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Hypothetical Learning Trajectory for Prospective Elementary School Teachers in Learning Mathematics Assisted Artificial Intelligence Based on STEM

Arvin Efriani*, Sujinal Arifin
Universitas Islam Negeri Raden Fatah Palembang, Indonesia.
*Corresponding Author. Email: arvinefriani_uin@radenfatah.ac.id

Abstract: This study aims to analyze the process of designing Hypothetical Learning Trajectory of STEM Learning assisted by Artificial Intelligence (AI) for prospective teachers and its application in Madrasah Ibtidaiyah Mathematics courses. This research method used a design research (DR) with a qualitative approach. The subjects of this study were Prospective elementary school teachers Madrasah Ibtidaiyah students totaling 102 people from 25 groups. This study was divided into three stages, namely preparation of the experiment (design), implementation of the learning experiment, and retrospective analysis. The data collection techniques used in this study were observation, interviews, and questionnaires. Then the data was analyzed qualitatively with the stages of data reduction, data presentation, and drawing conclusions. The product of this study was an estimate of the STEM learning trajectory assisted by Artificial Intelligence (AI) which contained the following activities: exploring information, finding learning concepts, initiating ideas, and developing ideas. These four activities were carried out in a two-cycle experimental activity. After the activities were carried out, the prospective teacher students showed that they could design activities according to the stages given. There were 8 activity designs at the pilot experiment stage and 17 activity designs at the teaching experiment stage. The results of the activity design should be tested to suit the students' abilities.

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Introduction

Mathematics learning plays an important role in the formation of the cognitive foundation of elementary school students. However, many prospective primary school teachers still experience difficulties in understanding and teaching basic mathematical concepts effectively (Superfine et al., 2020; Yilmaz, 2020). This creates a need for innovative approaches in mathematics education for prospective primary school teachers. Furthermore, Copur-Gencturk et al (2019) identified a gap between knowledge of mathematical content and pedagogical knowledge of mathematical content among prospective teachers, resulting in challenges in transferring their understanding into effective teaching practices. This creates a need for innovative approaches in mathematics education for prospective primary school teachers.

The gap between the knowledge of mathematical content and the pedagogical knowledge of mathematical content among prospective teachers, results in challenges in transferring their understanding into effective teaching practice. Jakobsen et al. (2016) point out that while prospective teachers may have a good understanding of mathematics, they often have difficulty applying this knowledge in a teaching context. As a result, elementary school students may not receive the strong mathematical foundation they need to succeed in further education and future careers (X. Chen, 2009; Y. Chen et al., 2024; KAZU & YALÇIN, 2021). In fact, effective early mathematics learning has an important role for long-term academic achievement and career success (Lang et al., 2018).

To address this problem, an interdisciplinary approach that combines modern technology with strong learning theories has shown promising results. For example, the integration of STEM-based learning (Science, Technology, Engineering, and Mathematics) has been proven to improve conceptual understanding and problem-solving skills of prospective teachers (Yildirim, 2021). Additionally, the use of Artificial Intelligence (AI) in teacher training has shown the potential to provide a more personalized and adaptive learning experience (Ayala-pazmi & Hisp, 2023; Lin et al., 2023).

Yildirim (2021) further elaborates that STEM learning in the education of prospective mathematics teachers not only improve conceptual understanding, but also develop 21st-century skills. Yildirim emphasized that STEM-based learning experiences help prospective teachers develop "pedagogical design capacity" - the ability to design meaningful and relevant learning experiences for students. This is especially important given the challenges faced in transferring content knowledge into effective teaching practices, as identified by Jakobsen et al (2016) Furthermore, Yildirim (2021)argues that STEM learning can help bridge the gap between theory and practice, giving aspiring teachers the opportunity to apply their mathematical knowledge in a broader real-world context, aligning with the demands of future careers.

The integration of STEM learning with Hypothetical Learning Trajectory (HLT) in mathematics learning has emerged as a promising area of research. HLT, which provides a framework for planning and analyzing math learning, can be enriched with context and applications from other STEM disciplines. Wickstrom et al. (2022) demonstrated how HLT can be used to design math learning in an engineering context, allowing students to see the relevance of mathematics in real-world problem-solving. In line with this, Stohlmann et al. (2020) explore the use of HLT in the development of an integrated STEM curriculum, demonstrating that this approach can improve students' conceptual understanding and knowledge transfer abilities across disciplines. Furthermore, Wan et al., (2023)identified that the use of HLT in STEM contexts can help teachers anticipate and overcome student misconceptions more effectively, especially when mathematical concepts are applied in interdisciplinary situations. Hanan & Agoestanto (2022) dan Sastradika & Defrianti (2020) expand this understanding by showing how HLT can be used to design STEM learning experiences that support the gradual development of students' mathematical reasoning. This integration of STEM and HLT not only increases the relevance and applicability of math learning, but also supports the development of problem-solving and critical thinking skills that are essential for success in today's digital age.

The exploration of the integration of STEM (Science, Technology, Engineering, and Mathematics), Hypothetical Learning Trajectory (HLT), and Artificial Intelligence (AI) in the development of mathematics learning has emerged as a promising and innovative research area. Triplett (2023) demonstrates how AI can be used to optimize STEM-based learning, including in the context of mathematics, by providing a more personalized and adaptive learning experience. In line with this, Hwang et al. (2020) explored the use of AI-based intelligent learning systems to support the implementation of HLT in STEM learning, demonstrating significant improvements in students' conceptual comprehension and problem-solving skills. Chen et al. (2022) further identified the potential of AI in predicting and analyzing student learning trajectories in STEM contexts, allowing for real-time adjustments to the HLT used. Research by Wan et al., (2023) shows how the integration of AI in STEM-

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based math learning can help identify and address student knowledge gaps more effectively, aligned with HLT principles. Furthermore, Triplett (2023) explore the use of machine learning techniques to optimize the design and implementation of HLT in the context of STEM integrated mathematics learning, demonstrating the potential of AI to improve the effectiveness and personalization of learning trajectory. The integration of these three elements – STEM, HLT, and AI – not only offers the potential to improve the quality and effectiveness of math learning, but also paves the way for the development of educational models that are more responsive and adaptive to the individual needs of students in the digital age.

There has been a lot of research related to HLT design such as (Agustiani & Nursalim, 2020) related to the logic of proof in the mathematics education study program, (Prahmana & Kusumah, 2016) related to mathematics learning in the mathematics education study program, (Efriani et al., 2023) related to STEM but for PGPAUD students, (Susanti & Kurniawan, 2020) related to number patterns in junior high school. This shows that research is important to be carried out in order to know the students' conjectures and ways of thinking. However, learning design research that contains allegations has never been conducted with prospective elementary school teacher students. Based on the results of observations with PGMI students who have taken field practice courses (internships), it turns out that when students practice, they teach mathematics like what they get when they are students. So that there are no learning stages that are in accordance with the activity. The activities are given without any conjecture and the flow of students' thinking. Therefore, it is important to teach design, especially PGMI students. This is because PGMI students will later become teachers in elementary schools (Ahmad et al., 2018; Kenedi, 2018). Elementary school is the first formal school that is the foundation for students to understand the concept of the material received. Thus, the researcher will conduct research related to AI-assisted STEM learning design by prospective PGMI teacher students. This study aims to analyze the process of designing Hypothetical Learning Trajectory of STEM Learning assisted by Artificial Intelligence (AI) for prospective teachers and its application in Madrasah Ibtidaiyah mathematics courses.

Research Method

This type of research is a design research (DR) (Gravemeijer, 2016; Prahmana, 2017) with a qualitative approach that aims to describe the process of designing a Hypothetical Learning Trajectory for Artificial Intelligence (AI)-assisted STEM Learning for Teacher Prospective Students. This research activity has been carried out in the even semester of the 2023/2024 school year. The subjects in this study are PGMI 7 teacher candidate students for cycle 1 and PGMI 8 and PGMI 9 teacher candidate students for cycle 2. The selection of research subjects used purposive sampling techniques. The experimental activities in this study were carried out offline. In addition, this study involved 3 experts for the HLT validation process.

This research is divided into three stages, namely the experimental preparation stage, the experimental design stage, and the retrospective analysis stage (Gravemeijer, 2015). Based on the theory of design research implementation, these stages take place in several cycles, where the research subjects in each cycle come from different classes. These cycles depend on the purpose of the research. In this study, the stages of design research are carried out in two cycles.

The data collection techniques in this study are questionnaires, observations, interviews, and documentation. The questionnaire instrument is used during expert reviews to

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get input and recommendations from experts about HLT. Interviews and observations were conducted to obtain data on the implementation of the HLT designed and its impact in supporting students in designing learning. The objects observed in this activity are the learning process and student design results. All research data is documented.

According to Bogdan and Biklen (Moleong, 2019), qualitative data analysis is a data processing activity that includes organizing data, sorting data into units using data codes, synthesizing, searching and finding patterns, reducing important data, and deciding what to describe to others. Qualitative data analysis is carried out continuously during research activities and intensively after leaving the research field to identify data that may be able to answer research questions (Moleong, 2019). In general, the steps of qualitative data analysis include data reduction, data presentation, and drawing conclusions. In this study, the data analyzed were HLT validation and HLT implementation.

Results and Discussion

In the Preparation stage of Trial/Experiment Activities, it begins by reviewing the theory and designing HLT. HLT contains mathematical goals, teaching learning activities, and conjectures of student's thinking. Based on the study of theory and experience of researchers teaching MI mathematics, the researcher compiled HLT which consists of 4 learning activities, namely activities to explore information, find learning concepts, initiate ideas, and develop ideas. These four activities are a series of activities that are suspected to help students design MI mathematics learning.

Furthermore, the HLT was carried out by an expert review process with 3 experts (MY, IBS, HT). From the results of the review, MY and IBS experts suggested describing the activities according to the STEM stages. Based on discussions with the team, the activities used are still the four activities, while the description of the STEM stages is described in activity 3 (idea initiation) and activity 4 (idea development). This is because of the researcher's hope that STEM learning will be implemented when prospective teacher students carry out the third and fourth activities. Meanwhile, the activity designed is a stage of how prospective teacher students can apply STEM learning assisted by artificial intelligence. Another review result is to adjust learning objectives to the ABCD (Audience, Behaviour, Condition, and Degree). As for the suggestion, the conjecture of the students' answers remained the same as the previously designed activities. This is because the design made is a learning design that will be carried out by students related to pedagogic, not conceptually that can be solved mathematically, so that the conjecture is a process of learning implementation. The results of the HLT that have been revised are as shown in figure 1.

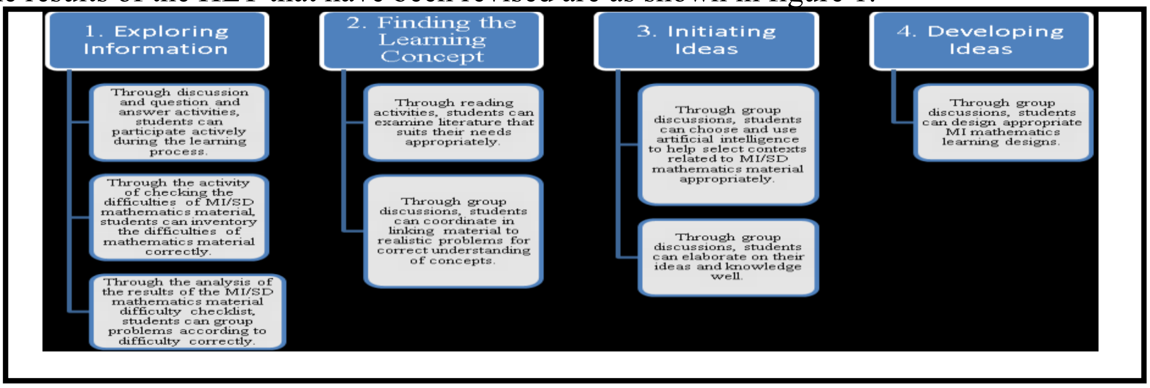

Figure 1. Hyphotetical Learning Tracjectory (HLT) STEM Learning

After the HLT and instruments have been reviewed and repaired, it will be continued with the next stage, namely the implementation stage. In the implementation stage, the HLT design results in the form of four activities were piloted to the pilot experiment stage. At this stage, it has been piloted in 1 class, namely PGMI 7 whose members are divided into 9 groups. The results of the activities produced are as follows:

In activity 1, exploring information, the goal is to multiply the information to inventory the suitability of mathematical material and group the problems according to the difficulty. Based on the results of exploring information, it turns out that the difficulties of mathematics material experienced by elementary school students and students' experiences when they are in elementary school are the volume material to build space. According to the P1 teacher, most students are not able to use formulas to solve a problem. In addition, according to the P2 teacher, students have difficulty understanding the basic concept of building a space, especially if they do not have a solid foundation in geometry. So that the volume material to build this space will be designed for learning.

In activity 2, finding the learning concept, which is to find a learning concept based on the results of exploring information obtained related to the difficulties of mathematics material in MI/SD, then it is continued by finding the learning concept with the aim of reviewing literature related to mathematics material, whether the mathematics material taught at school is appropriate or not so that the results of the study can overcome the difficulties of learning mathematics or not. Furthermore, students are given activity sheets to try to make a design plan based on the results of the study, so that they can design solutions to MI/SD mathematics learning problems. The following are the results of the K1 and K6 design designs from the results of the concept understanding made as shown in figure 2.

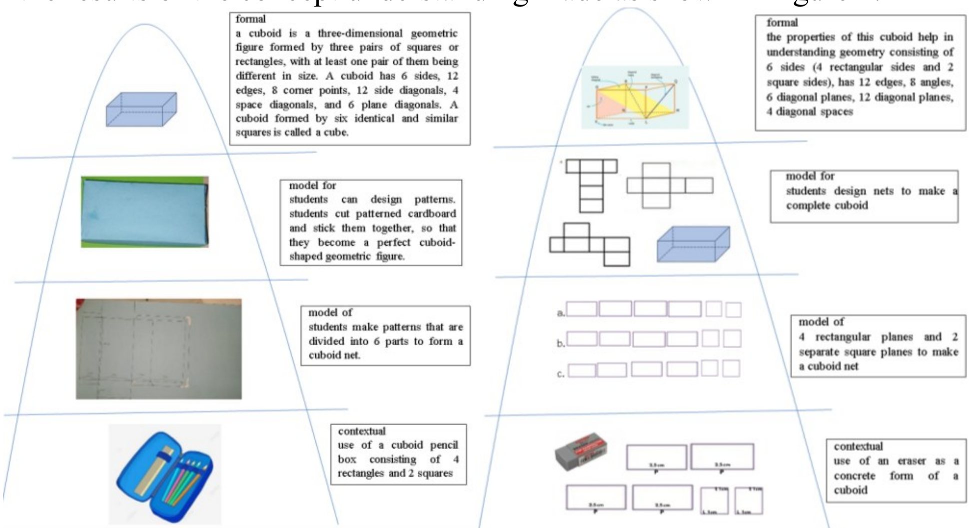

Figure 2. Understanding the Concept of Properties of Cube K1 and K6

From the results of the conceptual understanding that has been carried out, it can be seen that K1 and K6 found different concepts, for K1 the concept found is correct using contextual objects, namely erasers, while K6 the contextual objects used are not appropriate, namely pencil boxes, pencil boxes used do not meet the characteristics of the blocks, the angle of the beam formed is not 90 degrees. In addition, at the stage of the model of seen for K1 to utilize the context used by understanding the parts of the block, while for K6 to directly determine the nets do not utilize the context used. The activities used by K6 in the model of and model for stages are the same, so that the level of conceptual understanding for block property material is not seen. In addition, the design of the concept understanding given should be related to the volume material of the beam, not the properties of the beam. This shows the need for prerequisite material that must be understood so that the concepts given are in accordance with the directions and stages. This is because to study the volume of building a space, first know the building properties of the space.

In the third activity, initiating idea, is carried out using the help of artificial intelligence for idea discovery in designing MI/SD mathematics learning designs. In addition, students can also choose a context related to MI/SD mathematics material. Furthermore, students connect contexts related to the material with STEM and use the PMRI concept. In initiating ideas, students use artificial intelligence, namely chat gpt.

The results obtained from the search using chat gpt are storage of goods and packing. From this idea, students use the context of boxes in the delivery of goods by couriers. From this context, stages are designed in accordance with the PMRI stages. In the Contextual stage, students choose the right boxes according to the number and size of the goods they will be sent. In the Model of : Students are able to observe how several factors, such as the size and shape of the goods, as well as the availability of boxes, affect the selection of boxes for delivery. In the Model for: students begin to compare how large the goods will be delivered with the boxes needed to accommodate all the goods. In the Formal stage: Students use the formula for the volume of the block space: Length x Width x Height. Furthermore, the relationship with STEM. In Science: Knowledge of physics will consider the material properties of the goods to be shipped, such as weight, density, and strength. Technology: Technology can be used to develop software or applications that help calculate the volume of goods and select the right boxes. In engineering: Engineering principles are used in designing efficient and sturdy boxes. This includes the selection of appropriate materials, structural design to support the load, and optimal use of space to minimize the waste of free space. In mathematics: calculation of the volume of the space, volume and mileage, as well as to predict how changes in the size or number of items will affect the choice of the box needed.

In the fourth activity, developing idea, the stages of activities are presented in accordance with STEM learning using the engineering design process (EDP) stages. In addition, this EDP stage is also linked to the STEM and PMRI concepts that have been planned in the activity of initiating ideas. There are 5 stages of the engineering design process (EDP) used, namely problem analysis, problem identification, initiating ideas, testing ideas, and communicating. At the problem analysis stage, the initial design made does not appear to show the problem used, but after experiencing improvements, the questions expressed are adjusted to the designed concept, and lead students to answer based on the given problem. In the problem identification stage, the initial design of the question is almost the same as the problem analysis stage and the question asks students to determine how to determine the volume of the beam. In fact, it is better for students to identify questions at this stage based on the problems given by accompanying students to find the concept. At the stage of conceptualizing ideas, questions are given related to what ideas can be used to solve problems. The ideas used are adjusted to the PMRI stages where students are asked to provide ideas in solving problems starting from the use of non-standard measuring tools, standard measuring tools ending with the use of formulas. Furthermore, at the stage of testing the design, students should be able to do it based on experience and practice so that there are many assumptions generated. Meanwhile, at the stage of communication, students should be able to conclude problems from the activities that have been carried out, instead of asking how the understanding of concepts can be used in life. From the results of the pilot experiment stage, there are several improvements, namely the HLT application process should be given to subjects who already have an understanding of mathematical concepts so that they do not have difficulties in the stage of finding learning concepts. The researcher asked students to use diverse artificial intelligence, not just ChatGPT in initiating ideas. At the idea development stage, previously students only developed ideas using the EDP stage which contained questions and answers but not perfectly, so improvements were made by students being asked to develop ideas produced by utilizing artificial intelligence to make them more interesting and disseminated.

Furthermore, after making improvements from the pilot experiment stage, it was continued to the teaching experiment stage. At the teaching experiment stage, it was piloted in 2 classes, namely PGMI 8 and PGMI 9 with 17 groups. The selection of subjects is adjusted to the results of the previous stage improvement, namely choosing subjects who already have an understanding of mathematical concepts. The subject of this teaching experiment has received materials/lectures related to the stages of teaching MI mathematics according to the concept.

In activity 1, exploring information in the teaching experiment stage, it turned out that the material that was difficult for students to understand, namely the volume of the space. This is the same as what was done in the pilot experiment stage. In activity 2, finding the learning concept, did not experience problems like in the pilot experiment stage. This is because the concept of the subject chosen is adjusted to the results of improvement, namely choosing subjects who already have an understanding of mathematical concepts, so that it makes it easier in the process of finding the learning concepts according to the difficulties experienced. The concepts used for learning the volume of space building material are in accordance with the PMRI stages that have been designed, starting from the use of contextual, then at the model stage of using non-standard measuring tools, at the model stage for using standard measuring tools and the formal stage namely the use of formulas.

In the third activity, initiating idea, is carried out using the help of artificial intelligence for idea discovery in designing MI/SD mathematics learning designs. Because students already have an understanding of finding concepts so that in initiating ideas with the help of Artificial Intelligence they are more directed and the ideas given are also more interesting. The context used is to measure the volume of ice stone molds. From this context, stages are designed in accordance with the PMRI stages. At the contextual stage: Making ice cubes from water (liquid). At the model stage of: Measure using non-standard tools the volume of water needed to make ice cubes. At the model stage for: Measuring using raw materials and proving the change of the form of water into ice cubes. At the formal stage: Explain the cube volume formula. Furthermore, the context is also related to STEM. In Science, it is the change of the form of water into ice cubes and vice versa. Students can explain the process of changing liquid water to solid (frozen) and the reverse process through experiments clearly. Students can identify factors that affect the speed of water freezing. Technology: An instrument used when measuring water volume and freezing time. Students can use measuring tools such as spoons and ice cube molds to measure the volume of water correctly. Students can use a stopwatch or timer to measure the time it takes for water to freeze into ice cubes precisely. In Engineering: The process of making and measuring ice cubes. Students can design and conduct experiments to make ice cubes from water using various methods correctly. Students can measure and compare the results of ice cube making experiments with different methods. In Mathematics: Measure volume and count the number of ice cubes. Students can correctly measure the volume of water used to make ice cubes using a standard measuring instrument (e.g., measuring cup). Students can calculate the volume of ice cubes using the cube volume formula and calculate the number of ice cubes produced from the mold precisely. The results of the ideas produced are as shown in the figure 3a.

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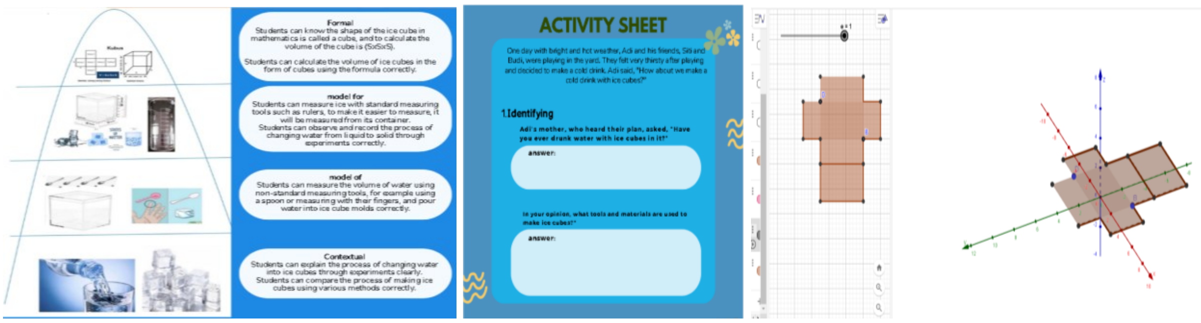

(a) (b)

Figure 3. (a) Activity 3 results of initiating ideas (b) Developing Idea Products

In the fourth activity, developing idea, the stages of activities are presented in accordance with STEM learning using the engineering design process (EDP) stages. In addition, this EDP stage is also connected to the PMRI and STEM concepts that have been planned in the activity of initiating ideas. At this stage, the process of making a plan and making improvements is carried out in the same way as a pilot experiment. The only difference is that the activities are designed to be further developed. The activity is designed in the form of a teaching module that not only presents questions, then adds visualizations in the form of using geogebra, and asks questions related to problem solving that are adapted to the context used.

Based on the results of the pilot experiment and teaching experiment, it can be seen that changes in the knowledge possessed by the research subjects will affect the quality of the design results obtained. It can be seen that in the pilot experiment stage, the subjects used do not have an understanding of mathematical concepts, while in the teaching experiment stage, subjects who already have an understanding of mathematical concepts are used. This will affect the second activity, which is to find the concept of learning. In the subject of the pilot experiment stage in finding concepts does not directly determine the intended concept according to the requested material, while in the teaching experiment stage it can directly determine the concept according to what is requested. In the pilot experiment stage, students have difficulty finding the concept of the volume of building a space so that they find the concept of the nature of building a space first, while in the teaching experiment stage, they can immediately find the concept of building volume of space starting from contextual, model of, model for, to formal. From these results, it is proven that subjects who have an earlier understanding of concepts will get better results than those who are new to learning. This is supported by the results of his research Wan et al., (2023) that STEM learning can be improved when teachers have sufficient content knowledge. Subjects who have an early understanding of the concept will affect the next stage such as in activity 3, which is to initiate ideas. This can be seen from the design results carried out by prospective teacher students that the initial idea of the context used in the pilot experiment stage is still simple, has not shown a connection with STEM, especially in the science section. Almost every group only thinks about the stages of learning mathematically but does not involve science in the learning process. Even though science has an influence in studying mathematics. This is because studying science in a relevant context and being able to transfer scientific knowledge to authentic situations is the key to true understanding (Chakravartty, 2023; Herfeld & Lisciandra, 2019).

From the results of the study, it was obtained that the context used in the pilot experiment stage was the delivery of packages using boxes by couriers while the teaching experiment used the context of ice cube molds. The context used by the teaching experiment is more visible in the science process and can be practiced by students, while at the stage of the pilot experiment it also still has a relationship with science, namely on material properties such as weight but the science activity cannot be practiced by students. This is because with science, students can find out the phenomena that occur (Heryuriani, 2020). In addition, Khuyen et al., (2024) also suggests that learning with practices can help in integrating STEM learning. Based on the results obtained, it turns out that the quality of the teaching experiment design results is more creative and adjusts to the PMRI and STEM concepts requested.

In addition, in the activity of brainstorming ideas using the help of artificial intelligence. The artificial intelligence used is chat gpt, Gemini, open.ai. Artificial intelligence is used only as a tool. This is because the results displayed through artificial intelligence are only limited to keywords that must be associated with the learning process, the suitability of the material experienced by students, and the proximity of the context to the activities carried out by students. This research is in contrast to Lukman (2023) that AI can provide problems for students. But in line with Putri (2023) that learning with the help of AI becomes more effective.

In addition, the linkage of STEM in learning design can be seen in the engineering stages that are designed in accordance with the engineering design process (EDP) (Capraro, 2013; Jang, 2016). The stages of EDP are problem analysis, problem identification, initiating ideas, testing designs and communicating. The difficulties experienced by prospective teacher students are difficulties in making questions that adjust to the mathematical stages and guessing student answers related to the questions made. Questions made by prospective teacher students are difficult for students to answer based on experience and are not suitable for elementary school students. So that the questions given must accompany students based on the experience carried out so that students do not experience difficulties and unconsciously get learning from the experience.

Conclusion

This research resulted in the design of Artificial Intelligent (AI)-assisted STEM Learning Trajectory for Teacher Prospective Students which contains activities to exploring information, finding the learning concept, initiating ideas, and developing ideas. After the implementation of the experimental activities, it was shown that the implementation of students in designing STEM learning assisted by artificial intelligence was good where all groups could complete the requested design.

Recommendation

Further research can develop the results of the learning trajectory in the form of teaching material products from each material. For teachers and/or prospective elementary school teacher can use learning trajectory in the learning process in the class.

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References

Agustiani, R., & Nursalim, R. (2020). Hypothetical learning trajectory (HLT) for proof logic topics on algebra course: What're the experts think about? *Al-Jabar : Jurnal Pendidikan Matematika*, *11*(1), 101–110. https://doi.org/10.24042/ajpm.v11i1.6204

Ahmad, S., Prahmana, R. C. I., Kenedi, A. K., Helsa, Y., Arianil, Y., & Zainil, M. (2018). The instruments of higher order thinking skills. *Journal of Physics: Conference Series*, *943*(1).

Ayala-pazmi, M. F., & Hisp, E. (2023). *Inteligencia artificial en la educación: Explorando los beneficios y riesgos potenciales Artificial Intelligence in Education: Exploring the Potential Benefits and Risks*. *3*, 892–899.

Capraro, R. M. (2013). *Stem project-based learning*. SENSE PUBLISHERS.

Chakravartty, A. (2023). Scientific Knowledge vs. Knowledge of Science: Public Understanding and Science in Society. *Science and Education*, *32*(6), 1795–1812.

Chen, X. (2009). Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education. Stats in Brief. NCES 2009-161. *National Center for Education Statistics*.

Chen, X., Zou, D., Xie, H., Cheng, G., & Liu, C. (2022). Two Decades of Artificial Intelligence in Education: Contributors, Collaborations, Research Topics, Challenges, and Future Directions. *Educational Technology and Society*, *25*(1), 28–47.

Chen, Y., Wing, W., So, M., Zhu, J., Wing, S., & Chiu, K. (2024). STEM learning opportunities and career aspirations : the interactive effect of students ' self ‑ concept and perceptions of STEM professionals. *International Journal of STEM Education*.

Copur-Gencturk, Y., Plowman, D., & Bai, H. (2019). Mathematics Teachers' Learning: Identifying Key Learning Opportunities Linked to Teachers' Knowledge Growth. *American Educational Research Journal*, *56*(5), 1590–1628.

Efriani, A., Zulkardi, Putri, R. I. I., & Aisyah, N. (2023). Developing a learning environment based on science, technology, engineering, and mathematics for pre-service teachers of early childhood teacher education. *Journal on Mathematics Education*, *14*(4), 647.

Gravemeijer, K. (2015). Design research on local instruction theories in mathematics education. *Development of Mathematics Teaching: Design, Scale, Effects. Proceedings of MADIF9*, 1–3.

Gravemeijer, K. (2016). Design-research-based curriculum innovation design research como modo de inovação curricular. *Quadrante*, *15*(2), 7–23.

Hanan, F., & Agoestanto, A. (2022). Development of STEM-Based Learning Tools to Increase Students ' Mathematical Creative Thinking Ability through Inquiry Learning. *Unnes Journal of Mathematics Education*, *6927*(1), 21–30.

Herfeld, C., & Lisciandra, C. (2019). Knowledge transfer and its contexts. *Studies in History and Philosophy of Science Part A*, *77*, 1–10.

Heryuriani, B. (2020). Pembelajaran Materi Aritmetika Sosial Dengan Pendekatan STEM. *INOMATIKA*, *2*(2), 147–160.

Hwang, G. J., Xie, H., Wah, B. W., & Gašević, D. (2020). Vision, challenges, roles and research issues of Artificial Intelligence in Education. *Computers and Education: Artificial Intelligence*, *1*, 1–5. https://doi.org/10.1016/j.caeai.2020.100001

Jakobsen, A., Kazima, M., & Kasoka, D. N. (2016). *Assessing prospective teachers ' development of MKT through their teacher education : a Malawian case*. *1995*.

Jang, H. (2016). Identifying 21st Century STEM Competencies Using Workplace Data. *Journal of Science Education and Technology*, *25*(2), 284–301.

KAZU, İ. Y., & YALÇIN, C. K. (2021). The Effect of Stem Education on Academic Performance : A Meta-Analysis Study. *TOJET: The Turkish Online Journal of Educational Technology*, *20*(4), 101–116.

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pp. 215-225
Email: jklppm@undikma.ac.id

Kenedi, A. K. (2018). Desain Instrument Higher Order Thingking Pada Mata Kuliah Dasar-Dasar Matematika Di Jurusan PGSD. *AR-RIAYAH : Jurnal Pendidikan Dasar*, *2*(1).

Khuyen, N. T. T., Bien, N. Van, Chang, Y.-H., Lin, P.-L., & Chang, C.-Y. (2024). Exploring teachers' epistemological framing through classroom discourse in 6E-STEM classes: From perception to practice. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(9), em2501. https://doi.org/10.29333/ejmste/15023

Lang, C., Bae, S., Battista, C., Qin, S., Chen, T., Evans, T., & Menon, V. (2018). Positive Attitude Toward Math Supports Early Academic Success: Behavioral Evidence and Neurocognitive Mechanisms. *Psychological Science*, *29*, 095679761773552.

Lin, C., Huang, A. Y. Q., & Lu, O. H. T. (2023). Artificial intelligence in intelligent tutoring systems toward sustainable education : a systematic review. *Smart Learning Environments*.

Lukman, Agustina, R., & Rihadatul Aisy. (2023). Problematika Penggunaan Artificial Intelligence (Ai) Untuk Pembelajaran Di Kalangan Mahasiswa Stit Pemalang. *Jurnal Madaniyah*, *13*(2), 242–255.

Moleong, L. J. (2019). *Metodologi penelitian kualitatif (Edisi Revisi)*. Rosdakarya.

Prahmana, R. C. I. (2017). *Design research (Teori dan implementasinya: Suatu pengantar)*. Rajawali Pers.

Prahmana, R. C. I., & Kusumah, Y. S. (2016). The hypothetical learning trajectory on research in mathematics education using research-based learning. *Pedagogika*, *123*(3), 42–54.

Putri, V. A., Andjani, K. C., & Rafael, R. A. (2023). Peran Artificial Intelligence dalam Proses Pembelajaran Mahasiswa di Universitas Negeri Surabaya. *Seminar Nasional Universitas Negeri Surabaya 2023* |, 615–630.

Sastradika, D., & Defrianti, D. (2020). Development of creative thinking skills through STEM-based instruction in senior high school student Development of creative thinking skills through STEM-based instruction in senior high school student. *6th International Conference on Mathematics, Science, and Education (ICMSE 2019)*.

Stohlmann, M. S. (2020). Integrated STEM education through game-based learning. *Mathematics Education Across Cultures: Proceedings of the 42nd Meeting of the North American Chapter of the International Group* :234429599

Superfine, A. C., Prasad, P. V., Welder, R. M., Olanoff, D., & Eubanks-Turner, C. (2020). Exploring mathematical knowledge for teaching teachers: Supporting prospective elementary teachers' relearning of mathematics. *Mathematics Enthusiast*, *17*(2–3).

Susanti, E., & Kurniawan, H. (2020). Design Pembelajaran Matematika Dengan Pendekatan STEM. *Jurnal Aksioma*, *11*(1), 37–52.

Triplett, W. J. (2023). Artificial Intelligence in STEM Education. *Cybersecurity and Innovative Technology Journal*, *1*(1), 23–29. https://doi.org/10.53889/citj.v1i1.296

Wan, Z. H., English, L., So, W. W. M., & Skilling, K. (2023). STEM Integration in Primary Schools: Theory, Implementation and Impact. *International Journal of Science and Mathematics Education*, *21*, 1–9. https://doi.org/10.1007/s10763-023-10401-x

Wickstrom, M. H., Baek, J., Barrett, J. E., Cullen, C. J., & Tobias, J. M. (2022). Developing spatial measurement conceptions: A learning trajectory approach in the context of 3D printing. *Mathematical Thinking and Learning*, *24*(1), 47–69.

Yildirim, B. (2021). Preschool STEM Activities: Preschool Teachers' Preparation and Views. *Early Childhood Education Journal*, *49*. https://doi.org/10.1007/s10643-020

Yilmaz, R. (2020). Prospective Mathematics Teachers ' Cognitive. *Journal on Mathematics Education*, *11*(1), 17–44.