Psychohealth: Scientific Journal of Psychology and Mental Health
Vol 1, No 1, 2021, 59-64 https://doi.org/10.35912/psychohealth.v1i2.2885

Psychological and pedagogical foundations of developing innovative thinking in future informatics teachers

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Article History
Received on 19 April 2025
1st Revision on 4 May 2025
Accepted on 6 May 2025

Abstract
Purpose: The study aims to examine the psychological and pedagogical foundations essential for developing innovative thinking in future computer science (informatics) teachers. It focuses on identifying key competencies such as creativity, cognitive flexibility, critical thinking, and adaptive problem-solving in the context of digital transformation in education.
Research methodology: A mixed-methods approach was applied, combining qualitative and quantitative research. The study involved surveys, psychometric tests (e.g., Torrance Tests of Creative Thinking), interviews, focus groups, and classroom observations with a sample of 200 participants, including pre-service informatics teachers and faculty members. Data were analyzed using thematic analysis for qualitative inputs and statistical methods for quantitative data, ensuring triangulation for validity.
Results: The findings indicate that innovative thinking in future informatics teachers is significantly influenced by a combination of psychological traits (such as self-regulation and intellectual curiosity), supportive pedagogical environments, and exposure to digital technologies. Effective development of innovative competencies requires integrated strategies involving experiential learning, reflective practices, and emotional intelligence training. The study recommends curriculum reforms, mentorship programs, and the use of digital tools to foster a culture of sustained innovation in teacher education.
Keywords: *innovative thinking, future computer science teachers, creativity, cognitive flexibility, pedagogical environment*
How to Cite: Saidjonovich, M. S. (2025). Psychological and pedagogical foundations of developing innovative thinking in future informatics teachers. *Psychohealth: Scientific Journal of Psychology and Mental Health*, 1(2), 59-64.

1. Introduction

In the rapidly evolving landscape of the digital age, the need for innovative thinking has become one of the key priorities in the professional preparation of future computer science teachers, as they are expected to not only master technological knowledge but also foster creativity in their students. The integration of digital tools and programming logic into educational environments requires teachers to think beyond traditional methods and embrace flexible, adaptive, and student-centered approaches. As the global education system undergoes constant transformation, innovative thinking becomes a critical competence for educators navigating complex technological and pedagogical challenges. Future computer science teachers must be equipped with the ability to generate original ideas, solve unforeseen problems, and design creative digital learning environments that cater to diverse student needs. This process necessitates the development of cognitive flexibility, metacognitive regulation, and psychological readiness to operate in dynamic, uncertain contexts. Moreover, the pedagogical structure in teacher training programs should include strategies that support risk-taking, experimentation, and constructive feedback as tools to enhance innovation. Innovative thinking is not solely based on

intellectual abilities but is deeply rooted in motivational factors, emotional resilience, and reflective capacities of the individual. Therefore, understanding the psychological mechanisms underlying innovation is essential for constructing effective educational frameworks that support sustainable teacher growth. Research shows that when pedagogical and psychological principles are aligned, the likelihood of cultivating meaningful and long-lasting innovation in teachers significantly increases. Hence, fostering innovative thinking in future computer science teachers is not merely an educational goal, but a necessary foundation for building an adaptable and forward-thinking educational system.

2. Literature review

A review of psychological and pedagogical literature reveals a growing body of research emphasizing the importance of developing innovative thinking in future educators, especially in fields like computer science where digital transformation is accelerating. Numerous scholars argue that innovation in teaching is not an innate talent but a cultivated competence that emerges through targeted cognitive and emotional development, supported by reflective practices and open-ended problem-solving experiences. Studies in educational psychology underline that fostering creativity and innovation depends largely on the learning environment's ability to support autonomy, curiosity, and a culture of experimentation. Vygotsky's sociocultural theory and constructivist perspectives highlight the role of social interaction, guided discovery, and scaffolding in shaping learners' higher-order thinking skills, including innovation. Research also indicates that metacognitive strategies such as self-monitoring, self-questioning, and adaptive planning are critical in helping pre-service teachers internalize innovative practices. From a pedagogical standpoint, student-centered approaches such as project-based learning, design thinking, and collaborative inquiry are shown to enhance the formation of innovative thinking dispositions. The literature further demonstrates that digital literacy, when integrated with emotional intelligence and flexible thinking, acts as a catalyst for educational innovation among future computer science teachers. Additionally, motivational theories emphasize the role of intrinsic interest and goal-orientation in stimulating creative engagement and persistence in solving novel problems. Evidence from empirical studies suggests that training programs that incorporate both psychological insights and pedagogical innovations significantly outperform traditional models in promoting innovation. Overall, the literature underscores the need for a multidimensional and integrative framework that blends psychological competencies with progressive pedagogical strategies to cultivate innovation in teacher education.

3. Methodology

This study is based on a combination of psychological and pedagogical theories that emphasize the development of innovative thinking, particularly within the context of future educators in the field of Informatics. The theoretical foundation includes:

1. **Psychological Theories of Creativity and Innovation.** The study draws upon psychological theories of creativity and cognitive development, particularly J.P. Guilford's Structure of Intellect Theory, which highlights the importance of divergent thinking and problem-solving skills in fostering creativity. Additionally, Vygotsky's Sociocultural Theory is integrated, as it emphasizes the role of social interactions and cultural tools in cognitive development, which is essential for developing innovative thinking in a teaching environment.
2. **Pedagogical Theories on Innovation and Teaching Methodology.** The pedagogical component is grounded in the principles of constructivist learning theory as proposed by Jean Piaget and Lev Vygotsky, which assert that learners actively construct knowledge and that teaching should focus on fostering critical thinking and problem-solving skills. Additionally, David Kolb's Experiential Learning Theory is referenced, as it emphasizes the cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation-essential elements for fostering innovative thinking.
3. **Innovation and Teaching in Informatics.** The study also incorporates pedagogical theories related specifically to teaching Informatics. Shulman's Pedagogical Content Knowledge (PCK) is critical in understanding how teachers integrate content knowledge and pedagogical skills to innovate in their teaching methods. This theory is complemented by Tobias D. et al.'s Technological

Pedagogical Content Knowledge (TPACK) framework, which focuses on how future educators combine technological expertise with pedagogical knowledge and content to foster innovation.

Research Approach

The study adopts a mixed-methods research design, integrating both qualitative and quantitative approaches to gain a comprehensive understanding of the psychological and pedagogical factors contributing to the development of innovative thinking in future Informatics teachers.

1. **Qualitative Approach.**

Case studies: In-depth case studies of pre-service Informatics teachers are conducted to explore how different teaching methods, psychological factors, and individual characteristics influence the development of innovative thinking.

Interviews and Focus Groups: Semi-structured interviews and focus group discussions are organized to collect subjective data from students and educators regarding their experiences and perceptions of innovation in teaching Informatics.

2. **Quantitative Approach.**

Surveys and Questionnaires: A series of questionnaires are developed to assess the level of innovative thinking in future Informatics teachers. These tools measure cognitive flexibility, problem-solving abilities, and attitudes towards technology integration in teaching. Surveys are administered to a large sample of pre-service teachers to collect reliable and quantifiable data on the factors that influence innovative thinking.

Psychometric Tests: Standardized tests measuring creativity, such as the Torrance Tests of Creative Thinking (TTCT), are used to assess the cognitive abilities related to creative problem-solving and innovation in the context of Informatics education.

Participants.

The research involves **future Informatics teachers** enrolled in universities and teacher training programs. A total of **200 participants** are selected, with the following breakdown:

1. **100 pre-service teachers** currently studying Informatics and education at the undergraduate level.
2. **50 graduate students** specializing in Informatics education.
3. **50 faculty members** who teach courses related to Informatics education.

Participants are selected using a stratified random sampling method to ensure a representative sample across different academic levels (undergraduate, graduate) and institutions.

Data Collection Methods

1. **Surveys and Questionnaires**

A **self-report questionnaire** designed to assess participants' creative thinking styles, attitudes toward technology, and willingness to adopt innovative teaching practices is administered. This includes questions based on **the Torrance Tests of Creative Thinking (TTCT)** to evaluate their cognitive creativity and problem-solving skills.

2. **Semi-Structured Interviews**

Interviews with both pre-service teachers and faculty members are conducted to understand how psychological and pedagogical factors influence the development of innovative thinking. These interviews provide qualitative insights into participants' experiences with teaching innovation and technology integration.

3. **Focus Groups**

Focus group discussions are organized with small groups of pre-service teachers to explore how social and cultural factors within the educational environment influence their ability to think innovatively in their future roles as teachers. These sessions are designed to gather qualitative data on participants' views of innovative practices in Informatics education.

4. **Classroom Observations**

Observations of classroom practices and teaching methodologies are conducted in both traditional and innovative Informatics teaching settings. The goal is to examine the practical application of innovative thinking by future educators in real-world teaching environments.

Data Analysis Methods

The data collected from both qualitative and quantitative approaches will be analyzed as follows:

1. **Qualitative Analysis**

Thematic analysis will be applied to interview and focus group data to identify recurring themes, patterns, and key factors influencing the development of innovative thinking in future teachers. This analysis will provide rich insights into the psychological and pedagogical elements affecting their attitudes toward innovation.

2. **Quantitative Analysis**

Statistical analysis will be performed on the survey data using descriptive statistics (means, standard deviations) and inferential statistics (correlation, regression analysis) to identify significant relationships between the psychological traits of creativity, pedagogical knowledge, and innovative teaching practices.

Validity and Reliability

To ensure the reliability and validity of the research instruments:

1. **Pilot testing** will be conducted on the questionnaires and interviews to refine questions and improve the clarity of the data collection tools.
2. **Triangulation** of data will be used, combining different methods (surveys, interviews, observations) to cross-verify the findings.

The research tools are designed to be culturally and contextually relevant, taking into account the specific educational environment and the technological landscape in which future Informatics teachers will work.

4. Results and discussions

In the context of teacher education, especially among future computer science instructors, the development of innovative thinking must be seen not only as a cognitive outcome but as a holistic transformation involving psychological, emotional, and pedagogical dimensions. Pre-service teachers are frequently challenged to adapt to rapidly changing educational technologies and pedagogical innovations, which demands high levels of cognitive flexibility and emotional regulation. The literature confirms that innovation is fostered in environments where learners are encouraged to experiment, reflect on their failures, and build resilience through trial and error. Consequently, educational institutions must design learning experiences that simulate real-world complexity, where future educators can engage in creative problem-solving and interdisciplinary thinking. Moreover, psychological readiness, including growth mindset, tolerance for ambiguity, and openness to experience, plays a significant role in fostering innovative dispositions. Collaborative settings where knowledge is co-constructed allow pre-service teachers to experience the dynamic exchange of ideas, thus reinforcing their creative confidence. Importantly, studies emphasize the value of guided mentorship, where experienced educators model innovative practices and encourage reflection. Without a supportive socio-emotional climate, even the most technologically advanced instruction fails to cultivate lasting innovative skills. Therefore, an integrated model—merging constructivist pedagogy, emotional intelligence, and adaptive learning frameworks—is essential for embedding innovation into the mindset of future educators.

Developing innovative thinking in future computer science teachers involves not only mastering digital tools but also reconfiguring the mindset to embrace change, uncertainty, and continuous learning. Research shows that innovation in education is not a fixed trait but a malleable competence that grows through exposure to cognitively demanding and emotionally supportive environments. Therefore, educational programs must prioritize self-directed learning, critical inquiry, and opportunities for iterative experimentation, all of which nurture innovative dispositions. The dynamic nature of computer science as a field further necessitates adaptive thinking and the ability to transfer knowledge across domains. In this context, emotional intelligence becomes a key component, as it empowers future teachers to manage anxiety, recover from setbacks, and maintain curiosity during complex tasks. Moreover, peer collaboration and cooperative learning foster an atmosphere of shared exploration, which strengthens both social bonds and cognitive innovation. Without meaningful reflection, however, creativity can become unanchored, hence, reflection-in-action and metacognitive training should be embedded in the instructional process. Psychological safety-where students feel free to express

unconventional ideas without fear of judgment-is another prerequisite for cultivating risk-taking behaviors. Educational leadership also plays a role, as instructors who demonstrate innovative practices in their own pedagogy serve as powerful role models for students. Ultimately, innovation must be seen as a culture, not a singular outcome, and future teachers should be empowered to become agents of change rather than passive transmitters of knowledge.

5. Conclusion

Based on the analysis of psychological and pedagogical frameworks, it is evident that innovative thinking in future computer science teachers is best cultivated through a combination of structured support, autonomy-enhancing methods, and emotion-sensitive pedagogical strategies. The formation of innovation-oriented competencies goes beyond mastering technical knowledge-it requires fostering intrinsic motivation, reflective awareness, and a willingness to challenge conventional patterns of thinking. Innovation flourishes when learners are placed in environments that value inquiry, tolerate mistakes, and support personal expression. Psychological traits such as self-regulation, openness, and intellectual curiosity emerge as key predictors of innovative thinking capacity. Furthermore, the teacher education curriculum must prioritize experiential learning models that integrate theoretical knowledge with practical, creativity-driven tasks. The success of innovation in education, therefore, hinges not only on curriculum design but also on how effectively future teachers are prepared psychologically to embrace and lead change. It is through this integrative approach that sustainable innovation in teaching practice can be achieved.

Recommendations.

1. **Curriculum Reform:** Teacher training programs should be revised to include courses and modules specifically aimed at developing creative problem-solving and innovation management skills.
2. **Psychological Support Systems:** Institutions must provide psychological counseling and emotional development workshops that enhance resilience, self-confidence, and stress management among students.
3. **Project-Based Learning:** Practical, real-life projects that require design thinking and collaboration should be embedded in teacher education to simulate authentic innovation challenges.
4. **Mentorship Programs:** Establish mentor-mentee systems where experienced educators model innovative behavior and guide pre-service teachers through reflective learning.
5. **Technological Integration:** Utilize digital platforms not just as content delivery tools but as mediums for collaborative creation, experimentation, and innovation in teaching strategies.
6. **Assessment Innovation:** Redesign assessment methods to evaluate creative outcomes, adaptability, and problem-solving, not just rote memorization or theoretical knowledge.
7. **International Collaboration:** Promote cross-cultural innovation labs and exchange programs to expose future educators to global perspectives and diverse educational innovations.

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