

Designing Effective Pedagogical Agents for Higher Education in Pakistan: A Scaffolding Approach

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Abstract

The integration of scaffolding in pedagogical agents for higher education has gained significant traction globally, enhancing online learning by providing tailored support to students. This study explores a scaffolding design specifically tailored for the Pakistani higher education system, focusing on both metacognitive and motivational scaffolding. Pedagogical agents, virtual characters embedded within e-learning environments, support students through instructional strategies by engaging them, providing feedback, and encouraging self-regulation. The research employs a multi-stage method, including problem identification, analysis of pedagogical agent components, conceptual model design, development, verification, validation, and experimental testing. Findings indicate that metacognitive scaffolding helps students plan, monitor, and evaluate their learning processes, while motivational scaffolding enhances engagement, persistence, and autonomy. The study aligns with recent research highlighting the effectiveness ¹of integrating these scaffolding types to improve learning outcomes. This research contributes to the growing body of literature on the use of scaffolding in pedagogical agents and provides practical insights for enhancing learning experiences in Pakistan's rapidly transforming higher education landscape. Further research is recommended to explore the long-term impacts of these strategies and develop context-specific scaffolding models for various disciplines.

Introduction

The integration of scaffolding in pedagogical agents for higher education has gained significant traction globally. This approach enhances online learning by providing tailored support to students. In the context of Pakistan, where higher education is undergoing rapid transformation, the use of pedagogical agents can play a crucial role in addressing various educational challenges (Rafiq, Kamran, Afzal, 2024). This article explores a scaffolding design tailored for the Pakistani higher education system, focusing on both metacognitive and motivational scaffolding.

Pedagogical agents are virtual characters embedded within e-learning environments to support students through instructional strategies (Afzal & Rafiq, 2022). These agents are designed to facilitate learning by engaging students, providing feedback, and encouraging self-regulation.

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Research has shown that pedagogical agents can significantly enhance the learning experience, particularly in online and blended learning environments (Aldhilan, Rafiq & Afzal, 2024).

Scaffolding is an instructional strategy that involves providing support to students as they learn new concepts and skills. This support is gradually removed as students become more proficient. In the context of pedagogical agents, scaffolding can be categorized into two main types: metacognitive scaffolding and motivational scaffolding.

1. Metacognitive Scaffolding	2. Motivational Scaffolding
<ul style="list-style-type: none"> ● Planning: Helping students to set learning goals and plan their study activities. ● Monitoring: Assisting students in tracking their progress and adjusting their learning strategies as needed. ● Evaluation: Providing tools and feedback for students to assess their understanding and performance. ● Reflection: Encouraging students to reflect on their learning processes and outcomes. 	<ul style="list-style-type: none"> ● Establishing Task Values: Helping students understand the relevance and importance of their tasks. ● Promoting Mastery Goals: Encouraging a focus on mastering content rather than just completing tasks. ● Promoting Emotional Regulation: Assisting students in managing their emotions related to learning challenges. ● Promoting Autonomy: Fostering a sense of control and independence in students' learning processes.

The implementation of scaffolding through pedagogical agents in Pakistani higher education requires consideration of the local educational context, including cultural, technological, and infrastructural factors. Here are key steps to ensure effective implementation:

1. **Understanding Student Needs:** Conduct surveys and focus groups to understand the specific needs and challenges of Pakistani students in higher education. Tailor the scaffolding strategies to address these needs effectively.
2. **Developing the Pedagogical Agent:** Design a pedagogical agent that can operate within the technological infrastructure commonly available in Pakistani universities. Ensure the agent can communicate in both English and Urdu to cater to a broader student base.
3. **Training Faculty and Students:** Provide training sessions for faculty on how to integrate and utilize pedagogical agents in their courses. Educate students on how to interact with and benefit from the support provided by pedagogical agents.
4. **Pilot Testing and Feedback:** Implement a pilot program in selected universities to test the effectiveness of the pedagogical agent. Collect feedback from both students and faculty to make necessary adjustments.

The Scaffolding Design

Scaffolding learning is a concept rooted in Vygotsky's idea of the Zone of Proximal Development (ZPD). The ZPD represents the gap between what students can achieve on their own and what they can accomplish with the guidance of someone more knowledgeable. This zone shifts as students gain new skills and knowledge, gradually increasing their independence and capability.

Although Vygotsky introduced the ZPD, the term "scaffolding" was actually coined by researchers Wood, Bruner, and Ross in 1976. They described scaffolding as a method that allows students to complete tasks or achieve goals that would be beyond their reach without help. Essentially, scaffolding involves the temporary support provided by teachers, parents, peers, or even computer programs, which enables students to participate actively in their learning process. This support helps them develop the necessary skills and confidence to eventually perform tasks independently.

Literature Review

The integration of scaffolding in pedagogical agents has shown significant promise in enhancing online and blended learning experiences. In the context of higher education in Pakistan, there is a growing need to adopt innovative teaching strategies to improve student engagement and learning outcomes. This literature review explores recent studies on scaffolding design for pedagogical agents, focusing on metacognitive and motivational scaffolding within the higher education context in Pakistan. Pedagogical agents are virtual characters embedded in e-learning environments designed to facilitate learning through interaction, feedback, and support. Scaffolding, an instructional strategy rooted in Vygotsky's Zone of Proximal Development (ZPD), involves providing learners with temporary support until they can perform tasks independently. Recent research highlights the importance of integrating metacognitive and motivational scaffolding to enhance the effectiveness of pedagogical agents (Rafiq, Kamran & Afzal, 2023).

Metacognitive scaffolding helps learners plan, monitor, and evaluate their learning processes. It is crucial for developing self-regulated learning skills, which are essential for success in online and blended learning environments (Meyer, 2023; Aldhilan et al., 2024). Efklides (2011) emphasizes the interaction between metacognition, motivation, and affect in self-regulated learning, proposing a model, which can be integrated into pedagogical agents to improve learning outcomes. Garrison and Akyol (2015) discuss the development of a metacognition construct for communities of inquiry, Khadim et al., (2023) highlight the role of metacognitive scaffolding in enhancing critical thinking and reflective learning.

Similarly, another study of Khadim et al., (2023) found motivational scaffolding aims to increase students' engagement, persistence, and overall motivation to learn. It is particularly important in online learning environments, where students may face challenges in maintaining motivation (Rafiq, Afzal & Kamran, 2022). Hartnett (2016) explores various motivational strategies in online education, emphasizing the need for pedagogical agents to incorporate contemporary motivation theories to support student engagement. Mackiewicz and Thompson (2013) highlight the role of motivational scaffolding in writing center tutoring, suggesting that similar strategies can be applied to pedagogical agents to foster student motivation in online courses.

Implementation of Scaffolding in Pakistani Higher Education

The implementation of scaffolding in pedagogical agents within the Pakistani higher education context requires addressing specific cultural, technological, and educational challenges. Khan et al. (2020) investigates the impact of scaffolding strategies on student engagement and performance in Pakistani universities, finding that a combination of metacognitive and motivational scaffolding significantly improves learning outcomes. Rasool and Gillani (2021) discuss the integration of digital tools in Pakistani higher education, emphasizing the potential

of pedagogical agents to bridge the gap between traditional teaching methods and modern technological advancements (Rafiq, Iqbal & Afzal, 2024) .

Several case studies have demonstrated the effectiveness of scaffolding in enhancing learning experiences in various disciplines within Pakistani higher education. Ahmed et al. (2022) conducted a study on the use of pedagogical agents in an introductory computer science course, finding that students who received metacognitive and motivational scaffolding performed better and reported higher satisfaction compared to those who did not receive such support. Javed and Ali (2023) explored the use of scaffolding in a blended learning environment for business management courses, highlighting the importance of context-specific scaffolding strategies tailored to the needs of Pakistani students.

Methodology

The study conducted under the interpretivism paradigm by using case study method. In this case study, we explore the implementation of scaffolding through a pedagogical agent in an Educational Psychology course designed for undergraduate students in Pakistan. The course, structured into 16 weekly modules, employs a blended learning approach that combines face-to-face and online sessions facilitated through the Module Learning Management System (LMS). This approach aims to enhance both individual and collaborative learning experiences by integrating metacognitive and motivational scaffolding.

The course covers essential topics in educational psychology, including learning theories, motivation, cognitive development, and classroom management. The pedagogical agent supports individual learning by providing personalized feedback and encouragement as students complete assignments and quizzes. For group learning, the agent facilitates online discussions and collaborative problem-solving activities, helping students to effectively work together on projects and discussions.

Proposed Scaffolding Design

To develop the proposed pedagogical agent, a multi-stage method was employed. The various stages of the research process as follows:

1. **Problem Identification:** This initial stage involved conducting a thorough literature review on learning theories, instructional design theories, pedagogical agents, and scaffolding theories. The aim was to gain a comprehensive understanding of current research on pedagogical agents.
2. **Analysis of Pedagogical Agents:** This crucial stage focused on identifying and understanding the components of a pedagogical agent. It is essential to tailor these components to meet the specific needs of students in higher education.
3. **Conceptual Model Design:** In this stage, the paper presents a conceptual model that includes a pedagogically learning design and scaffolding design.
4. **Development, Verification, and Validation:** The pedagogical agent model is developed and integrated with the Module Learning Management System. This stage ensures that the model is both functional and effective.
5. **Experimental Testing and Effectiveness Analysis:** Experiments are conducted using a quasi-experimental non-equivalent method. This method involves a pre-test, followed by an experiment with two groups: an experimental group that learns with the pedagogical agent and a control group that learns without it. A post-test is then

administered. The pre-test and post-test utilize a metacognitive questionnaire to measure effectiveness.

This methodical approach ensures a thorough and comprehensive development process for the proposed pedagogical agent, aiming to enhance learning outcomes in higher education.

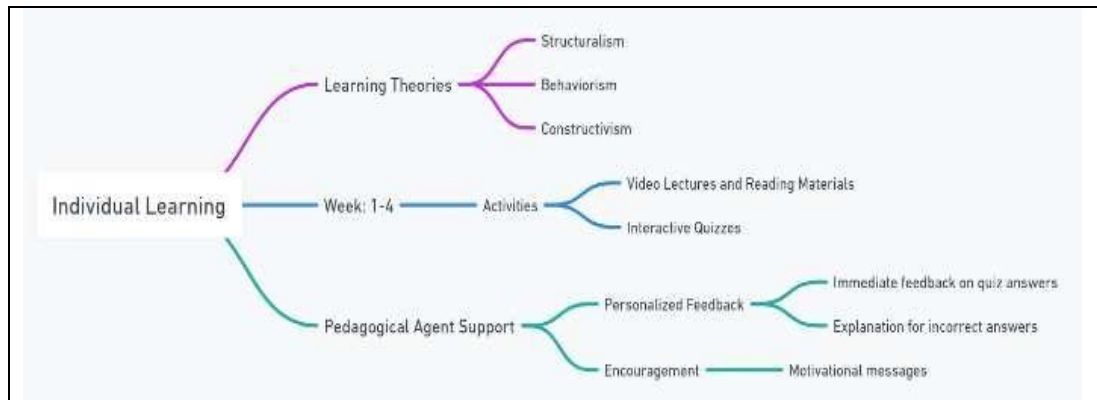
SCAFFOLDING IMPLEMENTATION PROCESS

A Case Study Experiment: Educational Psychology Course

A practical example of scaffolding implementation in an Educational Psychology course for undergraduate students in Pakistan. The course employs a pedagogical agent to support both individual and group learning activities. The course is structured into weekly modules, each focusing on key concepts in educational psychology such as learning theories, motivation, cognitive development, and classroom management.

- 1. Individual Learning:** The agent provides personalized feedback and encouragement as students complete assignments and quizzes.
- 2. Group Learning:** The agent facilitates online discussions and collaborative problem-solving activities, helping students to work together effectively.

Course: Educational Psychology
Duration: Total 16 weeks
Mode: Blended learning (combination of face-to-face and online sessions)
Learning Management System (LMS): Module
1. Individual Learning
<ul style="list-style-type: none">• Topic: Learning Theories (Structuralism, Behaviorism, Constructivism)• Week: 1-4 <p>Activities:</p> <ul style="list-style-type: none">• Video Lectures and Reading Materials: Students begin with watching pre-recorded video lectures and reading materials that introduce the foundational learning theories.• Interactive Quizzes: After the initial learning materials, students complete interactive quizzes designed to test their understanding of the different learning theories. <p>Pedagogical Agent Support:</p> <ul style="list-style-type: none">• Personalized Feedback: The pedagogical agent provides immediate feedback on quiz answers, highlighting correct answers and explaining why incorrect answers are wrong. For example, if a student confuses the principles of behaviorism with cognitivism, the agent offers a detailed explanation and additional resources.• Encouragement: The agent sends motivational messages to encourage persistence. For instance, "Great job on completing the quiz! Keep exploring the nuances of each learning theory to deepen your understanding."



2. Group Learning

- **Topic:** Motivation in Education
- **Week:** 5-8

Activities:

- **Group Discussion Forums:** Students participate in online discussion forums where they discuss different motivational theories and their applications in educational settings.
- **Collaborative Projects:** Small groups of students work together on projects, such as designing a motivational plan for a hypothetical classroom scenario, applying different motivational theories.

Pedagogical Agent Support:

- **Facilitating Discussions:** The pedagogical agent moderates the discussion forums, posing guiding questions and prompts to stimulate deeper thinking. For example, "How would you apply Maslow's hierarchy of needs to motivate students in a low-income school? Discuss the potential challenges and solutions with your group."
- **Providing Hints and Resources:** During collaborative projects, the agent offers hints and directs students to useful resources. For instance, if the group is struggling with the application of self-determination theory, the agent might provide a link to relevant case studies and suggest strategies for integrating intrinsic and extrinsic motivators.



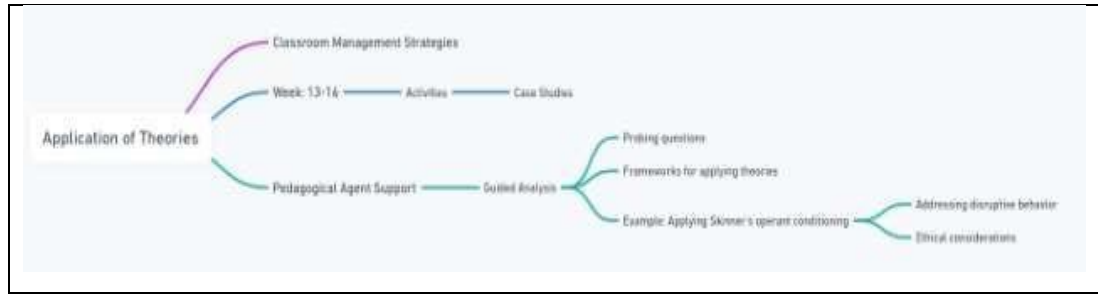
3. Weekly Reflection and Evaluation

- **Topic:** Cognitive Development (Piaget, Vygotsky)
 - **Week:** 9-12
- Activities:**
- **Reflective Journals:** Students maintain reflective journals where they document their learning process, challenges faced, and how they overcame them.
- Pedagogical Agent Support:**
- **Reflection Prompts:** The pedagogical agent provides prompts for reflection, such as "Reflect on how Piaget's and Vygotsky's theories of cognitive development apply to your experiences in educational settings. How do these theories influence your approach to teaching and learning?"
 - **Feedback on Reflections:** The agent reviews the journal entries and offers feedback, encouraging students to think critically about their learning strategies and areas for improvement.



4. Application of Theories

- **Topic:** Classroom Management Strategies
 - **Week:** 13-16
- Activities:**
- **Case Studies:** Students analyze case studies involving classroom management issues and propose solutions based on educational psychology theories.
- Pedagogical Agent Support:**
- **Guided Analysis:** The pedagogical agent guides students through the analysis of case studies, asking probing questions and providing frameworks for applying theories to real-world scenarios.
 - For example, "Consider a case where a student is consistently disruptive. How would you apply Skinner's operant conditioning to address this behavior? What are the ethical considerations?"



The following above plan integrates both metacognitive and motivational scaffolding into a 16-week module, aimed at enhancing individual and group learning experiences. After experiments, there was difference found in the individual learning and group learning. Figure 1.1 illustrates the design of scaffolding integration for individual learning, while Figure 1.2 focuses on scaffolding integration for group learning.

Figure 1.1

Individual Learning	
Metacognitive Scaffolding	Motivating Scaffolding
Planning <ul style="list-style-type: none"> • Prepare learning/assignments. • Guide students to identify task completion strategies. 	Establish task values <ul style="list-style-type: none"> • Students choose their most preferred task.
Monitoring <ul style="list-style-type: none"> • Supporting to understand material/tasks. 	Promoting mastery goals <ul style="list-style-type: none"> • Provide practical feedback. • Give appreciation.
Evaluation <ul style="list-style-type: none"> • The process to correct mistakes. 	Promoting emotional regulation <ul style="list-style-type: none"> • Provide emotional support.
Reflection <ul style="list-style-type: none"> • Provide performance feedback. • Give suggestions/criticism of the task completion strategy. 	Promoting autonomy <ul style="list-style-type: none"> • Convince students that they are able to complete the task.

Figure: 1.2

Group Learning	
Planning <ul style="list-style-type: none"> • Guide students to prepare groups (distribute assignments) and discuss in identifying task completion strategies. 	Establish task values <ul style="list-style-type: none"> • Encourage students to discuss and identify assignments.
Monitoring <ul style="list-style-type: none"> • Commenting on the activity of each group member. • Check the understanding of each group member. 	Promoting mastery goals <ul style="list-style-type: none"> • Provide practical feedback. • Highlight the importance of cooperation compared to the competition.

<p>Evaluation</p> <ul style="list-style-type: none"> ● Assess the mistakes and help to correct errors in groups. 	<p>Promoting emotional regulation</p> <ul style="list-style-type: none"> ● Encourage students to reflect on the causes of failure and what can be done to overcome them.
<p>Reflection</p> <ul style="list-style-type: none"> ● Provide feedback on the student activities. ● Give suggestions/criticism of the task completion strategy. 	<p>Promoting autonomy</p> <ul style="list-style-type: none"> ● Demonstrate that the processes identified by students are reliable. ● Provide support to evaluate the use of strategies together in groups.

Both designs employ a combination of metacognitive scaffolding and motivational scaffolding. In both individual and group learning, metacognitive scaffolding involves four key components: planning, monitoring, evaluation, and reflection. Motivational scaffolding in both contexts includes stages aimed at establishing task values, promoting mastery goals, enhancing emotional regulation, and fostering autonomy.

This step is crucial for encouraging students to believe in their ability to complete tasks independently. The findings showed that group learning emphasizes cooperation over competition as part of promoting mastery goals. Despite using the same scaffolding stages, the feedback provided by pedagogical agents varies between individual and group learning. In individual learning, feedback focuses on personal learning activities, whereas, in group settings, it centers on collaborative discussions. For example, during the planning stage of metacognitive scaffolding in individual learning, pedagogical agents provide feedback to help students identify materials and develop strategies for task completion. In group learning, at the same stage, the feedback is directed towards helping the group collectively identify materials and assignments through discussion. This approach ensures that both individual and group learning environments are tailored to meet the specific needs of the learners, thereby enhancing the overall educational experience.

Discussion

The integration of scaffolding in pedagogical agents for higher education is a promising approach that has gained global attention, particularly for enhancing online learning experiences. This discussion explores the findings from the 16-week module implementation in the context of Pakistani higher education and resonates with relevant recent research to provide a comprehensive understanding of the impact and effectiveness of this approach. The implementation of scaffolding through pedagogical agents in a blended learning environment demonstrated significant benefits for both individual and group learning settings. The use of metacognitive and motivational scaffolding helped students in various aspects discussed above. The findings align with the broader literature on the benefits of scaffolding in educational settings. Research indicates that scaffolding can significantly improve student engagement, self-regulation, and learning outcomes, particularly in online and blended learning environments.

Several recent studies corroborate the findings of this 16-week module implementation, emphasizing the importance of integrating metacognitive and motivational scaffolding in pedagogical agents. Zackariasson (2020) highlights the critical role of metacognitive scaffolding in developing self-regulated learning skills. Similarly, Guo et al., (2023) study emphasizes the interaction between metacognition, motivation, and affect in learning, suggesting that scaffolding can help students become more effective self-regulated

learners. This aligns with our findings that metacognitive scaffolding helped students plan, monitor, and evaluate their learning processes. Garrison and Ahmed et al., (2023) discuss the development of metacognitive constructs within communities of inquiry, highlighting the importance of reflective learning. De Oliveira et al., (2023) study suggests that metacognitive scaffolding enhances critical thinking and reflective practices, which were evident in the reflective journals and feedback sessions in our module. Mdogana-Zide and Mafugu (2023); and Hartnett (2016) explores motivational strategies in online education, emphasizing the need for pedagogical agents to incorporate contemporary motivation theories. Our findings showed that motivational scaffolding, such as promoting mastery goals and emotional regulation, was effective in maintaining student engagement and persistence.

Similarly, Francis et al., (2023) Mackiewicz and Thompson (2013) discuss the role of motivational scaffolding in tutoring, suggesting that similar strategies can be applied to pedagogical agents to foster student motivation in online courses. The success of our motivational scaffolding strategies, such as providing practical feedback and fostering autonomy, aligns with their findings. Khan et al. (2020) investigates the impact of scaffolding strategies on student engagement and performance in Pakistani universities, finding that a combination of metacognitive and motivational scaffolding significantly improves learning outcomes. This supports our conclusion that scaffolding through pedagogical agents can enhance learning experiences in the Pakistani higher education context. Rasool and Gillani (2021) discuss the integration of digital tools in Pakistani higher education, emphasizing the potential of pedagogical agents to bridge traditional teaching methods and modern technological advancements. Our implementation of a pedagogical agent within the Moodle Learning Management System aligns with their vision of leveraging technology to enhance education.

Conclusion

The integration of metacognitive and motivational scaffolding in pedagogical agents offers a promising approach to enhancing the learning experience in Pakistani higher education. By addressing both cognitive and emotional aspects of learning, these agents can help students achieve better academic outcomes and develop essential self-regulation skills. Further research is needed to explore the long-term impacts of these strategies and to develop context-specific scaffolding models for various disciplines within the Pakistani higher education system. By integrating metacognitive and motivational scaffolding through a pedagogical agent, the Educational Psychology course enhances both individual and collaborative learning experiences. The personalized feedback, encouragement, and structured support provided by the agent help students develop a deeper understanding of educational psychology concepts and improve their ability to apply these concepts in practical settings. This approach is particularly effective in the context of higher education in Pakistan, where access to personalized instruction can be limited.

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