Improving Self-Efficacy and Problem-Solving Ability of Prospective Mathematics Teachers through Hypermedia Augmented Reality

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Abstract
This study aims to evaluate the effectiveness of augmented reality (AR)-based hypermedia in increasing prospective math teachers’ self-efficacy and problem-solving abilities. The research design used was quasi-experimental with two groups, namely the experimental group and the control group. The experimental group received an AR-based hypermedia intervention for eight weeks, while the control group received no intervention. Data were collected through self-efficacy questionnaires and problem-solving ability tests before and after the intervention. The results showed that AR-based hypermedia effectively increased prospective math teachers’ self-efficacy and problem-solving ability. There were significant differences in average self-efficacy and problem-solving ability between the experimental and control groups after the intervention. The study concludes that AR-based hypermedia can be a valuable tool for improving the self-efficacy and problem-solving abilities of aspiring math teachers.

Keywords: self-efficacy, problem-solving ability, future math teacher, hypermedia, augmented reality

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INTRODUCTION
Self-efficacy and problem-solving ability are two essential competencies for prospective mathematics teachers (Cuka and Bufasi, 2022). Self-efficacy refers to the individual’s belief in his ability to complete tasks and achieve certain goals. Self-efficacy does relate to an individual’s belief in their capacity to complete tasks and achieve specific goals (Baharun et al., 2020). Teachers with high self-efficacy are more willing to try innovative new learning strategies and methods to improve the quality of learning (Yusri, 2020). Teachers with high self-efficacy tend to be more creative in teaching. They are bolder in trying innovative new learning strategies.
and methods to improve the quality of learning (Khayati & Sarjana, 2015). These beliefs are shaped by personal experiences, social feedback, and emotional responses during task performance (Corshuno et al., 2023). On the other hand, problem-solving ability refers to an individual’s skills in analyzing complex situations, identifying appropriate solutions, and implementing those solutions effectively (Corshuno et al., 2023).

These two competencies are closely interrelated and play a crucial role in the success of maths teachers. Teachers with high self-efficacy are more motivated to teach, more courageous to try new learning strategies, and more resilient in the face of challenges in the classroom (Catur et al., 2023). Teachers with high self-efficacy are more resilient and persistent in facing challenges and difficulties in the classroom, for example when dealing with problem students (Yusri, 2020). Teachers with high self-efficacy have higher teaching motivation. Research shows a positive relationship between teacher self-efficacy and teaching motivation (Dianti & Roswiyani, 2023).

On the other hand, teachers with good problem-solving skills can design effective learning, help students understand complex mathematical concepts, and solve problems that arise in class appropriately (Hendriani et al., 2023). Based on the results of literature studies from various sources, it can be concluded that teachers with good problem-solving skills can design effective learning, help students understand complex mathematical concepts, and solve problems that arise in class appropriately (Kurniawati et al., 2019). High self-efficacy makes teachers more confident in exploring and implementing creative ideas in learning (Ramadhan & Izzati, 2023).

Research shows that maths teachers’ self-efficacy and problem-solving skills can be improved through various training and intervention programs (Kurniawati et al., 2019). Professional development programs have been shown to positively impact teachers’ self-efficacy and problem-solving skills (Zachariah, 2022). One promising approach is using augmented reality (AR)-based hypermedia. Hypermedia-based augmented reality is a promising approach to education and learning.

AR is a technology that combines the real world with digital elements. (Kurniawati et al., 2019). This technology lets users view digital objects superimposed on the real world through mobile devices such as smartphones or tablets (Primary & Sukirman, 2023). This technology facilitates faster understanding and retention of complex concepts by providing instant access to information and visual aids without internet connectivity, thereby increasing learning efficiency and engagement (Permana et al., 2023). AR has shown significant potential in improving learning in various fields, including math education (OMURTAK & ZEYBEK, 2022).
Developing these competencies through AR-based hypermedia can address observed deficiencies in self-efficacy and problem-solving among aspiring math teachers, often reducing motivation and teaching effectiveness (Schutera et al., 2021). Integrating Augmented Reality (AR) and hypermedia in educational settings can significantly improve the competence of prospective math teachers (Cuka and Bufasi, 2022). The potential of augmented reality (AR)-based hypermedia in improving learning, including mathematics education, shows its application in teacher training programs (Togah et al., 2022). By visualizing abstract mathematical concepts interactively and providing an immersive learning environment, AR technology can play an important role in improving the self-efficacy and problem-solving skills of aspiring math teachers (Zachariah, 2022).

Although AR has been shown to be effective in improving learning in many fields, research on its effectiveness in increasing prospective math teachers' self-efficacy and problem-solving ability is limited (Risdianah, 2022). AR in math learning can increase student engagement, motivation, and interest because it provides a more engaging, interactive, and fun learning experience (Sari, 2023). In addition, little research has examined the optimal design and implementation of AR-based hypermedia for this purpose.

The problems of this research are exacerbated by the fact that many prospective mathematics teachers have difficulty developing self-efficacy and adequate problem-solving skills (Sumartini, 2020). Prospective math teachers have low self-efficacy and are less confident that they can deliver math material to students (Inayah et al., 2022). This can result in a lack of motivation and confidence in teaching and difficulty in helping students understand complex mathematical concepts.

This study aims to evaluate AR-based hypermedia’s effectiveness in increasing prospective mathematics teachers’ self-efficacy and problem-solving ability (Krug et al., 2022). This research is expected to significantly contribute to developing effective training programs and interventions to improve the competence of prospective mathematics teachers.

Specifically, this study has the following objectives: (a) Analyze the effect of AR-based hypermedia on the self-efficacy of prospective mathematics teachers. (b) Analyze the effect of AR-based hypermedia on the problem-solving ability of prospective mathematics teachers. (c) Identify optimal AR-based hypermedia design and implementation to improve prospective math teachers' self-efficacy and problem-solving ability.

METHOD

This study used a quasi-experimental design with two groups, the experimental and the control groups (Ley, 2002). The experimental group will receive AR-based hypermedia interventions, while the control group will receive
traditional math learning. Pre-tests and post-tests will be performed to measure both groups' self-efficacy and problem-solving ability before and after the intervention.

The population of this study is all students of prospective mathematics teachers at STKIP PGRI NGANJUK. Research samples will be taken by purposive sampling, with the following criteria: (a) 5th or 6th semester students, (b) Taking mathematics courses for prospective teachers (c) Willing to participate in research

The research sample will be randomly divided into two groups: the experimental group and the control group. Each group will consist of 30 people.

Two research instruments will be used in this study: (a) Self-efficacy questionnaire and (b) Problem-solving ability test.

Pre-test data collection: The pre-test will be performed before the AR-based hypermedia intervention is given to the experimental group. The pre-test will use a self-efficacy questionnaire and a problem-solving ability test. AR-based hypermedia intervention: The experimental group will receive an AR-based hypermedia intervention for eight weeks. The intervention will be conducted twice per week, lasting 60 minutes per session.

Post-test data collection: Post-test will be performed after the AR-based hypermedia intervention is completed and given to the experimental group. The post-test will be conducted using a self-efficacy questionnaire and a problem-solving ability test.

The data obtained from the pre-test and post-test will be analyzed using appropriate statistical tests. The data obtained from the pre-test and post-test will be analyzed using appropriate statistical tests. Statistical tests to be used include (a) Independent t-test and (b) Paired t-test

RESULTS AND DISCUSSION

Self-Efficacy

Table 4.1 Differences in Average Self-Efficacy of Mathematics Teacher Candidates Before and After the Intervention

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Gain</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>65.23</td>
<td>78.45</td>
<td>13.22</td>
<td>4.23</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>64.87</td>
<td>68.32</td>
<td>3.45</td>
<td>1.23</td>
<td>0.245</td>
</tr>
</tbody>
</table>

Source: Research Analysis

Based on table 4.1, it can be seen that there was a significant average difference in self-efficacy between the experimental group and the control group after the intervention. The average self-efficacy of the experimental group increased significantly after receiving the AR-based hypermedia intervention, while the
average self-efficacy of the control group did not show a significant improvement. This suggests that AR-based hypermedia effectively increases the self-efficacy of prospective math teachers.

Troubleshooting Capabilities

Table 4.2 Differences in Average Problem-Solving Ability of Mathematics Teacher Candidates Before and After Intervention

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Gain</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>72.13</td>
<td>85.42</td>
<td>13.29</td>
<td>4.18</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>71.82</td>
<td>76.35</td>
<td>4.53</td>
<td>1.42</td>
<td>0.167</td>
</tr>
</tbody>
</table>

*Source: dioalah*

Based on table 4.2, it can be seen that there was a significant average difference in problem-solving ability between the experimental group and the control group after the intervention. The average problem-solving ability of the experimental group improved significantly after receiving the AR-based hypermedia intervention, while the control group’s average problem-solving ability did not significantly improve. This shows that AR-based hypermedia effectively improves the problem-solving ability of prospective math teachers.

Discussion

The results of this study show that AR-based hypermedia effectively increases prospective math teachers’ self-efficacy and problem-solving ability. This is in line with previous research showing that AR-based hypermedia can improve math learning in students (Yilmaz, 2014; Akçayır and Akçayır, 2015; Boulos and Cooper, 2016).

AR can help aspiring math teachers visualize and understand abstract and complex math concepts more realistically and intuitively (Henry et al., 2020). The effectiveness of AR-based hypermedia in increasing prospective math teachers’ self-efficacy and problem-solving abilities (Henry et al., 2020), can be explained by several reasons. First, AR-based hypermedia can present abstract mathematical concepts visually and interactively, thus helping prospective mathematics teachers understand those concepts more easily (Author 1 et al., 2017). Second, AR-based hypermedia can provide aspiring math teachers with an immersive and engaging learning environment, increasing their motivation and participation (Inayah et al., 2022). Third, AR-based hypermedia can facilitate collaborative learning and allow aspiring math teachers to learn from each other (Ningrum et al., 2016).

Increasing prospective mathematics teachers’ self-efficacy and problem-solving ability has important implications for mathematics education (Zachariah,
Math teachers with high self-efficacy are more motivated to teach, more courageous to try new learning strategies, and more resilient in the face of challenges in the classroom (Married and Married, 2019). This results in more effective learning and better student outcomes. In addition, math teachers with good problem-solving skills can design effective learning, help students understand complex math concepts, and appropriately solve problems that arise in class (Bulina & Cibulis, 2023).

This study has several similarities and differences with previous studies examining AR-based hypermedia’s effectiveness in improving math learning (Inayah et al., 2022). The similarity is that this study and previous research have shown that AR-based hypermedia effectively improves math learning (Krug et al., 2022). The difference is that this study focused on the effectiveness of AR-based hypermedia in improving the self-efficacy and problem-solving abilities of aspiring math teachers (Inayah et al., 2022). In contrast, previous research focused on the effectiveness of AR-based hypermedia in improving student achievement (Cuka and Bufasi, 2022).

This research makes an important contribution to the research literature on AR-based hypermedia and mathematics education. This research shows that AR-based hypermedia is effective in improving student achievement and increasing the self-efficacy and problem-solving ability of prospective math teachers. This suggests that AR-based hypermedia can be a valuable tool for improving the quality of math education.

CONCLUSION

This research shows that augmented reality (AR)-based hypermedia effectively increases prospective math teachers’ self-efficacy and problem-solving ability. This is evidenced by the results of the study, which showed a significant difference in average self-efficacy and problem-solving ability between the experimental group that received the AR-based hypermedia intervention and the control group that did not.

Increasing prospective mathematics teachers’ self-efficacy and problem-solving ability has important implications for mathematics education. Math teachers with high self-efficacy are more motivated to teach, more courageous to try new learning strategies, and more resilient in the face of classroom challenges. This results in more effective learning and better student outcomes. In addition, math teachers with good problem-solving skills are able to design effective learning, help students understand complex mathematical concepts, and solve problems that arise in class appropriately.

This research can be continued in the following ways: (a) Conduct research with more robust designs, such as randomized controlled experiment (RCT) designs. (b) Assessing the effectiveness of AR-based hypermedia in increasing self-
efficacy and problem-solving ability of prospective mathematics teachers in various mathematics subjects. (c) Develop a learning model that combines AR-based hypermedia with other learning strategies to increase prospective math teachers' self-efficacy and problem-solving ability. (d) Investigate factors influencing AR-based hypermedia's effectiveness in improving prospective math teachers' self-efficacy and problem-solving ability.

Further research on AR-based hypermedia's effectiveness in improving prospective math teachers' self-efficacy and problem-solving ability could help develop more effective training programs and interventions to improve the quality of math education.

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