 \geq \alpha = 0.01$ and the posttest data group showed a value of $p_{value} = 0,122 \geq \alpha = 0.01$ so that the test decision from H_0 was accepted. This shows that the pretest and posttest groups for student creativity significantly come from a population that has a normal distribution. The mean pretest and posttest scores for student creativity can be seen in Table 2.

Table 3. The mean and standard deviation of students' creativity pretest and posttest scores before and after being subjected to the PjBL model which was integrated with media exhibition activities

Group		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pretest	61.4800	50	5.40876	0.76491
	Posttest	80.0500	50	5.03787	0.71246

Based on Table 3, it is known that the average student's creativity score before being given treatment is not greater than the average student's creativity score after being given the PjBL model which was integrated with the learning media exhibition. Next, a hypothesis test was conducted using a paired t-test on both groups, resulting in a p-value of 0.000, which is less than the significance level (α) of 0.01. Therefore, the null hypothesis (H_0) was rejected. This means that there is a statistically significant difference between the mean of creativity of prospective mathematics teachers before and after implementing the PjBL model and exhibition activity. In addition, the N-gain was calculated, resulting in a value of 0.48. These results fall within the medium category of effectiveness, according to the criteria established by Meltzer (2002). This means that the effectiveness of increasing the creativity of prospective teachers after implementing media exhibition activities through PjBL is in the medium category. The results of the N-gain value indicated

that the implementation of the mathematics learning media exhibition for secondary schools through the PjBL model has shown a positive impact on increasing the creativity of prospective mathematics teachers at IAIN Kudus. In addition, n gain from each aspect of creativity shown in Table 4.

Table 4. The Difference Between the Pretest Mean And Posttest Mean in Creativity Indicators

Indicator of Creativity	Pretest Mean	Posttest Mean	Difference	N Gain	Category
Sensitivity	2,98	3,73	0,75	0,73	High
Elaboration	2,708	3,25	0,542	0,42	Moderate
Fluency	2,43	3,11	0,68	0,43	Moderate
Fleksibel	2,168	2,99	0,822	0,45	Moderate
Original	2,01	2,93	0,92	0,46	Moderate

Discussion

The increased creativity of prospective mathematics teachers is due to lecture activities oriented to the PjBL model encouraging prospective teachers to innovate and collaborate in creating learning media. Before developing learning media, prospective teachers analyze the needs of students and teachers in learning mathematics. Teacher candidates collaborate with their group members to explore various ideas to meet the needs of these students and teachers. They actively conduct literature reviews and explore various digital media and other tools that can help realize their ideas. Prospective teachers are not only selective in choosing development ideas to be realized, but also consider the authenticity and novelty of the products to be developed.

The application of this learning model can encourage students to think critically to explore various problems in mathematics classes and turn them into ideas/bases for developing learning media. Apart from that, students are also required to be creative and innovative in developing learning media products together with their groups. FGD through the PjBL model also provides the opportunity for each group to provide input and comments on the media and teaching aids that their friends have developed. Prospective teachers who act as assessors will provide positive assessments to their colleagues so that they can provide feedback together until a valuable educational program is realized to increase creativity (Zhang, Pi, Chen, Zhang, & Yang, 2021). This is in line with several empirical findings which show that the application of the PjBL model has a good impact on student creativity (Ummah, Inam, & Azmi, 2019; Usmeldi, 2019; Yamin, Permanasari, Redjeki, & Sopandi, 2020) and student learning outcomes (Fadhil et

al., 2021). On this basis, implementing media exhibition activities through project-based learning can be a valuable and sustainable program for training and increasing the creativity of prospective teachers in the mathematics education department.

The most significant enhancement occurred in the sensitivity aspect, nearly incorporated in every PjBL model activity. For instance, during the initial stage of PjBL, prospective teachers were prompted to actively explore various issues faced by both teachers and students. They delved into research findings and conducted direct interviews with practitioners and students. Meanwhile, other aspects fell within the medium category. These facets were addressed in PjBL activities, encompassing planning and development stages significantly influenced by students' knowledge, experience, and active involvement. Despite this course being introduced at the start of the second year, additional courses necessary for media development were inaccessible to prospective teachers. Moreover, they bore the responsibility of attending lectures in other subjects, leading to time constraints. Recognizing that the PjBL learning model escalated workload and time commitment for both teachers and students (Halimatusyadiyah, Anasya, & Pajri, 2022), the result in Table 4 demonstrated the effectiveness of the PjBL model and exhibition activities in enhancing every aspect of prospective teacher creativity in media development.

However, this research still needs to be followed up because it only pays attention to external factors that can influence student creativity. For example, research regarding the application of the PjBL model by paying attention to internal factors of prospective teachers. In fact, further research can also be carried out by developing a PjBL model based on the intrinsic characteristics of prospective teachers. In line with Larraz-Rábanos (2021), apart from developing creativity in the curriculum which can be done through teaching and learning models, teachers also need to pay attention to the psychological processes involved in implementing these models. Apart from that, implementing this model requires lecturers to continue to develop their insight because the ideas and products produced by prospective teachers are not the same and are very developed. Apart from that, lecturers who give lecture assignments that involve creativity must be able to encourage their students to be skilled at higher level thinking, skilled at solving problems, thinking critically, and able to connect the subjects studied with their needs in the future. On the other hand, the research samples taken were relatively small.

Apart from this research testing the effectiveness of the PjBL model and media exhibition activities, this research produces media products that can be used by prospective mathematics teachers when practicing teaching at school. The

application of the PjBL model in the classes of mathematics learning media can be a reference for application in other courses. In other words, lecture activities in class are not only oriented towards understanding theory but are also oriented towards results through higher stages of thinking, namely creating.

Conclusion

In summary, the findings reveal a noteworthy enhancement in the creativity of prospective teachers following their engagement in media exhibition activities through project-based learning (PjBL). To further investigate creativity, future studies might consider exploring the application of prospective teachers' creativity in addressing contemporary issues with mathematical dimensions, fostering active and constructive contributions for the society. This exploration could be facilitated through qualitative and experimental research methodologies. Additionally, extending the development of the PjBL model to stimulate the entrepreneurial intentions of prospective mathematics teachers, integrating it with the utilization of the surrounding environment, holds potential for further research.

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