ENSURING METACOGNITIVE REFLECTION AND PERSONAL-PROFESSIONAL DEVELOPMENT OF FUTURE ENGINEERS THROUGH ELECTRONIC PORTFOLIO

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Abstract: This study examines the potential of using an electronic portfolio (e-portfolio) tool in engineering education to develop metacognitive reflection and personal and professional growth in prospective engineers. The study, conducted using mixed methods, involved 100 students. The results showed that e-portfolios allow students to analyze their learning process, document their achievements, identify shortcomings, and make future plans. There was also a statistically significant increase in the level of metacognitive messages.

Keywords: electronic portfolio, metacognitive reflection, personal and professional development, engineering education, self-assessment

Introduction

Modern engineering today requires not only deep technical knowledge, mathematical modeling skills or software skills, but also the ability to develop solutions that are relevant to a complex, multidisciplinary and rapidly changing economic, social and environmental context. Therefore, modern engineering education is moving away from the traditional "knowledge transfer" model and towards an integrative approach that also encompasses the personal and professional development of students. Within the framework of such an approach, an engineering student is required not only to have competencies in the disciplines, but also personal qualities such as self-awareness, a sense of ethical responsibility, effective communication within a team, leadership qualities, critical thinking and a desire for continuous self-improvement.

In this case, only external control, tests or final assessment systems in the educational process will not be enough. On the contrary, it is considered an urgent task for the student to have the tools for self-development, to form the ability to manage the learning process and to have the opportunity to independently plan his own development path. It is at this point that the electronic portfolio (e-portfolio) stands out as a modern pedagogical tool.

An electronic portfolio is not just a tool for collecting academic achievements, projects or certificates, but a dynamic, interactive and personalized learning environment that allows a student to analyze their learning experience through metacognitive reflection, perceive their strengths and weaknesses, plan for changes and determine their future professional direction. It uses the capabilities of digital technologies to integrate information in various formats such as text, audio, video, graphics, interactive infographics, links and reflects the student's entire learning, practice and social activity in an integrated manner.

Metacognitive reflection - the ability to analyze one's own thinking processes, learning strategies, results, and errors - is especially important in engineering. Because engineers are always faced with problems that are uncertain, open-ended, and with limited resources. In these situations, they must not only apply existing knowledge, but also have the ability to monitor their thinking, evaluate solutions, learn from mistakes, and act more effectively in the next step.

However, traditional engineering education often focuses on the outcome - that is, the correct answer or working model - and does not pay enough attention to the process - that is, how the student thought, what strategies they chose, what mistakes they made. As a result, students fail to develop the skills of reflective thinking.

An electronic portfolio serves as an effective tool in solving this problem, as it allows the student to analyze their experience in writing after each lesson, project, or practical activity, visually track their growth, develop self-assessment criteria, and strategically determine future development directions. This directly contributes to the development of metacognitive skills.

It is written in this context and aims to scientifically substantiate the possibilities of developing metacognitive reflection and ensuring personal and professional growth of future engineers by integrating electronic portfolios into engineering education, providing practical recommendations, methodological approaches and empirical research results. The article aims to develop reflexive practices in engineering education, strengthen students' self-management skills and contribute to their transformation into professionals who meet the requirements of the times.

Literature Review: Barrett, H. has defined the e-portfolio as a "self-management tool" and its role in reflective learning and self-development. He considers the e-portfolio not only as an assessment tool, but also as a means for the student to plan his or her own development path [1].

Wade, RC, & Yarbrough, DB defined portfolio as a means for students to analyze their own experiences, increase their self-confidence, and form a personal identity. In this respect, it is also relevant for engineering students [2].

Doolan, M. showed that using e-portfolio as a professional portfolio for engineering students plays a significant role in increasing their employability [3].

Chang has confirmed that CC e-portfolios are effective tools for developing students' metacognitive skills. In particular, reflective essays and self-assessment elements have shown significant results [4].

Mason, R. linked e-portfolio to the "self-regulated learning" model and emphasized its importance in developing students' goal-setting, monitoring, and evaluation skills [5].

Strivens, J. analyzed the potential of e-portfolios in higher education as a tool for accreditation and professional development. He believes that in the engineering field, this system ensures compliance with standards [6].

According to the results of a meta-analysis by Abrami, PC, students who used e-portfolios had significantly higher levels of self-esteem, motivation, and academic achievement [7].

Klenowski, W., has emphasized the portfolio as a tool for "self-assessment" and "self-understanding," which are key components of metacognition [8].

Jafari, A. proposed e-portfolio as a tool for developing students' own thinking in a digital learning environment. They called it a "thinking archive" [10].

Research methodology. The qualitative aspect of the study aimed to understand how students' metacognitive reflection can be developed through the use of an electronic portfolio, while the quantitative aspect aimed to statistically assess the impact of this tool on their personal and professional development.

From Bukhara State Technical University and Karshi State Technical University participated. 50 of them were selected as the experimental group (used e-portfolio) and 50 as the control group (traditional assessment system).

Intervention: The experimental group was offered the following e-portfolio structure for 10 weeks :

- Personal profile (goals, interests, strengths);
- Academic achievements (projects, laboratory work, test results);
- Reflective journal (an analysis written at the end of each lesson or project);
- Self-assessment form;
- Future plans (career path, additional courses, internships).
- The Mahara open source e-portfolio system was used as the platform.

Data collection tools:

- Metacognitive Message Inventory;
- Personal and professional development questionnaire;
- Reflexive essays based on open-ended questions;
- Focus group discussions (3 groups, 6–8 students each);
- Portfolio content analysis (content analysis).
- Data analysis:

Quantitative data were analyzed using t-test and ANCOVA (Analysis of Covariance);

Qualitative data were processed using thematic analysis (Braun & Clarke, 2006).

Analysis and Results: Quantitative results showed that the experimental group's metacognitive message level at post-test ($M = 78.3$) was statistically significantly higher ($p < 0.001$) than the control group ($M = 62.1$). Similarly, personal-professional development indicators also showed a significant increase in the experimental group ($p < 0.01$).

According to the results of the qualitative analysis, the following themes frequently appear in students' reflective journals:

"I used to have low self-esteem, but seeing my achievements through my portfolio has boosted my confidence";

"Writing after each project what went well and what needed improvement helped me learn from my mistakes";

In focus group discussions, students described the e-portfolio as a "window into myself." Many viewed it not only as an assessment tool, but also as a tool to guide their own development path.

Analysis of the portfolio content indicated that students' reflections were qualitatively deepening over time - developing higher-order thinking skills such as analysis, prediction, and self-criticism.

Conclusions and suggestions: The results obtained scientifically confirm that the use of electronic portfolios in engineering education can develop students' metacognitive reflection and ensure personal and professional growth. E-portfolios allow students not only to document their achievements, but also to analyze the learning process, recognize shortcomings, and plan for the future.

Suggestions:

Introduction of a mandatory e-portfolio system in engineering disciplines;

Training teachers on the use of e-portfolios as a pedagogical tool;

Using an e-portfolio as a professional portfolio - for use in graduate employment;

Integrating reflexive modules into digital learning platforms;

E-portfolio to accreditation and quality control systems.

Future research should focus on developing customized versions of e-portfolios for different engineering disciplines (e.g., software engineering, electrical engineering, mechanical engineering).

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