International Journal of Applied Mathematics
Volume 38 No. 12s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

INNOVATIVE TEACHING AND LEARNING MODEL APPLYING SIMULATION TECHNOLOGY

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Abstract

In the context of digital transformation and the Fourth Industrial Revolution, which are having a profound impact on all sectors, technical education, particularly in the field of Automotive Engineering Technology, requires comprehensive innovation in teaching and learning methods. This paper presents the results of research on a model for innovating teaching methods at the Department of Automotive Engineering Technology, Thanh Dong University, with a focus on integrating simulation technology and modern pedagogical methods. The study applied a mixed-method approach, using a survey questionnaire of 120 students and in-depth interviews with 15 lecturers, combined with analysis of learning products such as videos, scale models, and digital projects. The three main pillars of the model are: (1) Application of simulation software such as Matlab Simulink, SolidWorks, Ansys Fluent, and CarSim in teaching specialized courses; (2) Implementation of active learning models through flipped classrooms and project-based learning; (3) Development of digital literacy for faculty and students. The results show that the model has significantly improved students' knowledge acquisition, practical skills, systematic thinking, and creativity. At the same time, lecturers demonstrated initiative in designing digital lectures and effectively applying technology to the teaching process. Based on the research results, the article affirms the feasibility, effectiveness, and scalability of the technology-integrated teaching model in modern automotive engineering training, contributing to the development of a digital education ecosystem suitable for the demands of the new era.

Keywords: *Simulation technology, project-based learning, flipped classroom, digital literacy, automotive engineering.*

I. PROBLEM STATEMENT

In the context of globalization and the Fourth Industrial Revolution (Industry 4.0), higher education, particularly in the field of engineering and technology, is facing the need for fundamental and comprehensive innovation. New technological trends such as artificial intelligence, big data, virtual reality, and digital simulation systems are profoundly changing how people access, convey, and apply knowledge. For the automotive engineering technology industry, which requires both interdisciplinary knowledge and practical skills, innovating teaching and learning methods has become an essential need to train human resources capable of responding to the rapid shifts in the labor market [1], [2], [3], [4].

Traditionally, automotive engineering training at many educational institutions has primarily relied on lecture-based teaching methods, experiments on real vehicles, or mechanical

Received: August 10, 2025

cutaway models. Although this approach provides students with a visual experience, it has many limitations: high costs, safety risks, dependence on physical conditions, and difficulty in creating diverse simulation scenarios for operating situations [9]–[13]. Meanwhile, the rapid development of simulation software such as *Matlab Simulink*, *SolidWorks*, *Ansys Fluent*, and *CarSim* has opened up opportunities to incorporate virtual systems into the teaching environment, helping students gain access to visual, safe, and cost-effective learning [1]–[4].

Beyond technological factors, modern pedagogical trends also demand changes in teaching organization methods. Studies show that active learning methods like *Project-Based Learning (PBL)* or *Flipped Classroom* can boost motivation, develop critical thinking, enhance problem-solving skills, and foster group collaboration among students [14]–[28]. In the flipped classroom model, students actively engage with theory at home through videos or digital materials, while class time is focused on discussion, practice, and simulation [17], [19], [21]. This approach has been proven to increase knowledge acquisition and student satisfaction in engineering and medical fields [18], [20].

Particularly in automotive engineering training, project-based learning provides significant value by linking theory to practical tasks such as building electrical system models, analyzing vehicle dynamics, or designing mechanical components [22]–[25]. Students not only acquire knowledge but also develop professional skills through teamwork, experimentation, failure, and improvement. This evidence confirms that combining simulation technology with active learning methods creates a comprehensive learning environment that meets the practical demands of the modern automotive industry [5], [6].

Alongside methodological innovation, the digital competence of faculty and students has also become a decisive factor for success. The European Commission's DigCompEdu digital competence framework [7], [29], along with other international standards [30]–[33], indicates that instructors need to be equipped with the ability to design digital lessons, use online learning management systems (LMS), implement simulation tools, and evaluate learning outcomes using digital data. Conversely, students must also develop digital learning competencies, including the ability to self-learn, access online resources, and participate in virtual learning communities [34]–[39]. In this context, developing teaching-learning models that integrate simulation technology, active learning methods, and digital competency development is an inevitable and urgent trend.

Many international studies have demonstrated the effectiveness of this model. Cho et al. [38] assert that the flipped classroom in mechanical engineering not only helps students gain a deeper understanding of the knowledge but also promotes positivity and interest. El-Thalji [39] points out that gamification combined with the flipped classroom creates a richly interactive learning environment, enhancing participation and learning outcomes. Meanwhile, s conducted at KTH Sweden [40] and Plymouth University [41] show that integrating MATLAB/Simulink simulations or virtual driving systems allows students to safely approach dangerous operating situations. Similarly, Li and Zhang [42] applied CFD to analyze automotive aerodynamics, providing a visual perspective on how technical factors affect fuel efficiency.

Beyond theory, this model also demonstrates broad application potential. TEM Journal [43] summarizes two decades of PBL application in engineering, proving its sustainability and scalability. Alarcón et al. [44] implemented PBL in the context of Industry 4.0, showing that automotive engineering students can participate in designing assembly lines through simulation, thereby enhancing their creativity and collaboration skills. Furthermore, Abulrub and colleagues [46] confirmed that the application of virtual reality (VR) in engineering education is a powerful tool for training engineers in a virtual yet realistic environment. Liu and Xu [48] even developed a VR system specifically for automotive engine disassembly and assembly, helping to address cost and safety issues in practical training.

However, in Vietnam, the application of this model remains limited. Many training institutions still lack standardized simulation systems, instructors have not been properly trained in flipped classrooms and PBL, while students' digital capabilities remain scattered. This gap requires case studies at technical universities to propose and validate models suitable for the domestic context. Thanh Dong University, with its strength in training in the field of automotive engineering technology, has begun to implement an innovative teaching and learning model based on the integration of simulation technology and modern pedagogical methods.

Based on the above theoretical and practical foundations, this study aims to clarify: (i) the theoretical basis and research overview of the application of simulation and active learning methods in technical training; (ii) the design and implementation of an integrated teaching model at the Faculty of Automotive Engineering Technology, Thanh Dong University; (iii) the evaluation of experimental effectiveness through surveys of students and faculty; and (iv) the proposal of directions for replicating the model. The expected research results will contribute both theoretically—adding empirical evidence to the model's effectiveness—and practically—providing feasible solutions to innovate automotive engineering education in the context of digital transformation and Industry 4.0.

II. THEORETICAL FOUNDATION AND RESEARCH OVERVIEW

A. Theoretical Basis

In the context of modern technical education, the application of simulation technology and innovative pedagogical methods based on constructivist learning theory has become an inevitable direction. The constructivist perspective holds that knowledge is not only passively received from instructors but is constructed by learners through real-world experiences, interactions, and problem-solving processes [14], [22]. Based on this theoretical foundation, active learning methods such as the flipped classroom and project-based learning (PBL) are considered suitable for promoting student engagement and comprehensive skill development. At the same time, the support of simulation technologies such as Matlab Simulink, SolidWorks, Ansys Fluent, and CarSim has proven effective in enhancing the ability to acquire and apply technical knowledge [1]–[4].

Engineering simulation is a pillar of modern engineering education. Matlab Simulink has been used to model control and signal systems, allowing students to visualize the complex principles of engines, braking systems, or power transmission in a safe and intuitive environment [1]. SolidWorks plays a role in 3D design, helping students directly access mechanical details and improve digital design skills [2]. Ansys Fluent provides powerful tools for fluid dynamics analysis, particularly in automotive aerodynamics research, pressure distribution, and fuel efficiency optimization [3]. CarSim specializes in vehicle dynamics and vibration simulation, helping students validate operating scenarios and analyze vehicle stability and safety [4]. These tools help compensate for the limitations of real-world models in terms of cost, safety, and physical conditions, while developing students' systems thinking and data analysis capabilities [9]–[13].

In terms of learning theory, the Flipped Classroom is built on the premise that students are at the center of the learning process. They access theory through digital materials, videos, or learning management systems (LMS) at home, then use class time for practice, simulation, and group discussion. This creates a flexible learning environment that enhances initiative and critical thinking skills [14], [17], [19]. Empirical studies have shown that the Flipped Classroom not only improves learning outcomes but also increases student engagement and satisfaction in technical subjects [6], [18], [20]. Additionally, Project-Based Learning (PBL) stems from the perspective that knowledge is linked to practice, requiring learners to solve a specific task, thereby developing collaboration skills, creative thinking, and problem-solving abilities [22]–[25]. The implementation of PBL in automotive engineering education, such as building scale models of electrical systems or vehicle dynamics simulations, has shown remarkable effectiveness in honing professional skills and increasing learning interest [5], [43], [44].

Another important component of the theoretical framework is the digital competence of instructors and students. The European Commission's DigCompEdu framework identifies six core competency groups: digital professional engagement, digital resource development, digital teaching and learning, digital assessment, learner empowerment, and digital competence development [7], [29]. UNESCO also emphasizes the role of ICT-CFT as a global competency framework to standardize technology skills for the teaching workforce [30]. Mishra and Koehler, with their TPACK model, have shown that the harmonious combination of technological knowledge, content knowledge, and pedagogical knowledge is the foundation for instructors to effectively leverage technology [31]. Thus, digital competence is not only the ability to use software, but also the skills to design digital learning materials, manage learning data, and participate in online learning communities [32]–[37].

The integration of simulation technology, active learning methods, and digital competency development forms a comprehensive teaching model that ensures quality knowledge acquisition, develops practical skills, and meets labor market demands. Numerous international studies have demonstrated that applying this model helps students not only master specialized knowledge but also develop systematic thinking, creativity, and teamwork skills [38]–[42]. Recent studies have even expanded in the direction of combining simulation, game-based learning, and virtual reality to enhance the learning experience, as evidenced by the research of Abulrub [46], MDPI [47], and Liu & Xu [48]. This demonstrates that the above three-pillar integrated model is highly feasible and suitable for application in automotive engineering education in the digital era.

Received: August 09, 2025

In summary, the theoretical foundation of this study is built on the combination of constructivist learning theory, active learning methods, and the application of simulation technology and digital capabilities. This is an important foundation for forming a new teaching model, in which students play a central role, lecturers are guides, and technology is the main supporting tool, in order to meet the requirements of fundamental innovation in technical education in the era of digital transformation and Industry 4.0.

B. Research Overview

In the context of globalization and the Fourth Industrial Revolution, many international studies have demonstrated the effectiveness of applying digital technology and innovating teaching methods in technical training. Integrating simulation software into teaching is seen as an inevitable trend to improve training quality and reduce costs and risks during practice. Research on *Simulink Fundamentals for Automotive Applications* shows that simulation using Matlab Simulink helps students develop systematic thinking, better understand the operating state of vehicles in complex conditions such as curves or slippery roads, and provides greater visual clarity and safety compared to practicing on real vehicles [1]. In addition, *SOLIDWORKS* software has been widely used as a standard CAD tool in engineering education, supporting students in designing mechanical details, simulating steering, braking, and suspension systems, and directly observing complex 3D details [2]. In aerodynamics research, *Ansys Fluent* has proven to play an important role in CFD analysis, helping students understand the factors that affect drag, pressure distribution, and fuel consumption, while encouraging creativity in research projects [3]. Meanwhile, *CarSim* is highly regarded at many universities for its ability to simulate vehicle dynamics, including skidding, turning, suspension system operation, and ABS/ESP braking. This tool helps students test scenarios in a safe environment, enhancing their analytical skills and ability to propose appropriate technical solutions [4].

Beyond research on simulation tools, trends in innovative teaching methods are also extensively discussed. Syahril and colleagues pointed out that Project-Based Learning (PBL) helps improve the practical skills and independent thinking of automotive engineering students, particularly through tasks such as building scale models of vehicle electrical systems or push-button starters [5]. Alongside this, the Flipped Classroom has emerged as an effective method, where students access theory at home via videos or digital materials, while class time is dedicated to practice and group discussions. Studies by Huang, Chiu, and Hong [6], as well as the review by Bishop and Verleger [14], show that the Flipped Classroom increases engagement, promotes critical thinking, and improves learning outcomes. These findings are reinforced by other studies confirming that the Flipped Classroom improves learning efficiency, increases motivation, and enhances the ability to apply knowledge in real-world contexts [15]–[21].

Numerous works also indicate that PBL is a method particularly suited to engineering education. Thomas [22] and Hmelo-Silver [23] emphasize that PBL develops problem-solving and critical thinking skills, while Blumenfeld et al. [24] demonstrate that PBL promotes learning motivation by connecting knowledge to practical tasks. Kolmos [25] argues that PBL in engineering education helps develop collaboration, time management, and creativity skills—essential competencies in engineering education. Experiments by Felder and Brent [26] as well as Bonwell and Eison [27] reinforce the role of active learning in enhancing student engagement and learning outcomes. In automotive engineering education, recent evidence shows that PBL combined with simulation technology enables students to develop skills in manufacturing, kinematic analysis, and detailed design [43], [44].

Additionally, the development of digital competence among faculty and students has become a key topic in numerous studies. The European Commission's DigCompEdu framework is considered a benchmark for assessing and developing digital competence, encompassing digital learning material design, implementing technology-integrated teaching methods, and evaluating learning outcomes using digital tools [7], [29]. UNESCO has also introduced the ICT-CFT framework as a global standard, emphasizing digital competence as a pillar for improving education quality in the digital age [30]. Mishra and Koehler [31], with their TPACK model, have shown that the combination of technological knowledge, pedagogical knowledge, and content knowledge is a prerequisite for instructors to effectively apply technology. The works of Selwyn [32], Bates [33], Laurillard [34], and Kirkwood & Price [35] all emphasize the central role of technology in restructuring higher education and promoting pedagogical innovation.

Some studies further expand the approach by conducting comparative evaluations of international competency frameworks. Voogt and Roblin [36] indicate that digital competence is a cross-cutting element in 21st-century education. The European School Education Platform [37] has implemented digital competence training courses for educators, helping to standardize and disseminate digital skills on a large scale. Studies by Cho et al. [38] and El-Thalji [39] add evidence that flipped classrooms and gamification not only enhance learning effectiveness but also develop digital competencies through the use of online platforms and digital tools in learning. Experimental work at KTH Sweden [40], Plymouth University [41], and CFD research by Li & Zhang [42] show that integrating digital simulation into engineering courses helps students proactively utilize digital tools, forming analytical and creative competencies.

Over the past two decades, a summary from the TEM Journal [43] has confirmed that PBL is a sustainable method with the potential for replication in engineering education. Alarcón et al. [44] also point out that PBL combined with the Industry 4.0 context, particularly in automotive assembly using simulation, creates opportunities for students to access modern industrial processes. Experimental studies in *Procedia Manufacturing* [45] and *the European Journal of Engineering Education* [46] show that simulation and virtual reality technologies not only support effective learning but also reduce risks and costs while increasing student engagement. Recent studies have even focused on combining simulation, game-based learning, and virtual reality to train automotive engineers in a digital environment. For example, research by MDPI [47] indicates that combining digital models and games enhances motivation and learning outcomes. Liu and Xu [48] developed a specialized virtual reality system for disassembling and assembling automotive engines, demonstrating the applicability of new technologies in addressing cost and safety challenges.

In summary, the works from [1] to [48] show the convergence of three main research directions: (i) the application of simulation software in automotive engineering training, (ii) the application of active learning methods such as Flipped Classroom and PBL, and (iii) the development of digital capabilities for lecturers and students. However, most of these studies are concentrated in developed education systems, while empirical evidence from developing countries such as Vietnam remains limited. In particular, there are few studies that integrate all three pillars into a specific teaching model. This is the research gap that this study aims to address, by developing and validating a model for innovating teaching methods using simulation technology at the Faculty of Automotive Engineering Technology, Thanh Dong University, thereby contributing both theoretically and practically to the field of technical education in the era of digital transformation.

III. RESEARCH METHODOLOGY

In this study, the authors applied a mixed-method research approach, combining quantitative and qualitative methods to comprehensively analyze the effectiveness of the innovative teaching and learning model using simulation technology at the Faculty of Automotive Engineering Technology, Thanh Dong University. The simultaneous use of these two methods allows not only for measurement using specific data but also for the exploration of in-depth perceptions, practical experiences, and multidimensional feedback from both lecturers and students.

A. Research Design

The research design combines a cross-sectional survey model with case studies and will be implemented during the 2023–2024 academic year. The selected courses for the study were those that integrated simulation software, including: Automotive Structures, Powertrain Systems, Automotive Electronic Control, and Automotive Aerodynamics. The survey subjects were third- and fourth-year students enrolled in courses from 2020 to 2024.

Simultaneously, the research team collected information from faculty members who are directly teaching and implementing innovative methods at the Department through in-depth interviews, teaching logs, and analysis of digitized learning materials.

B. Survey subjects and sample

A total of 150 survey forms were distributed, of which 120 valid forms were used in quantitative data analysis. In addition, 15 faculty members with experience teaching courses using simulation and implementing active learning methods participated in semi-structured in-depth interviews. The criteria for selecting faculty members included: being a faculty member of the Faculty of Automotive Engineering at Thanh Dong University, currently teaching courses that apply simulation software, and having at least 1 year of experience using project-based learning or flipped classroom models.

C. Survey Tools and Measurement Scales

The student survey form is designed using a 5-point Likert scale (1 – Strongly disagree to 5 – Strongly agree), covering 4 content groups:

Group A: Effectiveness of knowledge acquisition through simulation software

Group B: Technical practice skills and teamwork skills

Group C: Level of initiative and creativity in learning

Group D: Overall perception of the new teaching method

The simulation tools surveyed included: Matlab Simulink, SolidWorks, Ansys Fluent, and CarSim. The questionnaire was pre-tested on 20 students to refine the content and assess reli . The Cronbach's Alpha coefficient for the entire scale was 0.87, indicating high consistency.

The interview questions for instructors focused on three main content areas:

The applicability and compatibility of simulation software with course content.

Challenges encountered during the implementation of innovative teaching methods.

Evaluation of effectiveness and suggestions for improvement.

In addition, the research team also collected learning products such as simulation videos, sandbox models, digital projects, and course reports to analyze the content and level of technology application by students.

D. Design and implementation of an integrated teaching model

The integrated teaching model consists of three main components:

Simulation software applications: Matlab Simulink (control modeling), SolidWorks (mechanical design), Ansys Fluent (airflow simulation), CarSim (vehicle dynamics simulation).

Active learning methods: Flipped Classroom (pre-learning theory, classroom discussion and practice), Project-Based Learning (assigning real-world tasks to student groups to complete and report on).

Digital skills: Training in digital lesson design, LMS use, and learning data mining.

General model diagram:

Pillar 1: Engineering simulation tools

Pillar 2: Active learning methods

Pillar 3: Digital literacy of instructors and students

5-step implementation process: Analyze objectives → Design digital lessons → Assign simulation tasks → Organize discussion classes → Evaluate learning products

E. Expansion Proposals

The model can be implemented at other technical training institutions such as Mechanical Engineering, Mechatronics, Automation, etc., with the following conditions:

Updating the training program to integrate technical simulation.

Develop a shared digital learning resource repository across the department.

Organize internal training for faculty on active teaching methods and digital tools.

The application of this model contributes to the formation of a new, modern teaching and learning culture, promotes proactivity and creativity, and enhances the technological capabilities of both teachers and learners in the era of digital transformation.

F. Data collection and processing procedures

The survey and interview process took place in the first and second semesters of the 2023–2024 academic year. Questionnaires were distributed via the LMS online learning system and distributed directly after class. After collection, the data was coded and entered into SPSS 26.0 software for descriptive statistical analysis (mean, standard deviation), testing for differences between course groups and correlations between variables.

Qualitative data from interviews were processed using content analysis, employing a thematic coding process. Notable excerpts were selected to illustrate characteristic viewpoints and support the interpretation of quantitative results.

In addition, the research team cross-referenced data between instructors, students, and learning materials to enhance the validity (triangulation) of the study.

G. Ensuring the reliability and validity of the study

The internal reliability of the measurement scale was verified using Cronbach's Alpha coefficient, with results above 0.85 for each content group. Content validity was ensured through a process of peer review and revision by three experts in the field of technical education and teaching technology.

External validity is enhanced by selecting representative samples by class, course, and module. At the same time, analyzing data from multiple sources (surveys, interviews, learning products) enhances the generality and depth of the research conclusions.

In summary, the research methodology is meticulously designed, diverse in data sources and analytical techniques, ensuring high scientific reliability. This provides a solid foundation for accurately evaluating the effectiveness of the innovative teaching-learning model applying technology at the Faculty of Automotive Engineering Technology in the context of comprehensive digital transformation.

IV. RESEARCH RESULTS

The research results show the clear positive impacts of the innovative teaching-learning model at the Faculty of Automotive Engineering Technology, Thanh Dong University. Through the integration of simulation technology and the application of modern pedagogical methods, the quality of knowledge acquisition, practical skills, and self-learning abilities of students have been significantly improved. The analysis of survey and interview data is presented in detail according to the following aspects:

A. Effectiveness of knowledge acquisition

The integration of simulation software into courses such as Powertrain Systems, Electronic Chassis Control, and Automotive Structures has yielded clear benefits. A survey of 120 students revealed:

87% of students reported that learning through simulation helps them better visualize the technical principles and operation of the system.

92% agreed that using software like Simulink or SolidWorks helped them remember information longer and apply it to practical exercises more easily.

The average grade for courses incorporating simulation increased by an average of 0.8 points compared to traditional courses.

The majority of students responded positively to learning in an environment that integrated simulation. The use of software such as Matlab Simulink and SolidWorks helped students gain a deeper understanding of the nature of technical systems without being completely dependent on physical practice. The results of the survey of 120 students are as follows:

TABLE 1. STUDENT AGREEMENT LEVEL ON THE EFFECTIVENESS OF LEARNING WITH SIMULATION TECHNOLOGY

Survey content	**Mean gaverage**	
Simulation helps understand technical principles	4.46	0.52
Simulation to enhance knowledge retention	4.32	0.59
Learning through simulation is more engaging than traditional lectures	4.21	0.63
Applying simulation to real-world technical error handling	4.38	0.49

The survey results shown in Table 1 indicate a very high level of agreement among students regarding the effectiveness of learning when applying simulation technology in automotive engineering courses. Specifically, the statement "Simulation helps to understand technical principles" achieved the highest average score (4.46), clearly reflecting the role of simulation tools in helping students accurately visualize the complex operating mechanisms of technical systems. Next, the item "Applying simulation to real-world technical problem solving" also achieved a high average score (4.38), indicating that students not only grasped the theory but also had the ability to apply their knowledge to real-world situations. Learning through simulation was also rated as helping to increase knowledge retention (4.32) and making the learning process more engaging than traditional methods (4.21). Notably, the standard deviation for all items was low (ranging from 0.49 to 0.63), indicating a high level of agreement among students, with no significant dispersion in feedback opinions. Thus, this data confirms the effectiveness, appeal, and practicality of applying simulation technology in innovating teaching methods for specialized technical courses.

B. Developing practical skills, systematic thinking, and creativity

One of the highlights of the innovation model is project-based learning and flipped classrooms. Through projects such as manufacturing a cutaway model of the vehicle body electrical system, aerodynamic simulation using Ansys Fluent, or kinematic analysis using CarSim, students not only apply their knowledge but also hone soft skills such as teamwork, presentation, and idea defense.

The models and videos created by students are incorporated into the official teaching materials for subsequent courses.

TABLE 2. NUMBER OF STUDENTS WHO HAVE MASTERED SIMULATION SOFTWARE OVER THE YEARS

Year	**Number of students**
2021	18
2022	32
2023	51
2024	73

Table 2 shows a steady increase in the number of students proficient in simulation software from 2021 to 2024. Specifically, the number of students proficient in software such as Matlab Simulink, SolidWorks, Ansys Fluent, and CarSim increased from 18 students in 2021 to 73 students in 2024, corresponding to an increase of nearly 305% in just three years. This growth trend clearly reflects the effectiveness of the teaching innovation strategy at the Faculty of Automotive Engineering Technology, particularly the integration of digital simulation tools into the curriculum. This development also shows that students are increasingly proactively accessing and mastering modern technologies, while demonstrating the feasibility and sustainability of the digital technology-integrated training model in the context of the current educational digital transformation.

TABLE 3. PERCENTAGE OF STUDENTS WHO HAVE USED ENGINEERING SIMULATION SOFTWARE

Software	**Percentage of students using (%)**
Matlab Simulink	76
SolidWorks	81
Ansys Fluent	52
CarSim	48%

The results presented in Table 2 show that most students have accessed and used engineering simulation software during their studies, with SolidWorks and Matlab Simulink being the two most commonly used software programs ( ) at rates of 81% and 76%, respectively. This indicates that students not only have access to but also have the opportunity to apply mechanical-electronic design and simulation software directly within their specialized courses. Although the percentage of students using Ansys Fluent (52%) and CarSim (48%) is lower, it is still significant, reflecting the expansion of specialized simulation software applications into topics such as aerodynamics, vibration, and vehicle dynamics control. The relatively even distribution among the software also partly reflects the multi-tool integration orientation in the teaching strategy, contributing to the development of students' multidimensional technical capabilities. From these results, it can be concluded that the learning environment at the Faculty has created favorable conditions for students to become familiar with and effectively utilize modern technical software—an indispensable requirement in training high-tech human resources for the automotive industry.

C. Digital Competence and Innovation in Teaching

Surveys of faculty members and analysis of interviews show that:

95% of faculty members know how to use at least one technical simulation software and LMS.

On average, each faculty member creates 2–3 lecture videos per year and applies them in at least 2 courses.

Classes using the Flipped Classroom method show that students interact more, actively ask questions, and engage in debate.

Faculty highly value the role of this model in improving training quality, despite the pressure of preparation time and differences in technological proficiency among individuals.

In summary, the research results confirm that innovating teaching and learning methods through the integration of simulation technology and active learning models not only improves the effectiveness of knowledge acquisition and practical skills but also contributes to changing the learning culture and traditional teaching methods. This is a solid foundation for replicating the model across the entire engineering industry.

D. Comprehensive impact on learning culture

Based on survey data and observations, it can be concluded that the learning culture in the department has shifted significantly:

Students proactively study in advance, ask questions, debate, and propose initiatives.

Student groups collaborate through sandbox models, digital videos, and a shared learning resource system.

Instructors play a supporting and guiding role, rather than merely imparting knowledge.

Thus, the research results not only confirm the effectiveness of the innovative teaching model, but also point to the trend of forming an open, modern learning ecosystem that is learner-centered and uses technology as the main tool.

The research results clearly reflect the positive changes in teaching and learning activities at the Faculty of Automotive Engineering Technology - Thanh Dong University after the implementation of teaching method innovations, especially the application of simulation technology and modern pedagogical models. Analysis of data from surveys and interviews reveals three prominent aspects: knowledge acquisition effectiveness, development of practical skills and technical thinking, and changes in the digital capabilities of faculty and students.

V. CONCLUSION

In the context of widespread digital transformation in all areas of social life, technical education, especially Automotive Engineering Technology, needs to implement strong reforms in teaching and learning methods to meet the requirements of training high-quality human resources. This study has demonstrated that integrating simulation technology with modern pedagogical methods such as Project-Based Learning and Flipped Classroom not only enhances knowledge acquisition but also comprehensively develops students' practical skills, systematic thinking, and self-learning abilities. Survey results show that students highly value the role of simulation technology in clarifying technical principles, supporting practice, and increasing the appeal of learning. At the same time, the teaching staff has also made positive changes in their approach to content and the development of digital learning materials, gradually forming a culture of open, proactive, and creative teaching and learning.

Based on the analysis and practical evidence obtained, it can be affirmed that the model of innovating teaching and learning methods using technology at the Faculty of Automotive Engineering Technology, Thanh Dong University is a suitable and effective approach. This model can be replicated and applied at other technical training institutions nationwide, contributing to the formation of a modern, flexible technical education ecosystem that effectively meets the demands of the Industry 4.0 era.

REFERENCES

[1] MathWorks, "Simulink Fundamentals for Automotive Applications," MathWorks – Maker of MATLAB and Simulink.

[2] Dassault Systèmes, “SOLIDWORKS for Students,” SOLIDWORKS.

[3] Ansys Inc., “Ansys Academic – Engineering Simulation Software for Students,” Ansys.

[4] Mechanical Simulation Corporation, “CarSim for Education,” CarSim.

[5] M. Syahril, S. B. Wibowo, and T. S. Prabowo, “Project-Based Learning Model to Increase the Competency of Automotive Engineering Teacher Candidates,” ResearchGate, 2021.

[6] Y. Huang, L. Chiu, and C. Hong, “Using a Flipped Classroom Approach in a Mechanical Engineering Course: Student Engagement and Learning Outcomes,” International Journal of STEM Education, vol. 8, no. 1, pp. 1–14, 2021.

[7] European Commission, “DigCompEdu: European Framework for the Digital Competence of Educators,” Joint Research Centre, 2017.

[8] School Education Gateway, “Unlocking the Power of Teachers’ Digital Competences: Course Series,” European School Education Platform, 2022.

[9] Rajamani, R. (2011). *Vehicle dynamics and control*. Springer.

[10] Guzzella, L., & Sciarretta, A. (2013). *Vehicle propulsion systems*. Springer.

[11] Gillespie, T. D. (1992). *Fundamentals of vehicle dynamics*. SAE International.

Received: August 09, 2025

[12] Wong, J. Y. (2008). *Theory of ground vehicles* (4th ed.). Wiley.

[13] Reif, K. (2014). *Automotive mechatronics*. Springer.

[14] Bishop, J. L., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. *ASEE National Conference Proceedings*.

[15] Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *PNAS, 111*(23), 8410–8415.

[16] Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223–231.

[17] Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom. *Higher Education Research & Development, 34*(1), 1–14.

[18] Chen, F., Lui, A. M., & Martinelli, S. M. (2017). A systematic review of the effectiveness of flipped classrooms in medical education. *Medical Education, 51*(6), 585–597.

[19] O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education. *The Internet and Higher Education, 25*, 85–95.

[20] Karabulut-Ilgu, A., Cherrez, N. J., & Jahren, C. T. (2018). A systematic review of research on the flipped learning method in engineering education. *Computers & Education, 118*, 268–284.

[21] Stöhr, C., Demazière, C., & Adawi, T. (2020). Scaling flipped classrooms in higher education: Faculty development and institutional change. *Computers & Education, 147*, 103777.

[22] Thomas, J. W. (2000). *A review of research on project-based learning*. Autodesk Foundation.

[23] Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266.

[24] Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning. *Educational Psychologist, 26*(3–4), 369–398.

[25] Kolmos, A. (2009). Problem-based and project-based learning in engineering education. *European Journal of Engineering Education, 34*(5), 561–570.

[26] Felder, R. M., & Brent, R. (2009). Active learning: An introduction. *ASQ Higher Education Brief, 2*(4).

[27] Bonwell, C. C., & Eison, J. A. (1991). *Active learning: Creating excitement in the classroom*. ASHE-ERIC Higher Education Report No. 1.

[28] Thai, N. T. T., De Wever, B., & Valcke, M. (2017). The impact of a flipped classroom design on learning performance in higher education. *Computers & Education, 107*, 113–126.

[29] Redecker, C. (2017). *European framework for the digital competence of educators: DigCompEdu*. Publications Office of the European Union.

[30] UNESCO. (2019). *ICT competency framework for teachers*. UNESCO Publishing.

[31] Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

[32] Selwyn, N. (2016). *Education and technology: Key issues and debates*. Routledge.

[33] Bates, T. (2015). *Teaching in a digital age*. BCcampus Open Textbook.

[34] Laurillard, D. (2012). *Teaching as a design science*. Routledge.

[35] Kirkwood, A., & Price, L. (2014). Technology-enhanced learning and teaching in higher education. *Higher Education, 68*(1), 1–14.

[36] Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences. *Journal of Curriculum Studies, 44*(3), 299–321.

[37] European School Education Platform. (2022). *Unlocking the power of teachers' digital competences*.

[38] Cho, M. H., Kim, S., & Choi, D. (2021). Active learning through flipped classroom in mechanical engineering. *International Journal of STEM Education, 8*(1), 1–15.

[39] El-Thalji, I. (2025). Boosting active learning through a gamified flipped classroom: A retrospective case study. *Education Sciences, 15*(4), 430.

[40] KTH Royal Institute of Technology. (2023). *Modeling of a high-performance vehicle in a MATLAB/Simulink* (Master's thesis).

[41] Plymouth University. (2020). *Modeling and evaluation of a driving simulator for education/training*.

[42] Li, X., & Zhang, Y. (2019). Automotive aerodynamics analysis using two CFD tools. *Engineering, 11*(1), 1–11.

[43] TEM Journal. (2024). Two decades of project-based learning in engineering. *TEM Journal, 13*(4), 3514–3525.

[44] Alarcón, F., et al. (2022). Project-based learning for engineering students in the context of Industry 4.0: Application to automotive assembly system. *Proceedings of the Design Society, 2*, 1659–1668.

[45] Elsevier Procedia. (2019). Implementation of experiential learning for vehicle engineering using computer-based simulation. *Procedia Manufacturing, 38*, 1483–1490.

[46] Abulrub, A. G., Attridge, A. N., & Williams, M. A. (2011). Virtual reality in engineering education. *European Journal of Engineering Education, 36*(6), 569–586.

[47] MDPI. (2021). Incorporation of modeling, simulation, and game-based learning in vehicle dynamics education. *Machines, 9*(2), 30.

[48] Liu, Y., & Xu, J. (2023). A virtual reality training system for automotive engine assembly and disassembly. *arXiv preprint arXiv:2311.02108*.

Received: August 09, 2025