Kaizen continuous improvement technology in the educational process of future computer science teachers: a case study in Kazakhstan

Riza Akhitova

L.N. Gumilyov Eurasian National University
Astana, Kazakhstan

ABSTRACT: This study aims to apply the technology of continuous improvement, specifically Kaizen, in the educational process to develop professional competencies among future computer science teachers in Kazakhstan. The development of professional competencies encompasses motivational, cognitive and activity components, which are fostered through the acquisition of knowledge, analysis and evaluation of cases, and the ability to select optimal solutions. The study involved doctoral students, teachers and students of the educational program 5B011100 - Informatics at *L.N. Gumilyov* Eurasian National University, Astana, Kazakhstan. The collaboration of all participants resulted in the development of a pedagogical model based on case technology, ultimately leading to the creation of the digital educational environment *Kaizen in Education*. The experimental group utilised the Kaizen continuous improvement technology to develop their professional skills and competencies, while the control group followed traditional teaching methods. The results highlight the effectiveness of the proven Kaizen technology and the pedagogical model in improving the quality of education for future computer science teachers.

Keywords: Higher education, case technologies, Kaizen, continuous improvement. pedagogical model, computer science

INTRODUCTION

As the significance of lifelong learning becomes increasingly evident, it is imperative for the education system to adapt to the evolving needs of society, while considering advancements in science and modern information and communication technologies. The development and implementation of new information technologies necessitate updates in professional requirements, potentially leading to an enhancement in the quality of education for students studying computer science. The competence of future computer science teachers in effectively utilising these new technologies will significantly influence the overall quality of education. During their university studies, computer science students prepare for teaching disciplines, while continuously improving their administrative skills.

The primary objective of continuous education is to develop qualities, such as purposefulness, independence, responsibility, diligence, adaptability to the rapidly changing modern world, and the ability to effectively assimilate new information.

In this article, the author presents an original and reflective study on how Kaizen technologies can positively impact learning motivation and improve the quality of education for future computer science teachers. Undoubtedly, the quality of teaching and learning has become a strategic issue in higher education systems worldwide [1].

Abad-Segura et al analysed digital transformation trends in education and emphasised the need for sustainable management to adapt to changes brought about by new technologies [2]. As the world of education undergoes changes, there is a pressing need to re-evaluate teacher training approaches and incorporate innovative teaching methods [3].

Kaizen methodology, initially developed for the business sector, particularly industry, aims to achieve optimal employee performance through continuous improvement. Recently, the application of Kaizen in the field of education has gained attention [4]. Kaizen technology effectively integrates existing tools and innovative methodologies, addressing the shortcomings of traditional teaching methods and complementing them with more innovative approaches [5].

LITERATURE REVIEW

As mentioned earlier, continuous education aims to develop qualities, such as independence, purposefulness, diligence, responsibility and adaptability to innovations. In Denmark, VIA University College initiated a strategic-level lifelong

learning project to increase blended learning and on-line education in its portfolio. The school aimed to play a more active role in technology-supported diploma and academic courses [6][7].

The education sector is vital and vulnerable in the evolving system. Digitalisation in education is a new paradigm for high-tech development. Digital technologies are relevant and widely used in various areas of society, including management, economic relations, science and education [8].

The University of Toronto used innovative approaches to improve teaching quality and assess student learning outcomes. They employed anonymous quizzes via the Nearpod on-line educational application, leading to improved self-learning abilities, increased subject socialisation, and greater responsibility and activity in knowledge acquisition and transfer [9].

This study utilises Kaizen continuous improvement technology to enhance the quality of education for computer science students. The Kaizen methodology, originating in Japan, emphasises continuous, persistent development rather than radical change and offers a cohesive framework for strategic planning and evaluation. Kaizen principles have been successfully applied to various fields, including education [10].

Kaizen-based work readiness training, rooted in lean manufacturing methods, is founded on principles like respect for others, work motivation, continuous improvement, collaboration as a performance foundation, and innovation as a complement to work processes [11]. Kaizen's idea focuses on continuous, sustainable development rather than radical change, and offers a holistic framework for combining the basic elements of strategic planning and evaluation. Teaching is most effective when teachers, students, administrators and staff work together to identify and improve all aspects of the learning process. Initially focused on improving the quality of business management.

According to Danese et al, lean management popularised the Japanese manufacturing approach aimed at eliminating waste to improve operational performance and customer satisfaction [12]. And over the years, this concept has evolved into a management paradigm and is applied to various sectors and processes.

Today, it is used in the public sector and in the education sector with impressive results. In education, Kaizen is an innovative approach to organise the educational process and constantly improve knowledge and skills. The article describes the application of Kaizen technology in solving cases, which involves using various cases in the educational process to identify problems, discuss potential solutions and foster classroom interaction. Competitions using case technologies have proven effective in student engagement [13].

The success of Kaizen has been demonstrated in various organisations worldwide. In education, the successful introduction of Kaizen technology has significant implications for the training of future teachers. The teacher's influence on student learning quality makes it a critical issue in higher education worldwide [14][15].

To date, Kaizen technology has been successfully introduced into the educational process to improve the quality of education. Improving the quality of education of future teachers is a key issue for pedagogical higher education institutions in all countries. The teacher influences the quality of students' education, and, consequently, the quality of life of society as a whole. Quality management is a set of management practices and procedures implemented by universities in order to ensure and develop higher education quality [16].

The study outlined in this article aimed to utilise Kaizen continuous improvement technology in the educational process to enhance the professional competencies of future computer science teachers, thereby improving the overall quality of their education. The study tasks included developing a pedagogical model for enhancing the quality of education through case technology, creating a digital educational environment *Kaizen in Education* based on this model, and conducting an educational experiment with computer science students to test the model's effectiveness and evaluate the development of their professional competencies.

METHODS AND MATERIALS

The educational experiment was conducted at *L.N. Gumilyov* Eurasian National University, Astana, Kazakhstan The experiment involved doctoral students, teachers and students from the educational programme 5B011100 - Informatics, specifically in the discipline *data analysis*.

The study included 40 students, with 15 students in the control group and 25 students in the experimental group. The experimental group used Kaizen continuous improvement technology to develop their professional skills and competencies, while the control group followed the traditional teaching method.

Due to the pandemic, some classes were held remotely using platforms like Microsoft Teams and Zoom. The students installed necessary software on their personal computers, such as Microsoft Excel, Statistica and Trello.

During the study, students worked on case-tasks related to the discipline's thematic plan. Examples of these case studies included: *Overview of the modern market of statistical programs and their comparison*, *Visualisation of analytical data and their capabilities* and *Types of dispersion and their calculation*.

Interviews and questionnaires were used to gather data from the students. The interview method was used to assess the exchange of information, interaction within the group, disputes, conflicts, and the use of a creative approach while solving cases. The interview method is one of the most frequently used in the field of pedagogical research [17].

The students' responses were entered into the MS Excel program, and subsequent analysis was conducted. The interview questions were formulated by teachers and doctoral students. The key inquiries for the students were as follows:

1. How would you evaluate the exchange of information and interaction within the group during problem solving?
2. Were there any disputes or conflicts encountered while solving the cases?
3. Did all students take into consideration the opinions of their peers?
4. Did you employ a creative approach in solving the problems presented in the cases?
5. If yes, what creative approaches did you utilise while addressing the cases?
6. In your opinion, was the task completed efficiently?
7. How much time did it take to solve the problem? Were you able to meet the specified timeframe?

Throughout the study, the internal consistency of the questionnaire was measured using the Cronbach's alpha test. The interpretation of the Cronbach's alpha values is as follows: (0.9; 1) excellent; (0.8; 0.9) good; (0.7; 0.8) acceptable; (0.6; 0.7) questionable; (0.5; 0.6) poor; and (0; 0.5) unacceptable. The cumulative Cronbach's alpha value for the questionnaire was 0.93, with individual values of 0.87, 0.93, 0.92, 0.94, 0.95 and 0.96 for the six parameters in the aforementioned order. Based on the results of the Cronbach's alpha test, it can be concluded that the questionnaire demonstrates satisfactory reliability and is suitable for conducting surveys.

The entire group participated in the survey, and the students were informed about the data collection and analysis procedures, as well as the objectives of the study. The age range of the students was 20-21 years.

During the research, doctoral students and teachers developed and evaluated a pedagogical model aimed at enhancing the quality of education for future computer science teachers through the utilisation of case technology. The objective of this model is to foster professional competencies among future computer science teachers, thereby improving the overall quality of their education. These professional competencies encompass motivational, cognitive and activity components. For students, these competencies are cultivated through the acquisition of knowledge, the ability to analyse cases, evaluate situations and select optimal solutions. The methodological model comprises three main blocks: objectives, content and results, as shown in Figure 1.

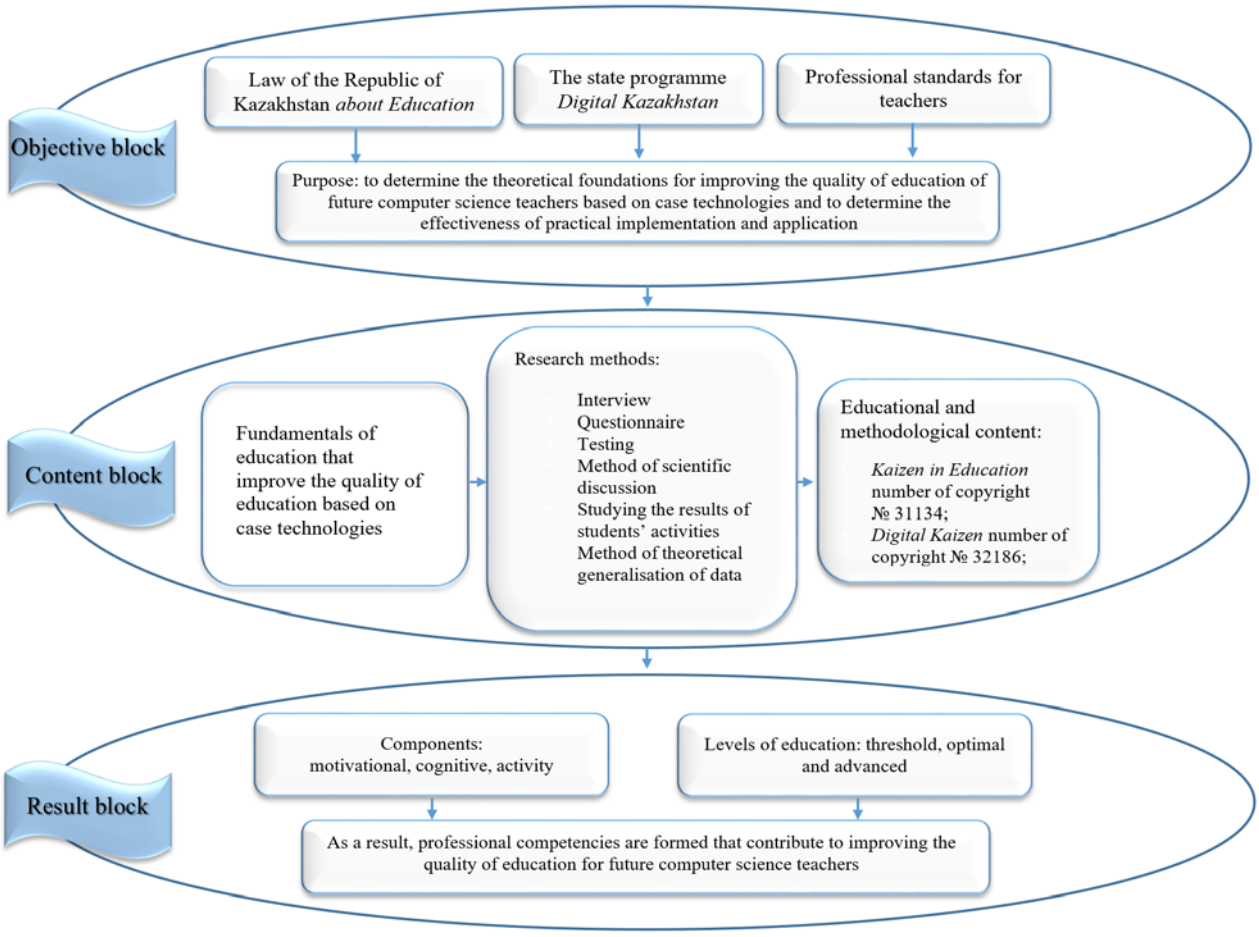

Figure 1: Pedagogical model of improving the quality of education of future computer science teachers based on case technology.

The present study is centred on a pedagogical model that aims to enhance the quality of education for future computer science teachers through the utilisation of case technology. This model served as the foundation for the development of the digital educational environment *Kaizen in Education*, which was created by doctoral students. The digital educational environment incorporates the innovative Kaizen methodology, which facilitates the learning process for both students and teachers [18].

The *Kaizen in Education* digital educational environment consists of lectures and practical tasks that involve cases, thereby contributing to the improvement of knowledge quality and the development of professional competencies among future computer science teachers. This educational environment has been granted an author's certificate and certificates of implementation in the educational process.

Within the *Kaizen in Education* digital educational environment, principles of technology are described and applied to solve cases. These principles include workplace organisation, as exemplified by the 5S concept, and the *Five Whys*? method. The application of these principles during the learning process aids in the development of professional competencies among future computer science teachers. This is achieved through the enhancement of their analytical skills, their ability to evaluate different situations and their aptitude for selecting optimal solutions.

In the context of workplace organisation and case solving, students in the experimental groups employed the 5S concept. This concept, widely utilised in enterprises, institutions and offices worldwide, focuses on organising workspaces and creating favourable conditions by maintaining order, cleanliness, attentiveness and time efficiency.

The implementation of the 5S concept not only restored order in the students' workspaces, but also fostered discipline and improved teamwork. The achievement of specific indicators for each of the five components of the 5S concept was recorded at each stage, thus ensuring systematic implementation and reducing resistance to change among students. This approach promotes the active involvement of all students in the case-solving process.

Another method employed for case solving was the *Five Whys?* method, named after the five consecutive questions asked during the analysis of a case. This method involves identifying contradictions or problems and seeking answers to the question *Why did this happen?* Through the use of this method, students can objectively identify and address problems, enabling effective problem-solving.

The hierarchical presentation of problems in the form of a hierarchy allows students to analyse specific parts of a case, make immediate corrections and implement their own changes. This method teaches students to allocate time and tasks efficiently in order to achieve quick and optimal results. The step-by-step application of the *Five Whys?* method by students in the experimental group is as follows:

1. Students identify discrepancies or problems that require solutions and record them on paper or using the Trello program board.
2. Students ask the question *Why did these inconsistencies arise during the case analysis?* or *Why did this happen?* and determine multiple answers, which are also recorded.
3. Students analyse the causes identified in the previous step and ask the question *Why did this happen?* for each specific cause. The results of these analyses are recorded at a third level of detail.
4. Students check if further clarification of the reasons is necessary. If so, they repeat the cycle of asking *Why did this happen?* up to five times to detail the causes to the lowest level.
5. At the final stage of this method, students conduct an analysis and provide detailed explanations of the causes identified in the case. The main results are determined based on all the identified causes.

In the process of case solving, students in the experimental group utilised the Trello cloud program developed by Fog Creek Software. This visual tool promotes teamwork, tracks case progress, sets deadlines and stores all necessary information in a centralised location.

To address the challenges of group work and conflicts that may arise, instructors can implement the following strategies:

- Establish clear expectations and norms for working together;
- Design or have students design protocols for handling conflict and disagreement, enabling them to resolve issues within their teams;
- Teach students active listening skills;
- Provide opportunities for students to develop leadership, decision-making, trust-building, communication and conflict-management skills;
- Conduct mini-lessons on ways to respect others and train students in conflict resolution;
- Use icebreaker activities to help students find common ground;
- Specify desired behaviours and teach students how to work effectively in a group.

By implementing these strategies, instructors can promote a co-operative and collaborative learning environment, enhance student collaboration, and effectively address conflicts that may arise during group work [19].

Continuous improvement in the learning process was achieved through the implementation of Kaizen Blitz, a group work format that encompasses the complete cycle of case work, including diagnostics, solution development, implementation and control. In Kaizen Blitz sessions, students discuss ways to solve cases and are responsible for implementing changes that can improve specific problems.

In summary, the principles of Kaizen technologies provide a creative and innovative approach to the educational process, taking into account the development of professional competencies and the individual characteristics of students, as well as the importance of independently shaping their own educational trajectory [20][21].

RESULTS AND DISCUSSION

The findings of this study demonstrate that the incorporation of Kaizen continuous improvement technology into the educational process enhances the development of professional competencies among future computer science teachers, thereby improving the overall quality of education. The utilisation of Kaizen technology in the analysis of specific cases allows for the identification of key details, consideration of various aspects of each task, drawing of informed conclusions, and enables students to express their thoughts logically. Consequently, the integration of Kaizen technology in the educational process exhibits a positive trend in achieving favourable outcomes.

Throughout the progression of each case, there was a steady increase in the percentage of successful problem solving, indicating an upward trajectory in the quality of education and affirming the effectiveness of the implemented measures to enhance results. The study employed a valid methodology, including interviews conducted with both experimental and control groups. All obtained results from the study exhibit statistical reliability. This methodology is suitable for verbal and communicative research, as it involves the collection of information. Figure 2 illustrates the results for three parameters:

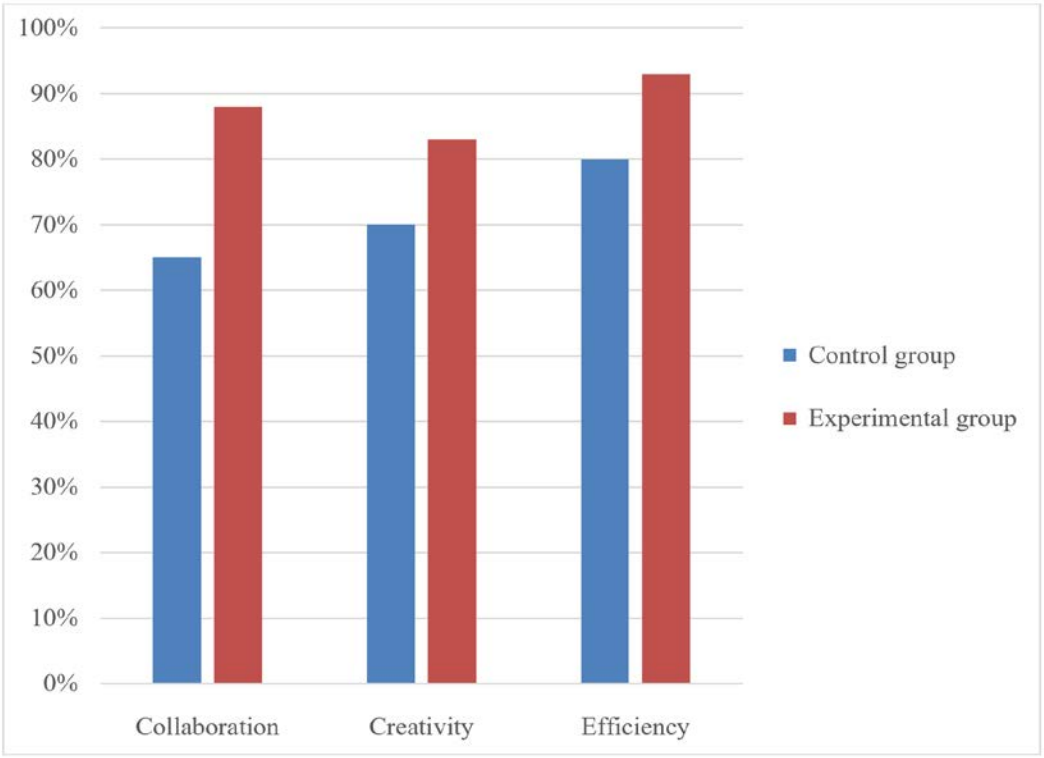

Figure 2: Evaluation of interview results.

The results of the study indicated that the implementation of Kaizen continuous improvement technology in the educational process positively influenced the development of professional competencies, thereby enhancing the quality of education for future computer science teachers. The experimental group, which underwent training with the Kaizen methodology, demonstrated higher levels of co-operation compared to the control group. Specifically, 88% of students from the experimental group reported working well together on cases without conflicts or disagreements, whereas only 65% of students from the control group reported the same. This indicates that the use of Kaizen technology fosters a collaborative and harmonious learning environment.

Moreover, a significant number of students in the experimental group (83%) reported applying a creative approach to solving the proposed cases. These students offered innovative solutions that had not been previously explored in the classroom, drawing upon their own work experiences. In contrast, only 70% of students in the control group believed that a creative approach was utilised. This highlights the effectiveness of Kaizen technology in promoting creativity and critical thinking among students.

In terms of overall satisfaction and perceived effectiveness, the experimental group rated their experience with working on cases and utilising Kaizen technology at an impressive 90%. Conversely, the control group rated their experience at 80%. This demonstrates the positive impact of Kaizen technology on students' perception of the educational process.

The integration of Kaizen technology into the educational process offers an alternative to the traditional approaches to learning. It provides an opportunity for students to apply practical skills that may have been underutilised before, such as teamwork, collaborative problem-solving and simulating real-world work scenarios. Additionally, it nurtures creative thinking and problem-solving abilities, enabling students to tackle non-standard tasks that deviate from textbook examples. By engaging students in these novel learning approaches, Kaizen technology promotes interest, motivation and self-discipline, while preparing them for future professional challenges.

During the discussion of the interview results, several positive aspects of introducing Kaizen technology into the educational process were identified. These include an increase in students' interest and motivation to master the discipline, improved group dynamics and collaboration, enhanced sense of responsibility, development of creative thinking skills, and cultivation of self-discipline and effective planning.

In conclusion, the findings suggest that the incorporation of Kaizen technology in education presents a valuable opportunity for enhancing the quality of education for future computer science teachers. By embracing this methodology, educators can foster a collaborative and creative learning environment that equips students with the necessary skills and competencies for their professional journeys.

The introduction of Kaizen technology into the educational process has been noted to have positive aspects, including increasing students' interest in mastering the discipline, increasing motivation to study, ease of working in a group, increased responsibility, formation of creative thinking and enhancement of creative abilities, self-discipline and hard work training, and planning. However, difficulties and problems encountered include a psychological factor associated with the emotional load of the student, which appears during disputes, discussions and argumentation of the solution of the case.

During the testing of the pedagogical model of improving the quality of education of future computer science teachers based on case technology, positive dynamics in the formation of professional competence levels were revealed, which includes motivational, cognitive and activity components. The motivational component includes the presence of a motive to master the skill and awareness of the importance of the skill in the structure of professional activity. The cognitive component includes the presence of a system of knowledge about the means and methods of actions necessary in the implementation of organisational and managerial activities. The activity component is determined by the possession of skills necessary for professional activity, professional literacy and the ability to transfer skills to changed situations.

To address the difficulties and problems encountered, instructors can conduct mini-lessons on ways to respect others, teach students conflict-resolution, establish clear expectations for group members, increase individual accountability and explain why working in groups is worth the frustration. Additionally, instructors should note that coordination costs increase with conflict within groups, which can erode morale and cause members to withdraw. Therefore, it is important to address conflict effectively to prevent negative impacts on group work.

During the initial phase of the experiment, a preliminary test was conducted to assess the levels of various components, including the motivational component, cognitive component and activity component. As depicted in Figure 3, there were notable disparities observed in the outcomes between the control group and the experimental group.

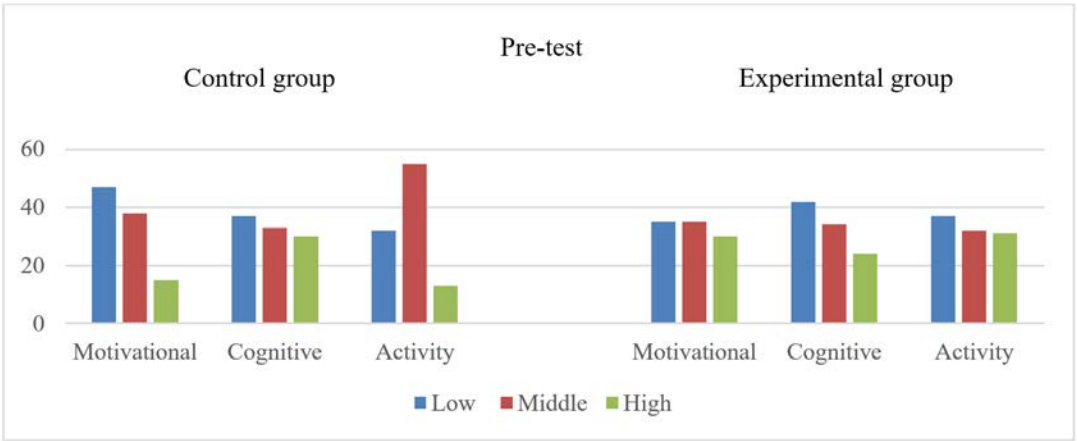

Figure 3: Levels of component formation at the formation stage.

According to the graph, it can be observed that at the formation stage, both groups had low and medium levels of more than 30% for all components. Specifically, in the control group, the activity component at a high level was 13%, while in the experimental group, this indicator reached 31%. Additionally, it can be noted that in the experimental group, the percentage of the motivational component at a high level was twice as high as in the control group.

At the final stage of the experiment, similar to the formation stage, a knowledge slice was conducted after testing to determine the levels of components and track their dynamics. Figure 4 illustrates the levels of component formation at the final stage.

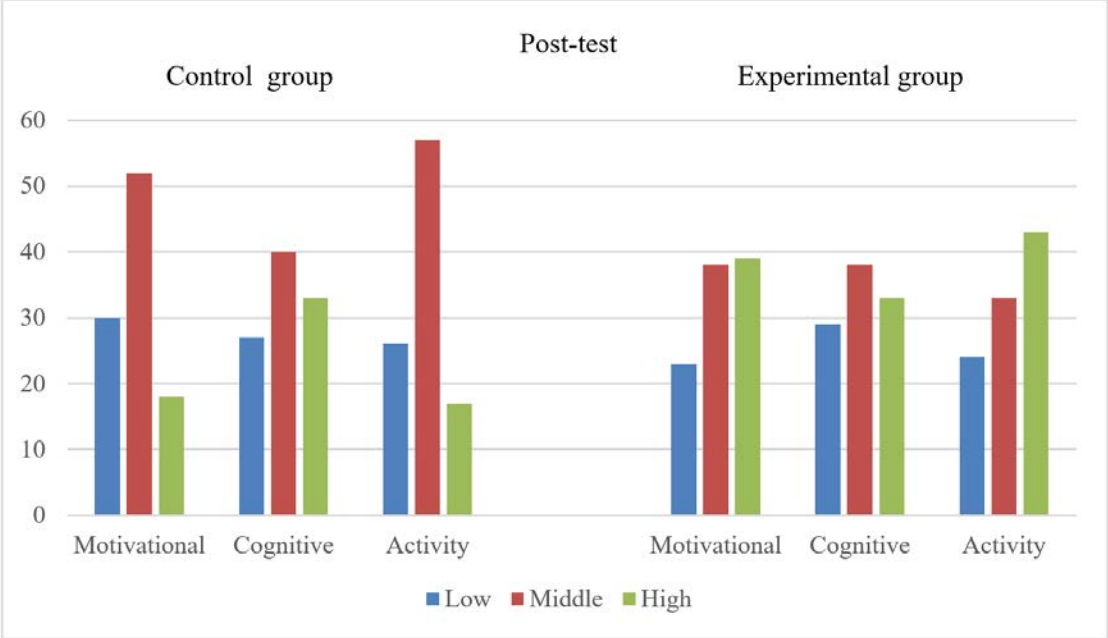

Figure 4: Levels of component formation at the final stage.

According the findings from the concluding phase of the study, the high level of the activity component in the experimental group exhibited a significant increase from 31% to 43% compared to the formative stage. Conversely, the low level of the activity component decreased from 37% to 24%. The diagram visually represents that, on average, the experimental group achieved a high level for all components at the final stage, totalling 36%.

As a result of implementing the proposed model, the experimental group displayed a higher level of component formation compared to the control group. This indicates that students in the experimental group developed professional competencies, which consequently enhances the quality of education for future computer science teachers.

CONCLUSIONS

The study demonstrated that the pedagogical model based on Kaizen continuous improvement technology effectively improved the quality of education for future computer science teachers. The positive dynamics in the development of professional competencies among students participating in the experiment confirmed the model's effectiveness. The integration of Kaizen technologies in the educational process offered an innovative approach, fostering creativity, teamwork and problem-solving skills.

The levels of formation of the components (motivational, cognitive and activity) were measured at the formative and final stages of the experiment. The experimental group showed significant improvements in all components compared to the control group. The use of Kaizen technology resulted in higher levels of professional competencies among the experimental group students.

This research is valuable for improving the quality of education, especially in Kazakhstan, and provides insights for educators seeking effective pedagogical technologies and digital tools to enhance their teaching practices. The successful implementation of Kaizen technology in education opens new possibilities for continuous improvement fostering a desire for optimal and rational means of achieving educational goals.

REFERENCES

1. Harvey L. and Williams J., Fifteen years of quality in higher education. *Quality in Higher Educ*., 16, **1**, 3-36 (2010).
2. Abad-Segura E., González-Zamar M.-D., Infante-Moro J.C. and García G.R., Sustainable management of digital transformation in higher education: global research trends. *Sustainability*, 12, **5**, 2107 (2020).
3. Gouthro, P.A., Lifelong learning in a globalized world: the need for critical social theory in adult and lifelong education. *Inter. J. of Lifelong Educ*., 41, **1**, 107-121 (2022).
4. Zambrano-López, S., Solís-Quinteros, M.M., Zayas-Márquez, C. and Ávila-López, L.A., Kaizen method applied in higher education: case study of Autonomous University of Baja California. *Proc. AHFE Conf. on Human Factors in Training, Educ. and Learning Sciences*, USA, 122-130 (2021).

5. Gourlay, L. and Stevenson, J., Teaching excellence in higher education: critical perspectives. *Teaching in Higher Educ.*, 22, **4**, 391-395 (2017).
6. Buus, L. and Georgsen, M., A learning design methodology for developing short learning programmes in further and continuing education. *J. of Interactive Media in Educ.*, 2018, **1**, 1-10 (2018).
7. Dembereldorj, Z., Review on the impact of world higher education rankings: Institutional competitive competence and institutional competence. *Inter. J. of Higher Educ.*, 7, **3**, 25-35 (2018).
8. Dinis Sousa, R., Karimova, B. and Gorlov, S., Digitalization as a new direction in education sphere. *Proc. 1st Inter. Conf. on Business Technol. for a Sustainable Environmental System*, Almaty, Kazakhstan, 1-7 (2020).
9. Burra, T., Peck, J.R. and Waddell, A.E., Content and process: using continuous quality improvement to teach and evaluate learning outcomes in quality improvement residency education. *BMJ Open Quality*, 11, **4**, e001806 (2022).
10. Imai, M., *Gemba Kaizen: a Commonsense Approach to a Continuous Improvement Strategy*. New York: McGraw Hill, 53-78 (2012).
11. Nofemela, F. and Winberg, C., The relevance of Kaizen-based work-readiness training for South African University of Technology students. *The J. for Transdisciplinary Research in Southern Africa*, 16, **1,** 1-13 (2020).
12. Danese, P., Manfè, V. and Romano, P., A Systematic literature review on recent lean research: state-of-the-art and future directions. *Inter. J. of Manage. Reviews*, 20, **2**, 579-605 (2018).
13. Avdeenko, A., Sabirova, F. and Konyushenko, S., STEM education: key challenges in the common practice. *Inter. J. of Web-based Learning and Teach. Technol.*, 16, **6**, 1-11 (2021).
14. Guskova, N.D., Vdovin, S.M., Krakovskaya, I.N. and Slushkina, Y.Y., The quality of education as a primary concern of the sustainable development. *European Research Studies*, 19, **3**, 239-257 (2016).
15. Filippakou, O., The idea of quality in higher education: a conceptual approach. *Discourse: Studies in the Cultural Politics of Educ.*, 32, **1**, 15-28 (2011).
16. Seyfried, M. and Pohlenz, P., Assessing quality assurance in higher education: quality managers' perceptions of effectiveness. *European J. of Higher Educ.*, 8, **3**, 258-271 (2018).
17. Bidabadi, N., Isfahani, A., Rouhollahi, A. and Khalili, R., Effective teaching methods in higher education: requirements and barriers. *J. of Advances in Medical Educ. & Professionalism*, 4, **4**, 170-178 (2016).
18. Kregel, I., Kaizen in university teaching: continuous course improvement. *Inter. J. of Lean Six Sigma*, 10, **4**, 975-991 (2019).
19. Valente, S., Afonso Lourenço, A. and Németh, Z., School Conflicts: Causes and Management Strategies in Classroom Relationships (2020), 23 December 2020, https://www.intechopen.com/chapters/74550
20. Supriyanto, A. and Benty, D.D.N., Kaizen: quality improvement innovation higher education in the Industrials Revolution 4.0. *Proc. 4th Inter. Conf. on Educ. and Manage.*, Malang, Indonesia, 108-113 (2019).
21. Chen, J.K., A novel Kaizen technique for service quality: case study in educational organization. *The TQM J.*, 30, **4**, 269-280 (2018).

BIOGRAPHY

Mrs Riza Akhitova obtained her Bachelor's degree in computer science from *L.N. Gumilyov* Eurasian National University (ENU), Astana, Kazakhstan, in 2013. Subsequently, she pursued a Master's degree in the same field at the ENU, graduating in 2015. In 2019, Mrs Akhitova embarked on her doctoral journey, specialising in the training of computer science teachers at the ENU. Currently, she is in the final stages of completing her doctoral dissertation, which focuses on enhancing the quality of education for future computer science teachers through the application of case technologies. With over 10 years of extensive teaching experience, Mrs Akhitova has made several contributions to the field of education. Since 2016, she has served as a teacher at the ENU. Additionally, in 2015, she worked as the leading engineer at the India-Kazakhstan Centre of Excellence in ICT with a PARAM BILIM supercomputer, the only one such device in the country. Presently, she holds the position of computer science teacher at the Kazakh National Academy of Choreography, Astana, Kazakhstan. Mrs Akhitova's dedication to research is evidenced through her publication record. She has authored and co-authored more than 20 articles, presenting her research findings at conferences and refereed journals within the realms of education and computer science.