Research on cultivating computational thinking in university computer courses - Based on PBL strategies

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Abstract. This study focuses on the cultivation of computational thinking in the "University Computer" course, proposing a teaching model strategy based on PBL (Problem-Based Learning). By designing authentic and challenging teaching problems, students are guided to actively explore and collaborate to solve them, thereby cultivating their computational thinking abilities. The research found that the PBL teaching model can effectively enhance students' computational thinking skills, as well as strengthen their problem-solving and innovation abilities. Additionally, this study also discusses the issues and challenges encountered during implementation, providing valuable insights for future teaching practices.

Keywords: Computational thinking, Project-based learning, University computer courses.

1 Introduction

1.1 The importance of computational thinking in modern education

In the modern information age, computational thinking has emerged as a fundamental skill that learners must possess. This thinking paradigm is not only vital for enhancing individual competitiveness in the rapidly evolving technology field but also crucial for meeting the demands of our increasingly digitalized society. Particularly in non-computer-related fields, the need for computational thinking is becoming increasingly urgent, as it enables professionals to analyze, solve problems, and make informed decisions using data-driven insights. Therefore, the question of how to effectively enhance the computational thinking abilities of non-computer major students through university computer education has become an important and timely topic worthy of further exploration and innovation.

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1.2 Application of project-based learning in enhancing computational thinking skills

This comprehensive study aims to delve into the application of a project-based learning (PBL) teaching model, emphasizing computational thinking, within the "University Computer" course framework. To accomplish this, a range of rigorous research methods will be employed, encompassing literature review, questionnaire surveys, experimental methods, and interviews. Initially, through a thorough literature review, we will explore the theoretical foundations of computational thinking and project-based teaching, pinpointing the existing research gaps and the pressing need to cultivate computational thinking among non-computer major university students. Subsequently, questionnaire surveys will provide us with valuable insights into the learning needs and current proficiency levels of non-computer major students, enabling us to design teaching processes and case studies with greater precision and relevance. This holistic approach will ensure a comprehensive understanding of the topic, leading to effective strategies for enhancing computational thinking abilities among students.

1.3 Research methods and approaches for effective implementation

During the experimental phase, we will meticulously integrate real-world scenarios to develop a project-based teaching model tailored to fostering computational thinking among students. By adopting this innovative teaching approach, we aspire to significantly enhance students' computational thinking abilities across multiple dimensions, including decomposition and abstraction thinking, algorithmic thinking, abstract thinking, and evaluative thinking. Through rigorous experimental methods, we will diligently observe and document the shifts in students' computational thinking proficiency, their embrace of project-based learning, and the progress of their projects, thereby objectively evaluating the effectiveness of our teaching methods.

Furthermore, we will conduct interviews with students and teachers to gather valuable feedback, which will inform the further optimization of our teaching design and strategies. This research endeavor not only aims to empower non-computer major students with enhanced computational thinking skills but also strives to establish a comprehensive project-based teaching framework and case designs, serving as a valuable reference and guidance for educational reform in other courses. We firmly believe that the implementation of this research will elevate the quality of university computer education, foster a new generation of talents equipped with advanced computational thinking abilities, and contribute significantly to the technological advancement and societal progress of our nation.

2 Theoretical foundation of computational thinking and PBL teaching model

2.1 The importance of computational thinking in education

Computational thinking, as a distinct mode of cognitive processing, encompasses a range of intellectual activities that involve solving problems, designing systems, and understanding human behavior through the application of fundamental computer science concepts and methodologies. It transcends the realm of mere computer programming or algorithm construction, instead emphasizing a problem-solving strategy that is centered on computational principles, methods, and systems. In the context of computer science education, computational thinking holds paramount importance as a core competency, aimed at fostering students' logical, abstract, and innovative thinking capabilities to navigate the rapidly evolving digital landscape.

2.2 The synergy of computational thinking and problem-based learning

The Problem-Based Learning (PBL) teaching model, originating in the field of medical education in the 1960s, represents a student-centered approach to education that is firmly anchored in problem-solving. PBL underscores the importance of students actively constructing knowledge by engaging with real-world problems, thereby promoting self-directed learning and collaborative skills. As educational philosophies have evolved and teaching methodologies have innovated, PBL has increasingly gained traction in higher education, particularly in disciplines that demand the cultivation of innovative thinking and practical proficiencies. The integration of computational thinking with the PBL teaching model offers a promising framework for enhancing student learning outcomes and preparing them for the demands of the modern, technology-driven world.

There exists a profound and natural synergy between computational thinking and the Problem-Based Learning (PBL) teaching model. Firstly, PBL is inherently problem-oriented, focusing on real-world challenges that students must navigate to achieve a deeper understanding of concepts. Meanwhile, computational thinking, at its core, is centered around solving problems through the application of computational principles and methodologies. When these two frameworks are combined, students are able to apply computational thinking to real-world problems, bridging the gap between theoretical knowledge and practical application.

Moreover, PBL places a strong emphasis on student autonomy and creativity, allowing them to take ownership of their learning process and explore innovative solutions. This emphasis complements the computational thinking approach, which fosters logical, abstract, and innovative thinking. Through PBL, students are able to continuously practice and refine their computational thinking skills, applying them to a diverse range of problems and scenarios.

In conclusion, the integration of computational thinking and the PBL teaching model offers a powerful educational tool that not only enhances students' computer science literacy but also cultivates their innovative and practical abilities. By adopting a PBL teaching model grounded in computational thinking in courses such as "Introduction to Computer Science," we can significantly develop students' computational thinking abilities, preparing them to thrive in the rapidly changing information society. This approach encourages students to think critically, solve complex problems, and collaborate effectively, skills that are increasingly valued in today's workplace.

3 Strategies for cultivating computational thinking in the "University Computer Science" course based on PBL

Strategies for fostering computational thinking in the "University Computer Science" course, grounded in Problem-Based Learning (PBL), are pivotal in ensuring students not only acquire theoretical knowledge but also develop practical skills. At the core of our course design is the emphasis on the authenticity, challenge, and hierarchy of problem design. We strive to present problems that are closely aligned with real-life scenarios and professional applications, ensuring that students are able to exercise and refine their computational thinking abilities through hands-on experiences.

The challenge and hierarchy of problems play a crucial role in igniting students' curiosity and fostering a deeper understanding of computational thinking. By gradually escalating the complexity of problems, we guide students to explore, question, and innovate, encouraging them to delve deeper into the nuances of computational concepts.

During the teaching process, we embrace the PBL model, introducing a series of authentic and engaging problems that require students to think critically and collaborate effectively. For instance, a practical problem such as "How can we develop an algorithm to optimize image compression for efficient storage?" prompts students to brainstorm and explore various solutions. Working in groups, they engage in lively discussions, identifying key issues, devising algorithms, and testing their solutions.

Teachers occupy a central role in this process, providing timely guidance and support to students. They encourage the application of computational thinking principles, guiding students through logical reasoning, abstract thinking, and algorithm design. This iterative process of problem-solving not only equips students with robust computational thinking skills but also prepares them to apply these skills in real-world contexts, making them ready for the complexities of the modern digital era.

Let's delve deeper into the application and effectiveness of the PBL teaching model in cultivating computational thinking through the case study of "ID photo background color replacement" in the "University Computer Science" course. In this scenario, students initially need to grasp the essence of the task - replacing the background color of an ID photo. This initial step requires abstract and conceptual thinking, challenging students to identify the core objective and visualize a solution.

Next, students embark on the journey of algorithmic thinking and logical reasoning. They explore how to utilize various tools and functions within image editing software, such as Photoshop, to achieve the desired outcome. This process involves breaking down the problem into smaller, manageable parts, devising algorithms, and testing their effectiveness.

During the operation, students encounter challenges and make adjustments, optimizing their solutions to achieve optimal results. This phase highlights the importance of evaluative thinking, where students assess their progress, identify weaknesses, and iterate on their strategies.

Through this case study, we can clearly see the benefits of the PBL teaching model in fostering computational thinking. Students not only acquire specific image processing skills but also develop a deeper understanding of problem-solving, logical reasoning, and abstract thinking. They learn to analyze complex scenarios, devise innovative solutions, engage in practical activities, and evaluate the outcomes of their efforts. This holistic approach not only enhances their computational thinking skills but also cultivates higher-order thinking abilities that are crucial for success in the modern digital age.

In conclusion, the strategies for cultivating computational thinking in the "University Computer Science" course based on PBL, through introducing real-life problems, employing effective teaching strategies, and analyzing specific teaching cases, can effectively enhance students' computational thinking skills, laying a solid foundation for their future learning and career development.

4 Research results and discussion

After implementing Problem-Based Learning (PBL) strategies for a semester, our study has yielded remarkable results. Students' computational thinking abilities have undergone a significant transformation, with visible progress in their capacity to apply acquired knowledge to tackle real-world challenges. Their enhanced logical reasoning, abstract thinking, and innovative approaches towards problem-solving are noteworthy achievements.

Comparing pre- and post-experimental data, we observed a clear increase in students' computational thinking test scores. At the conclusion of the course, they displayed a greater proficiency in independently handling tasks of varying complexity. This transformation is not just quantifiable but also qualitatively evident in their problem-solving strategies and outcomes.

To comprehensively evaluate the teaching strategies' effectiveness, we utilized multiple assessment methods. Questionnaires revealed that a vast majority of students were pleased with the PBL approach, believing it sparked their interest in learning and bolstered their problem-solving capabilities. Grade analysis further corroborated this sentiment, with students performing better in assignments, project practices, and final exams. Notably, scores in computational thinking-oriented application questions improved significantly.

However, during the implementation of PBL strategies, we encountered some challenges. Some students struggled with problem analysis and solution formulation, necessitating additional guidance. Additionally, technical barriers arose due to varying levels of computer proficiency among students. To address these issues, we propose several measures. Firstly, enhancing students' problem analysis skills through additional case studies and discussion forums would be beneficial. Secondly, offering basic computer operation courses or providing online resources could assist students in bridging the technical gap.

The PBL-based "University Computer" course holds immense promise in fostering computational thinking among students. Looking ahead, we are committed to further refining our teaching strategies. We aim to uncover even more authentic, engaging, and challenging problems that will ignite students' curiosity and spark their desire to learn. By doing so, we hope to not only enhance their computational thinking skills but also instill a lifelong love of learning.

Moreover, we plan to strengthen our collaborations with industry leaders. By introducing more practical case studies and projects, we can ensure that the course content remains relevant and aligned with real-world applications. This will provide students with invaluable hands-on experience, preparing them for future success in the workplace.

However, it's important to recognize that, despite our progress, there are still challenges and areas for improvement. We are committed to addressing these issues head-on through continuous exploration and practice. We believe that, with time and effort, the PBL model will continue to evolve and make significant contributions to cultivating a new generation of innovative and practical talents.

The PBL-based "University Computer" course is a powerful tool for enhancing computational thinking among students. Through ongoing refinement and collaboration, we are confident that this teaching model will play a pivotal role in shaping the future of higher education.

5 Conclusion

This research has successfully harnessed the potential of PBL-based teaching strategies in the "University Computer Science" course, leading to a noteworthy enhancement in students' computational thinking abilities. The PBL model has proven to be an effective tool in igniting students' interest and initiative, encouraging them to engage actively in problem-solving activities. Not only does it foster their problem-solving skills, but it also sharpens their logical reasoning and innovative capabilities.

Nonetheless, this research also highlights the existence of certain limitations, particularly pertaining to the sample size and the variety of problem designs employed. These areas offer opportunities for further exploration and improvement, ensuring a more comprehensive and impactful application of PBL in computational thinking education.

Looking ahead, future studies are encouraged to delve deeper into the optimization and innovation of PBL teaching strategies. By doing so, we can better promote the advancement of computational thinking education and foster the emergence of outstanding talents who possess integrated high-order thinking abilities. It is anticipated that such endeavors will contribute significantly to the overall development of higher education and the cultivation of innovative talents, thereby shaping a brighter future for the field of computer science and beyond.

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