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ORIGINAL

From theory to practice the future of education through innovation and sustainability

De la teoría a la práctica: el futuro de la educación a través de la innovación y la sostenibilidad

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ABSTRACT

This study delved into the efficacy of project-based learning and technology integration in cultivating student satisfaction and engagement within a sustainability course. By employing a mixed-methods approach, involving both quantitative and qualitative data from 200 business students, this research examined the impact of these innovative pedagogical strategies. The findings unveiled that these methods not only augmented students' learning experiences but also significantly fostered a profound comprehension of corporate social responsibility. Students reported increased motivation, critical thinking skills, and collaboration abilities as a result of their involvement in real-world projects. Furthermore, the integration of technology facilitated access to diverse information and resources, thereby enriching the learning process. These results align with the assertion by Bonnett (2008) that project-based learning can be instrumental in developing students' higher-order thinking skills and fostering a sense of civic responsibility. This study contributes to the growing body of research advocating for experiential and technology-enhanced learning as effective approaches to sustainability education.

Keywords: Project-Based Learning; Technology Integration; Student Satisfaction; Sustainability; Corporate Social Responsibility.

RESUMEN

Este estudio exploró la eficacia del aprendizaje basado en proyectos y la integración de la tecnología en la promoción de la satisfacción y el compromiso de los estudiantes dentro de un curso de sostenibilidad. Mediante un enfoque de métodos mixtos, que incluyó datos cuantitativos y cualitativos de 200 estudiantes de negocios, esta investigación analizó el impacto de estas estrategias pedagógicas innovadoras. Los hallazgos revelaron que estos métodos no solo mejoraron la experiencia de aprendizaje de los estudiantes, sino que también fomentaron significativamente una comprensión profunda de la responsabilidad social corporativa. Los estudiantes informaron un aumento en la motivación, el pensamiento crítico y las habilidades de colaboración como resultado de su participación en proyectos del mundo real. Además, la integración de la tecnología facilitó el acceso a diversas fuentes de información y recursos, enriqueciendo así el proceso de aprendizaje. Estos resultados concuerdan con la afirmación de Bonnett (2008) de que el aprendizaje basado en proyectos puede ser fundamental para desarrollar habilidades de pensamiento de orden superior

y fomentar un sentido de responsabilidad cívica. Este estudio contribuye al creciente cuerpo de investigación que aboga por el aprendizaje experiencial y mejorado con tecnología como enfoques efectivos para la educación en sostenibilidad.

Palabras clave: Aprendizaje Basado en Proyectos; Integración de Tecnología; Satisfacción del Estudiante; Sostenibilidad; Responsabilidad Social Corporativa.

INTRODUCTION

As climate change and societal challenges grow increasingly urgent, the role of sustainability education in preparing students to address these issues has become paramount. Educational innovations like project-based learning (PBL) and technology integration offer promising pathways to engage students, foster critical thinking, and develop problem-solving skills (Bonnett, 2008; Issa et al., 2006). PBL enables students to apply theoretical knowledge to real-world contexts, enhancing teamwork and essential soft skills critical for modern workplaces. Meanwhile, technology tools such as digital materials, simulations, and online platforms provide unprecedented opportunities for interactive and collaborative learning, equipping students with essential digital competencies (Haleem et al., 2022).

Despite these advancements, research has yet to thoroughly investigate the combined effects of PBL and technology on sustainability education—particularly in the context of corporate social responsibility (CSR). This study bridges this gap by evaluating the effectiveness of these approaches in enhancing student satisfaction, engagement, and understanding within a CSR module focused on sustainability. Anchored in constructivist and systems thinking theories, the study employs a mixed-methods approach to provide empirical evidence supporting the role of experiential, technology-enhanced learning in cultivating the competencies required for sustainable development. As climate change and societal challenges become more pressing, sustainable education has emerged as a critical focus in global curricula. Research emphasizes the need for pedagogical innovations that foster not just theoretical understanding but also the practical application of sustainability concepts (Bonnett, 2008; Wiek et al., 2011). Project-based learning (PBL) has shown remarkable potential in equipping students with essential 21st-century skills such as collaboration, problem-solving, and adaptability (Issa et al., 2006; Bell, 2010).

Combining PBL and technology creates a flexible and creative learning environment where students can actively explore, construct knowledge, and solve real-world problems. This is especially important for sustainability education, as it requires students to be able to think systematically, assess the social and environmental impacts of decisions, and find creative solutions to complex problems.

This study evaluates the impact of integrating PBL and technology within a business school module on corporate social responsibility, explicitly designed for sustainability education. It aims to assess whether these approaches foster higher-order thinking, student satisfaction, and engagement, while also enabling students to navigate complex social and environmental issues.

Literature Review

Project-based learning (PBL) and technology integration have emerged as promising pedagogical approaches to promote deep learning and student engagement. In the context of sustainability education, these strategies offer unique opportunities to equip students with the knowledge, skills, and attitudes needed to address complex environmental and societal challenges. This paper explores existing research on the effectiveness of PBL and technology integration in sustainability education, with a particular focus on student satisfaction, engagement, and understanding of corporate social responsibility (CSR) curriculum. The integration of PBL and technology is rooted in constructivist learning theories, which advocate active student engagement in constructing knowledge through real-world experiences (Piaget, 1970; Kolb, 1984). In the context of sustainability education, these approaches align with systems thinking frameworks, which are essential for understanding and addressing multifaceted environmental challenges (Sterling, 2001).

The PBL approach is a typical form of cooperative and research-based learning technique, characterized by active student engagement and comparative learning (Loyens et al., 2015). Students who learn through the PBL method usually work together to solve a specific problem, develop a product for a specific audience, and then evaluate the project and development process (Kokotsaki et al., 2016)

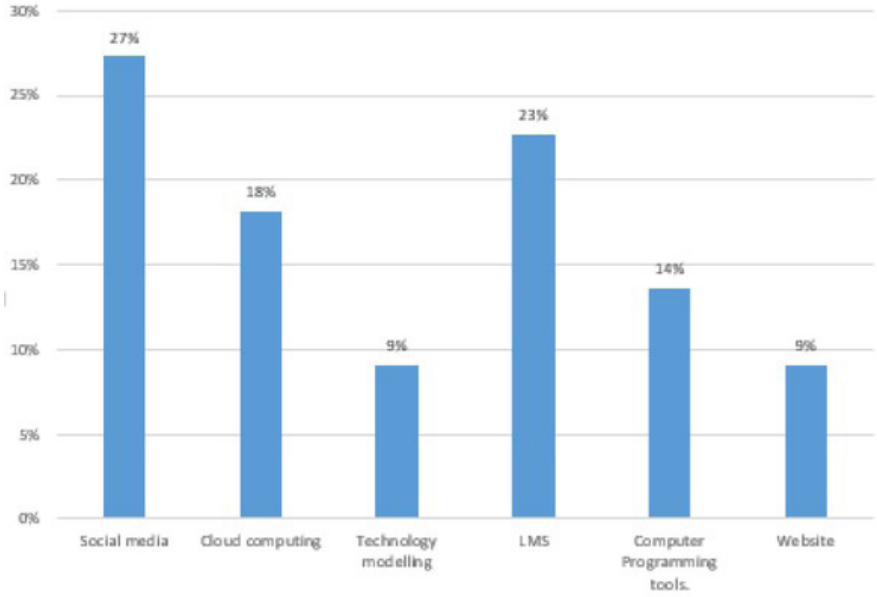
In terms of PBL, characterized by its emphasis on real-world projects and authentic learning experiences, has been widely studied in various educational contexts. Several studies have highlighted the benefits of PBL in promoting student motivation, critical thinking, problem solving, and collaboration (Issa and Khataibeh, 2021). In the field of sustainability education, PBL can provide students with opportunities to engage in meaningful projects that address pressing social and environmental issues. Several studies have shown that PBL can help

students develop a deeper understanding of sustainability concepts, develop critical thinking and problem-solving skills, creativity, collaboration, and effective communication skills, and cultivate a sense of civic responsibility (Issa and Khataibeh, 2021; Marsiti et al., 2023).

Integrating technology into education has the potential to enhance the learning experience and provide students with access to a wide range of resources. In the context of sustainability education, technology can be used to simulate practical situations, access data and information, and collaborate with peers around the world. Studies have demonstrated the effectiveness of integrating technology in promoting student engagement, motivation, and critical thinking skills (Mdhlalose and Mlambo, 2023). Additionally, technology can be used to support PBL activities by providing tools for collaboration, communication, and project management.

The combination of PBL and technology integration can create a powerful learning environment that promotes deep engagement and meaningful learning. Studies have shown that the use of technology can enhance the effectiveness of PBL by providing students with tools for research, collaboration, and communication. Hence, students can use technology to access data on environmental issues, collaborate with peers from different countries, and share their project results with a wider audience (Pitura et al., 2018; Lo, 2009).

On the other hand, the most common technology integrated with PBL is social media, followed by learning management systems, cloud computing, computer programming, and websites. Teachers' ability to guide technology-integrated learning is the most influential factor in the success of technology integration in PBL, along with communication skills, student learning frameworks, student self-efficacy, student needs and interests, previous experience with technology, technological advancement, and the availability of various IT tools (Rahmawati et al., 2020).



Source: Rahmawati et al. (2020)
Figure 1. The percentage of technologies used

Table 1. PBL Common Activities Mapped To Technology Tools	
Sharing	Dropbox, Zotero, Diigo, YouTube, Facebook, Flickr, Twitter, Blogger, Delicious, Digg, Box.net, SlideShare, LogMeIn, TeamViewer
Discussing	Facebook, LinkedIn, Zoom, Skype, MSN, Twitter, Blogger, Doodle, SignAppNow, Canvas, Adobe Connect, Lectio.dk, Microsoft OneNote, FirstClass
Reading	Google
Communicating	Google Docs, Typewith.me, MS Office with Dropbox
Reflecting	Facebook, LinkedIn, YouTube, Flickr, Zoom, Skype, MSN, Yahoo Messenger, Twitter, Blogger, FirstClass
Argumenting	Facebook, LinkedIn, YouTube, Flickr, Zoom, Skype, MSN, Yahoo Messenger, Twitter, Blogger, FirstClass, Email, Microsoft OneNote
Diagramming	Gliffy, Diagramly, Dabbleboard
Source: Khalid et al. (2012)	

Research has consistently shown that PBL and technology integration can increase student satisfaction and engagement (Mohammad et al., 2023). By providing students with opportunities to work on meaningful projects

and collaborate with peers, these strategies can foster a sense of ownership and investment in their learning (Rahmawati et al., 2020). Additionally, PBL and technology integration can help students develop a deeper understanding of CSR by exposing them to practical challenges and providing opportunities to contribute to sustainable solutions (Nguyen et al., 2024; Marcinauskas et al., 2024).

This research highlights the potential of PBL and technology integration to create effective and engaging learning experiences in the context of sustainability education (Chueh and Kao, 2024). By combining these approaches, educators can provide students with opportunities to develop critical thinking skills, cultivate a sense of civic responsibility, and contribute to sustainable solutions. Future research is needed to explore the long-term effects of PBL and technology integration on student learning and outcomes, as well as to investigate best practices for implementing these strategies in different educational settings.

Wang (2023) argued that experimental teaching in colleges and universities is beneficial to promoting students' creative thinking and practical ability and plays an important role in the talent training system. The study combines the analytical hierarchy process (AHP) and the TOPSIS method of prioritization to propose an index system for evaluating the quality of experimental teaching. The criteria included in the evaluation as follows: (i) Teaching content (Clear teaching objectives, and scientific and reasonable teaching contents; Teaching contents are deep and broad; Teachers prepare lessons fully, and teaching documents are complete and standard) (ii) Teaching method (Teach students in accordance of their aptitudes, and teaching is enlightening, Reasonable blackboard-writing and multimedia design, Using appropriate learning modes positively) (iii) Teaching effect (Students complete the learning objective well, Students have active thinking and participate in classroom learning positively, Teaching style is prominent, and teaching mode is novel) (iv) Teaching reflection (Elaborate the teaching design idea of the lesson clearly, Self-evaluation and improvement positively after class, After-class teacher evaluation on experimental operation of students, Classmates can give positive mutual evaluations). Some major conclusions could be drawn, teachers' good preparation of lessons and complete and standard teaching documents, as well as students' active thinking and positive participation in classroom learning, have the highest weight.

Spooren et al. (2007) approached a Likert scale with 8 main criteria divided into 22 sub-criteria to evaluate and rank courses as well as lecturers' teaching skills. The criteria used are as follows: (1) Course objectives (Clarity of objectives, Quality of objectives); (2) Subject matter (Value of subject matter, Attractiveness of subject matter, Build-up of the subject matter); (3) Course structure (Linking up with advance knowledge, Harmony with other courses in the programme, Linking up with social reality and future profession); (4) Teaching activities (Presentation skills, Harmony between objectives and organization of the course, Harmony between organization of the course and learning process of the students); (5) Course materials (Contribution to understanding the subject matter, Contribution to preparing for examination, Link–up with organization of the course); (6) Course feasibility (Course difficulty); (7) Coaching (Help of the teacher during the learning process, Contribution of the teacher to preparing for examination, Stimulation of the teacher in order to learn to be self-responsible); (8) Evaluation (Transparency of the examination, Authenticity of the examination, Content validity of the examination, Formative examination).

Nguyen and Le (2017) applied the TOPSIS fuzzy method in evaluating the teaching performance of lecturers. The TOPSIS algorithm was improved and applied on fuzzy data in 7 steps: Step 1: Rank the criteria; Step 2: Find the decision matrix; Step 3: Normalize the decision matrix; Step 4: Find the weight of the normalized matrix; Step 5: Find the positive and negative fuzzy ideal solutions; Step 6: The fuzzy distance of each choice from the positive and negative fuzzy ideal solutions; Step 7: Find the fuzzy distance coefficient. There are 10 criteria included in the evaluation: The lecture content is clear, coherent and easy to understand; Consistent with the course syllabus approved by the school; Updating new knowledge; Inspiring learners to participate in lectures; Creating conditions for learners to promote self-study and self-research; Demonstrating the ability to master classroom activities; Allocating teaching time reasonably; Expressing clearly, easy to listen to, easy to understand; Use appropriate teaching tools and equipment; Dress politely and behave in a way that reflects the style of a teacher.

Zadeh (1965) introduced fuzzy theory to solve problems with ambiguous, unclear, and complex data. This is also a widely applied method in decision making problems. It can be seen that this method has allowed people to quantify the value of fuzzy propositions, thereby conveying some information to machines through natural language.

Hwang & Yoon (1981) introduced the TOPSIS method for evaluating object ranking, introduced by with the following idea: A choice is called the best if this choice has the closest value to the positive ideal solution (PIS) and the farthest value to the negative ideal solution (NIS) of the multi-state problem.

While studies demonstrate the potential of PBL and technology integration in fostering student engagement, few have specifically explored their combined impact on sustainability education, particularly within the domain of corporate social responsibility (Haleem et al., 2022; Brundiers et al., 2013). This study seeks to address this gap by examining how these methods can enhance students' understanding of systemic sustainability challenges and their ability to devise actionable solutions.

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METHOD

TOPSIS method is one of the MCDM model methods. This model is based on the fuzzy set theory of Zadel (1965) to solve complex choice problems including many criteria with many choices. This is an effective tool to quantify vague, unclear information from which we can apply to practical problems when making decisions with many criteria. Let A be a fuzzy number (fuzzy set) on the set of total real numbers R then A ∈ ℑ (R) and the membership function of A has the form A μ →: R [0;1]. The membership function is always normal, convex and usually has three forms: Triangular, trapezoidal and bell-shaped. However, in practice, the triangular fuzzy number form is commonly used.

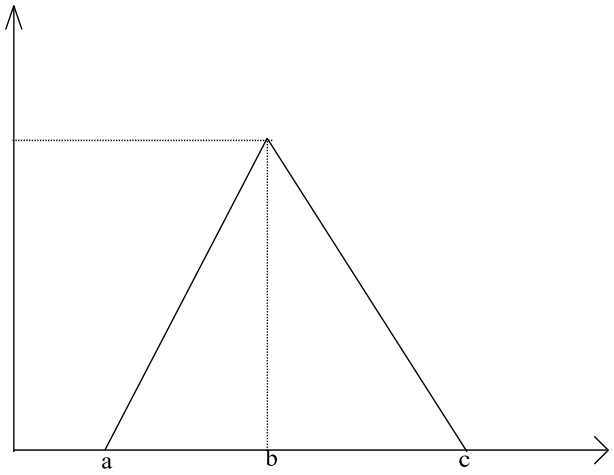

Figure 2. Triangular membership function

A triangular fuzzy number is defined by three parameters a, b, c; denoted by A (a, b, c). In a specific context, the parameters of the fuzzy number represent linguistic concepts, then the fuzzy variable is called a linguistic variable. Linguistic variables are very diverse and are defined based on a set of base variables. In a linguistic variable, the linguistic values represent an approximation of the base variable, then these linguistic values are fuzzy numbers.

There have been many studies in the world applying MCDM with methods such as: TOPSIS, AHP, DEA, ANP, etc. TOPSIS method of Hwang and Yoon (1981) is a popular tool to solve MCDM multi-criteria decision making problems. The main content of the TOPSIS method is to evaluate options by simultaneously measuring the distance from options to the positive optimal solution (PIS) and the negative optimal solution (NIS). The selected option must have the shortest distance from PIS and the longest distance from NIS. TOPSIS method is built on weights, this weight is based on probability theory to evaluate the probability of an event occurring, which limits the subjective effects that other methods encounter, such as the Delphi method and AHP hierarchy analysis. The input data of the model is collected through a survey of students majoring in Business Administration - University of Economics and Business - Vietnam National University, Hanoi.

RESULTS

Step 1: Identify a set of criteria for evaluating optimal teaching methods

Suppose a decision-making panel of l student decision-makers (Dt, t = 1,...,l) is responsible for evaluating m (Ai, i = 1,…,n) optimal teaching methods based on n criteria (Cj, j = 1,…,m), where the proportion of evaluating optimal teaching methods based on each criterion and the weights of the criteria are represented as linguistic variables and presented as triangular fuzzy numbers.

The data used in this study is based on in-depth interviews with students majoring in Business Administration at University of Economics and Business, Vietnam National University, Hanoi. This decision-making committee consists of 10 students who are class monitors. Using the standards from the document overview combined with the practical teaching situation of the School, the criteria for evaluating the optimal teaching method include: Clear and coherent teaching content (C1), New teaching methods that attract learners (C2), Teaching methods that help evaluate learners fairly and transparently (C3), Teaching methods that apply information technology (C4), Learners gain practical experience through teaching methods (C5), Reasonable allocation of time between theory and practice (C6), New knowledge is continuously updated (C7), Learners promote self-discipline in learning (C8), Learners interact regularly in class (C9), Learners are provided with adequate materials (C10). The optimal teaching methods included in the assessment are: A1: Problem solving, A2: Brainstorming, A3: Situational learning, A4: Role playing, A5: Games, A6: Field trips, A7: Debate, A8: Application of modern information technology.

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Step 2: Determine the weight of each criterion

To determine the weight of each criterion, the language variable and the weight of the criteria are both represented as triangular fuzzy numbers:

Table 2. Table of proportions and weights

Symbols	Language Variables	Triangular Fuzzy Sets
ENG	Very Unimportant	(0,1, 0,2, 0,3)
NG	Unimportant	(0,2, 0,3, 0,4)
A	Normal	(0,3, 0,5, 0,7)
G	Important	(0,5, 0,7, 0,9)
VG	Very Important	(0,8, 0,9, 1,0)

After determining the set of criteria for evaluating optimal teaching methods, each student in the decision-making panel (D1, D2, D3, D4, D5, D6. D7, D8, D9, D10) will determine the importance of the criteria using linguistic variables as shown in table 2.

Step 3: Determine the average ratio of choices based on each criterion

Suppose a group of users Ut with t = 1, 2, …, k evaluate m choices Ai with i = 1,…, m with h evaluation criteria Cj, j = 1, 2,…, h.

Let:

$$x_{ijt} = (e_{ijt}, f_{ijt}, g_{ijt})$$

With i = 1,… m, j = 1,…, h and t = 1,…, k be the norm for each choice A_i with the user set U_t and criterion C_j. The average norm:

$$x_{ij} = (e_{ij}, f_{ij}, g_{ij})$$

Is calculated as follows:

$$x_{ij} = \frac{1}{k} \times (x_{ij1} + x_{ij2} + ... + x_{ijt} + ... + x_{ijk}) \qquad (1)$$

Include:

$$e_{ij} = \frac{1}{k}\sum_{t=1}^{k} e_{ijt}\ ,\ f_{ij} = \frac{1}{k}\sum_{t=1}^{k} f_{ijt}\ ,\ \text{và}\ g_{ij} = \frac{1}{k}\sum_{t=1}^{k} g_{ijt}$$

In this step, the decision-making students will evaluate each teaching method (A1, A2, A3, A4, A5, A6, A7, A8) based on the selected set of criteria. The percentage value and the average value of the 8 teaching methods on each criterion are evaluated by the decision-making committee. Applying formula (1), we have the following table:

Table 3. Average of the proportions of the choices based on each criterion

Criterion		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Fuzzy number merge
C1 Teaching content is clear and coherent	A1	VG	VG	A	G	VG	G	VG	G	VG	VG	(0,730, 0,840, 0,950)
	A2	G	A	G	G	G	G	G	G	G	A	(0,640, 0,760, 0,880)
	A3	VG	G	G	G	VG	VG	G	G	G	G	(0,730, 0,830, 0,930)
	A4	A	A	A	G	A	G	A	G	G	A	(0,520, 0,680, 0,840)
	A5	A	A	A	G	G	G	VG	G	A	A	(0,560, 0,710, 0,860)
	A6	G	A	A	G	G	G	G	G	G	A	(0,610, 0,740, 0,870)
	A7	G	A	G	G	VG	VG	VG	G	G	G	(0,700, 0,810, 0,920)
	A8	VG	A	G	G	G	VG	G	G	G	VG	(0,700, 0,810, 0,920)

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C2 New teaching methods, attracting learners	A1	VG	G	G	G	VG	VG	A	G	A	G	(0,670, 0,790, 0,910)
	A2	G	G	G	A	VG	G	VG	G	A	G	(0,660, 0,780, 0,900)
	A3	VG	A	G	G	G	VG	G	G	G	A	(0,660, 0,780, 0,900)
	A4	VG	A	A	G	VG	G	G	G	VG	G	(0,670, 0,790, 0,910)
	A5	G	A	A	G	VG	G	G	VG	VG	A	(0,640, 0,770, 0,900)
	A6	A	A	VG	G	VG	VG	VG	VG	VG	A	(0,670, 0,800, 0,930)
	A7	G	A	VG	G	G	VG	VG	G	A	G	(0,670, 0,790, 0,910)
	A8	G	A	G	G	G	VG	VG	VG	G	VG	(0,710, 0,820, 0,930)
C3 Teaching methods help evaluate learners fairly and transparently	A1	G	VG	G	G	G	G	G	VG	VG	VG	(0,740, 0,840, 0,940)
	A2	G	G	A	G	G	A	VG	G	G	NG	(0,600, 0,730, 0,860)
	A3	VG	G	A	G	G	G	A	A	G	G	(0,620, 0,750, 0,880)
	A4	VG	G	G	G	A	G	A	A	A	NG	(0,540, 0,690, 0,840)
	A5	G	A	A	G	A	G	G	A	G	NG	(0,530, 0,680, 0,830)
	A6	A	A	G	G	G	A	VG	VG	G	NG	(0,580, 0,720, 0,860)
	A7	VG	G	G	G	G	G	VG	VG	VG	G	(0,740, 0,840, 0,940)
	A8	G	A	G	G	VG	A	G	VG	G	A	(0,630, 0,760, 0,890)
C4 Teaching methods applied information technology	A1	G	VG	A	A	G	VG	A	G	G	A	(0,600, 0,740, 0,880)
	A2	G	VG	A	A	VG	A	VG	G	A	A	(0,580, 0,730, 0,880)
	A3	G	VG	G	A	VG	VG	G	G	G	NG	(0,650, 0,770, 0,890)
	A4	A	G	G	A	G	G	G	G	A	NG	(0,560, 0,700, 0,840)
	A5	VG	A	VG	A	VG	G	VG	G	VG	A	(0,660, 0,790, 0,920)
	A6	VG	A	G	A	G	G	G	G	G	NG	(0,600, 0,730, 0,860)
	A7	G	G	G	A	A	VG	VG	G	G	NG	(0,610, 0,740, 0,870)
	A8	VG	VG	VG	A	VG	VG	VG	VG	VG	G	(0,750, 0,860, 0,970)
C5 Learners get real-world experience through teaching methods	A1	VG	G	VG	G	VG	G	VG	G	A	A	(0,680, 0,800, 0,920)
	A2	G	G	G	G	G	G	VG	G	A	NG	(0,630, 0,750, 0,870)
	A3	VG	VG	VG	G	VG	VG	G	G	G	A	(0,720, 0,830, 0,940)
	A4	VG	G	G	G	VG	VG	VG	G	VG	NG	(0,700, 0,810, 0,920)
	A5	VG	G	G	G	A	VG	G	G	G	NG	(0,640, 0,760, 0,880)
	A6	G	VG	VG	G	VG	VG	VG	VG	VG	VG	(0,780, 0,880, 0,980)
	A7	G	G	VG	G	A	VG	VG	G	VG	A	(0,680, 0,800, 0,920)
	A8	VG	A	VG	G	VG	G	G	G	G	A	(0,670, 0,790, 0,910)
C6 Allocate time reasonably between theory and practice	A1	VG	VG	G	G	VG	VG	G	G	G	G	(0,740, 0,840, 0,940)
	A2	G	VG	A	G	VG	VG	G	G	A	A	(0,640, 0,770, 0,900)
	A3	VG	G	G	G	G	G	VG	G	A	A	(0,660, 0,780, 0,900)
	A4	A	A	A	G	G	A	VG	G	VG	NG	(0,550, 0,700, 0,850)
	A5	A	A	A	G	G	VG	VG	G	G	NG	(0,580, 0,720, 0,860)
	A6	G	A	G	G	G	G	VG	G	G	A	(0,650, 0,770, 0,890)
	A7	VG	G	A	G	VG	VG	G	G	VG	G	(0,710, 0,820, 0,930)
	A8	G	NG	G	G	G	VG	A	G	G	A	(0,600, 0,730, 0,860)
C7 New knowledge is constantly updated	A1	VG	VG	VG	G	VG	G	VG	G	G	G	(0,750, 0,850, 0,950)
	A2	VG	A	G	G	G	A	G	G	A	NG	(0,570, 0,710, 0,850)
	A3	G	G	VG	G	VG	G	VG	G	VG	A	(0,710, 0,820, 0,930)
	A4	VG	A	A	G	VG	A	A	G	G	NG	(0,550, 0,700, 0,850)
	A5	VG	A	A	G	G	VG	G	G	G	NG	(0,610, 0,740, 0,870)
	A6	G	A	VG	G	VG	VG	G	G	VG	A	(0,680, 0,800, 0,920)
	A7	G	VG	VG	G	VG	G	G	G	VG	NG	(0,690, 0,800, 0,910)
	A8	VG	A	VG	G	VG	G	VG	G	G	G	(0,710, 0,820, 0,930)

C8 Learners develop autonomy in learning	A1	VG	VG	G	A	VG	G	VG	G	G	VG	(0,720, 0,830, 0,940)
	A2	VG	VG	A	A	VG	G	G	G	A	A	(0,610, 0,750, 0,890)
	A3	G	G	A	A	VG	VG	VG	G	G	ENG	(0,610, 0,730, 0,850)
	A4	A	A	VG	A	VG	A	VG	G	VG	A	(0,590, 0,740, 0,890)
	A5	G	A	A	A	VG	A	A	G	VG	ENG	(0,510, 0,660, 0,810)
	A6	A	A	VG	A	G	G	A	G	A	A	(0,530, 0,690, 0,850)
	A7	VG	G	VG	A	VG	VG	VG	G	VG	G	(0,730, 0,840, 0,950)
	A8	G	NG	VG	A	A	G	A	G	G	NG	(0,520, 0,670, 0,820)
C9 Learners interact regularly in the classroom	A1	VG	VG	VG	VG	VG	VG	VG	G	A	A	(0,710, 0,830, 0,950)
	A2	G	G	G	VG	A	G	G	G	A	NG	(0,600, 0,730, 0,860)
	A3	VG	G	G	VG	VG	VG	G	G	G	G	(0,740, 0,840, 0,940)
	A4	VG	A	A	VG	VG	A	A	VG	G	G	(0,620, 0,760, 0,900)
	A5	G	A	A	VG	VG	A	VG	VG	G	G	(0,650, 0,780, 0,910)
	A6	VG	A	G	VG	G	G	A	G	A	NG	(0,580, 0,720, 0,860)
	A7	VG	VG	VG	VG	G	VG	G	VG	G	G	(0,760, 0,860, 0,960)
	A8	VG	A	VG	VG	A	VG	G	G	G	NG	(0,630, 0,760, 0,890)
C10 Learners are provided with full materials	A1	G	VG	A	G	VG	VG	VG	G	G	A	(0,680, 0,800, 0,920)
	A2	A	G	A	G	G	G	G	G	G	NG	(0,590, 0,720, 0,850)
	A3	VG	A	A	G	A	VG	A	G	VG	A	(0,580, 0,730, 0,880)
	A4	G	NG	A	G	A	G	A	A	G	ENG	(0,470, 0,620, 0,770)
	A5	G	NG	A	G	A	A	G	A	G	A	(0,500, 0,660, 0,820)
	A6	VG	NG	G	G	G	VG	A	G	VG	NG	(0,600, 0,730, 0,860)
	A7	VG	A	G	G	G	VG	VG	G	G	A	(0,670, 0,790, 0,910)
	A8	VG	NG	G	G	G	G	G	G	G	NG	(0,610, 0,730, 0,850)

Step 4: Calculate the weighted averages

Let:

$w_{jt} = (o_{jt}, p_{jt}, q_{jt})$, $w_{jt} \in R^*, j = 1,...,h, t = 1,...,k$

Be the importance assigned by user group U_t to criterion C_j. The average importance of criterion:

$w_j = (o_j, p_j, q_j)$

Of criterion C_j as rated by k user groups is determined as follows:

$$w_j = \frac{1}{k} \times (w_{j1} + w_{j2} + ... + w_{jk}) \quad (2)$$

Include:

$$o_j = \frac{1}{k}\sum_{t=1}^{k} o_{it}, p_j = \frac{1}{k}\sum_{t=1}^{k} p_{jt}, q_j = \frac{1}{k}\sum_{t=1}^{k} q_{jt}.$$

Applying formula (2), we have the following table:

Table 4. Weights and weighted averages of the criteria

Criterion	The board makes decisions										W_{ij}
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	
C1	VI	VI	I	I	VI	I	I	VI	VI	I	(0,650, 0,800, 0,950)
C2	I	I	VI	I	VI	I	I	I	VI	I	(0,590, 0,760, 0,930)
C3	I	VI	I	VI	VI	N	VI	I	I	VI	(0,630, 0,780, 0,930)
C4	N	I	I	I	N	VI	N	I	VI	N	(0,480, 0,660, 0,840)
C5	VI	I	I	VI	VI	I	I	VI	I	I	(0,620, 0,780, 0,940)
C6	N	I	I	VI	N	I	I	N	I	VI	(0,500, 0,680, 0,860)
C7	I	VI	VI	I	I	VI	VI	VI	I	I	(0,650, 0,800, 0,950)
C8	I	VI	I	N	I	I	I	VI	N	VI	(0,550, 0,720, 0,890)
C9	VI	VI	I	VI	VI	I	I	VI	VI	I	(0,680, 0,820, 0,960)
C10	VI	I	I	VI	I	VI	I	VI	VI	I	(0,650, 0,800, 0,950)

Step 5: Standardize the representation of choices with objective criteria

Criteria are usually divided into benefits (B) and costs (C). The benefits criterion is of the nature "More is better", the costs criterion is of the nature "Less is better". Therefore, to ensure compatibility between the average rating and the average importance, the average rating must be standardized to a comparable range. Suppose:

$$r_{ij} = (a_{ij}, b_{ij}, c_{ij})$$

Is the expression of choice i on criterion j. The standardized value x_{ij} has the form:

$$x_{ij} = (\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}), j \in B$$

$$x_{ij} = (\frac{\bar{a}_j}{c_{ij}}, \frac{\bar{a}_j}{b_{ij}}, \frac{\bar{a}_j}{a_{ij}}), j \in C$$

Include:

$$\bar{a}_j = \min_i a_{ij}, c_j^* = \max_i c_{ij}, i = 1,...,m, j = 1,...,n.$$

Table 5. Normalized value of options with criteria

		D1			D2			D3			D4			D5			D6			D7			D8			D9			D10		
C1	A1	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1
	A2	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A3	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9
	A4	0,4	0,6	0,8	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A5	0,4	0,6	0,8	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8
	A6	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A7	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9
	A8	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1
C2	A1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9
	A2	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9
	A3	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A4	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9
	A5	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8
	A6	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8
	A7	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9
	A8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1
C3	A1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1
	A2	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
	A3	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9
	A4	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,4	0,6	0,8	0,2	0,4	0,6
	A5	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,2	0,4	0,6
	A6	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,2	0,4	0,6
	A7	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9
	A8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8
C4	A1	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A2	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8
	A3	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6

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	A4	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,2	0,4	0,6
	A5	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8
	A6	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
	A7	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
	A8	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9
C5	A1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8
	A2	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,2	0,4	0,6
	A3	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A4	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,2	0,4	0,6
	A5	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
	A6	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1
	A7	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8
	A8	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
C6	A1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9
	A2	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8
	A3	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8
	A4	0,4	0,6	0,8	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,2	0,4	0,6
	A5	0,4	0,6	0,8	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
	A6	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A7	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9
	A8	0,7	0,8	0,9	0,2	0,4	0,6	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
C7	A1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9
	A2	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,2	0,4	0,6
	A3	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8
	A4	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
	A5	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
	A6	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8
	A7	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,2	0,4	0,6
	A8	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9

C8	A1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1
	A2	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8
	A3	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,1	0,2	0,3
	A4	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8
	A5	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,1	0,2	0,3
	A6	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8
	A7	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9
	A8	0,7	0,8	0,9	0,2	0,4	0,6	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
C9	A1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8
	A2	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,2	0,4	0,6
	A3	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9
	A4	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9
	A5	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9
	A6	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,2	0,4	0,6
	A7	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9
	A8	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,8	0,9	1	0,4	0,6	0,8	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
C10	A1	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A2	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6
	A3	0,8	0,9	1	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8
	A4	0,7	0,8	0,9	0,2	0,4	0,6	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,1	0,2	0,3
	A5	0,7	0,8	0,9	0,2	0,4	0,6	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8	0,7	0,8	0,9	0,4	0,6	0,8
	A6	0,8	0,9	1	0,2	0,4	0,6	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,8	0,9	1	0,2	0,4	0,6
	A7	0,8	0,9	1	0,4	0,6	0,8	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,8	0,9	1	0,8	0,9	1	0,7	0,8	0,9	0,7	0,8	0,9	0,4	0,6	0,8
	A8	0,8	0,9	1	0,2	0,4	0,6	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,4	0,6

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Step 6: Calculate the importance of the standardized norm

The standardized rating importance G is calculated by multiplying the standardized average x_{ij} multiple with the importance w_{jt}.

$$G_j = x_{ij} \times w_j, i = 1,...,m, j = 1,...,n \qquad (3)$$

Applying formula (3) we have the following table:

Table 6. Average rating of suppliers based on each criterion

Criterion		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	Rij		
C1	A1	VG	VG	A	G	VG	G	VG	G	VG	VG	0,4745	0,672	0,9025
	A2	G	A	G	G	G	G	G	G	G	A	0,416	0,608	0,836
	A3	VG	G	G	G	VG	VG	G	G	G	G	0,4745	0,664	0,8835
	A4	A	A	A	G	A	G	A	G	G	A	0,338	0,544	0,798
	A5	A	A	A	G	G	G	VG	G	A	A	0,364	0,568	0,817
	A6	G	A	A	G	G	G	G	G	G	A	0,3965	0,592	0,8265
	A7	G	A	G	G	VG	VG	VG	G	G	G	0,455	0,648	0,874
	A8	VG	A	G	G	G	VG	G	G	G	VG	0,455	0,648	0,874
C2	A1	VG	G	G	G	VG	VG	A	G	A	G	0,3953	0,6004	0,8463
	A2	G	G	G	A	VG	G	VG	G	A	G	0,3894	0,5928	0,837
	A3	VG	A	G	G	G	VG	G	G	G	A	0,3894	0,5928	0,837
	A4	VG	A	A	G	VG	G	G	G	VG	G	0,3953	0,6004	0,8463
	A5	G	A	A	G	VG	G	G	VG	VG	A	0,3776	0,5852	0,837
	A6	A	A	VG	G	VG	VG	VG	VG	VG	A	0,3953	0,608	0,8649
	A7	G	A	VG	G	G	VG	VG	G	A	G	0,3953	0,6004	0,8463
	A8	G	A	G	G	G	VG	VG	VG	G	VG	0,4189	0,6232	0,8649
C3	A1	G	VG	G	G	G	G	G	VG	VG	VG	0,4662	0,6552	0,8742
	A2	G	G	A	G	G	A	VG	G	G	NG	0,378	0,5694	0,7998
	A3	VG	G	A	G	G	G	A	A	G	G	0,3906	0,585	0,8184
	A4	VG	G	G	G	A	G	A	A	A	NG	0,3402	0,5382	0,7812
	A5	G	A	A	G	A	G	G	A	G	NG	0,3339	0,5304	0,7719
	A6	A	A	G	G	G	A	VG	VG	G	NG	0,3654	0,5616	0,7998
	A7	VG	G	G	G	G	G	VG	VG	VG	G	0,4662	0,6552	0,8742
	A8	G	A	G	G	VG	A	G	VG	G	A	0,3969	0,5928	0,8277
C4	A1	G	VG	A	A	G	VG	A	G	G	A	0,288	0,4884	0,7392
	A2	G	VG	A	A	VG	A	VG	G	A	A	0,2784	0,4818	0,7392
	A3	G	VG	G	A	VG	VG	G	G	G	NG	0,312	0,5082	0,7476
	A4	A	G	G	A	G	G	G	G	A	NG	0,2688	0,462	0,7056
	A5	VG	A	VG	A	VG	G	VG	G	VG	A	0,3168	0,5214	0,7728
	A6	VG	A	G	A	G	G	G	G	G	NG	0,288	0,4818	0,7224
	A7	G	G	G	A	A	VG	VG	G	G	NG	0,2928	0,4884	0,7308
	A8	VG	VG	VG	A	VG	VG	VG	VG	VG	G	0,36	0,5676	0,8148
C5	A1	VG	G	VG	G	VG	G	VG	G	A	A	0,4216	0,624	0,8648
	A2	G	G	G	G	G	G	VG	G	A	NG	0,3906	0,585	0,8178
	A3	VG	VG	VG	G	VG	VG	G	G	G	A	0,4464	0,6474	0,8836
	A4	VG	G	G	G	VG	VG	VG	G	VG	NG	0,434	0,6318	0,8648
	A5	VG	G	G	G	A	VG	G	G	G	NG	0,3968	0,5928	0,8272
	A6	G	VG	VG	G	VG	VG	VG	VG	VG	VG	0,4836	0,6864	0,9212
	A7	G	G	VG	G	A	VG	VG	G	VG	A	0,4216	0,624	0,8648

	A8	VG	A	VG	G	VG	G	G	G	G	A	0,4154	0,6162	0,8554
C6	A1	VG	VG	G	G	VG	VG	G	G	G	G	0,37	0,5712	0,8084
	A2	G	VG	A	G	VG	VG	G	G	A	A	0,32	0,5236	0,774
	A3	VG	G	G	G	G	G	VG	G	A	A	0,33	0,5304	0,774
	A4	A	A	A	G	G	A	VG	G	VG	NG	0,275	0,476	0,731
	A5	A	A	A	G	G	VG	VG	G	G	NG	0,29	0,4896	0,7396
	A6	G	A	G	G	G	G	VG	G	G	A	0,325	0,5236	0,7654
	A7	VG	G	A	G	VG	VG	G	G	VG	G	0,355	0,5576	0,7998
	A8	G	NG	G	G	G	VG	A	G	G	A	0,3	0,4964	0,7396
C7	A1	VG	VG	VG	G	VG	G	VG	G	G	G	0,4875	0,68	0,9025
	A2	VG	A	G	G	G	A	G	G	A	NG	0,3705	0,568	0,8075
	A3	G	G	VG	G	VG	G	VG	G	VG	A	0,4615	0,656	0,8835
	A4	VG	A	A	G	VG	A	A	G	G	NG	0,3575	0,56	0,8075
	A5	VG	A	A	G	G	VG	G	G	G	NG	0,3965	0,592	0,8265
	A6	G	A	VG	G	VG	VG	G	G	VG	A	0,442	0,64	0,874
	A7	G	VG	VG	G	VG	G	G	G	VG	NG	0,4485	0,64	0,8645
	A8	VG	A	VG	G	VG	G	VG	G	G	G	0,4615	0,656	0,8835
C8	A1	VG	VG	G	A	VG	G	VG	G	G	VG	0,396	0,5976	0,8366
	A2	VG	VG	A	A	VG	G	G	G	A	A	0,3355	0,54	0,7921
	A3	G	G	A	A	VG	VG	VG	G	G	ENG	0,3355	0,5256	0,7565
	A4	A	A	VG	A	VG	A	VG	G	VG	A	0,3245	0,5328	0,7921
	A5	G	A	A	A	VG	A	A	G	VG	ENG	0,2805	0,4752	0,7209
	A6	A	A	VG	A	G	G	A	G	A	A	0,2915	0,4968	0,7565
	A7	VG	G	VG	A	VG	VG	VG	G	VG	G	0,4015	0,6048	0,8455
	A8	G	NG	VG	A	A	G	A	G	G	NG	0,286	0,4824	0,7298
C9	A1	VG	VG	VG	VG	VG	VG	VG	G	A	A	0,4828	0,6806	0,912
	A2	G	G	G	VG	A	G	G	G	A	NG	0,408	0,5986	0,8256
	A3	VG	G	G	VG	VG	VG	G	G	G	G	0,5032	0,6888	0,9024
	A4	VG	A	A	VG	VG	A	A	VG	G	G	0,4216	0,6232	0,864
	A5	G	A	A	VG	VG	A	VG	VG	G	G	0,442	0,6396	0,8736
	A6	VG	A	G	VG	G	G	A	G	A	NG	0,3944	0,5904	0,8256
	A7	VG	VG	VG	VG	G	VG	G	VG	G	G	0,5168	0,7052	0,9216
	A8	VG	A	VG	VG	A	VG	G	G	G	NG	0,4284	0,6232	0,8544
C10	A1	G	VG	A	G	VG	VG	VG	G	G	A	0,442	0,64	0,874
	A2	A	G	A	G	G	G	G	G	G	NG	0,3835	0,576	0,8075
	A3	VG	A	A	G	A	VG	A	G	VG	A	0,377	0,584	0,836
	A4	G	NG	A	G	A	G	A	A	G	ENG	0,3055	0,496	0,7315
	A5	G	NG	A	G	A	A	G	A	G	A	0,325	0,528	0,779
	A6	VG	NG	G	G	G	VG	A	G	VG	NG	0,39	0,584	0,817
	A7	VG	A	G	G	G	VG	VG	G	G	A	0,4355	0,632	0,8645
	A8	VG	NG	G	G	G	G	G	G	G	NG	0,3965	0,584	0,8075

Teaching Methods

- A1: Problem Solving
- A2: Brainstorming
- A3: Situational Learning
- A4: Role Playing
- A5: Games
- A6: Field Trips
- A7: Debate
- A8: Applying Modern Information Technology

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Step 7: Calculate A^+, A^-, d_i^+, d_i^-

La solución difusa óptima – positiva (FPIS, A+) y la solución difusa óptima – negativa (FNIS, A-) se calculan de la siguiente manera:

$$A^+ = (1;1;1)$$
$$A^- = (0;0;0)$$

The distance from each option A_i, i=1,…,m từ A^+ và A^- is calculated as follows:

$$d_i^+ = \sqrt{\sum_{j=1}^{n}(G_i - A^+)^2}$$
$$d_i^- = \sqrt{\sum_{j=1}^{n}(G_i - A^-)^2} \qquad (4)$$

Include d_i^+ represents the shortest distance of the selection A_i, and d_i^- represents the longest distance of the selection A_i.

The study chooses the optimal fuzzy solutions A+ and A- as shown in the table. Use the formula to calculate the distance of each choice to the optimal solution.

Table 7. Optimal fuzzy solution

A^+	1	1	1
A^-	0	0	0

Step 8: Calculate the tightness coefficient

The tightness factor of each choice is often used to determine the rank order of all the choices, and is calculated as:

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-} \qquad (5)$$

Applying formulas (4), (5) to calculate, we have the following table:

Table 8. Distance and tightness coefficient of criteria

Teaching Methods	d^+	d_-	Tight coefficient
A1: Problem Solving	0,706	1,139	0,61739
A2: Brainstorming	0,793	1,048	0,56929
A3: Situational Learning	0,740	1,101	0,59813
A4: Role Playing	0,823	1,023	0,55424
A5: Games	0,813	1,031	0,55910
A6: Field Trips	0,775	1,069	0,57969
A7: Debate	0,713	1,129	0,61288
A8: Applying Modern Information Technology	0,755	1,087	0,59024

Step 9: Determine the order of the options based on the tightness factor

The higher the tightness coefficient, the closer the choice is to the optimal solution – positive PIS and the further away from the optimal solution – negative NIS. From this tightness coefficient, we will choose the best choice from the given choices.

Therefore, the ranking order of the optimal teaching methods is: A1>A7>A3>A8>A6>A2>A5>A4. The results of the model run showed that the teaching methods that were most highly rated by students in order were: Problem solving, Debate, Situational learning, Application of modern information technology, Field trips, Brainstorming, Games, Role playing.

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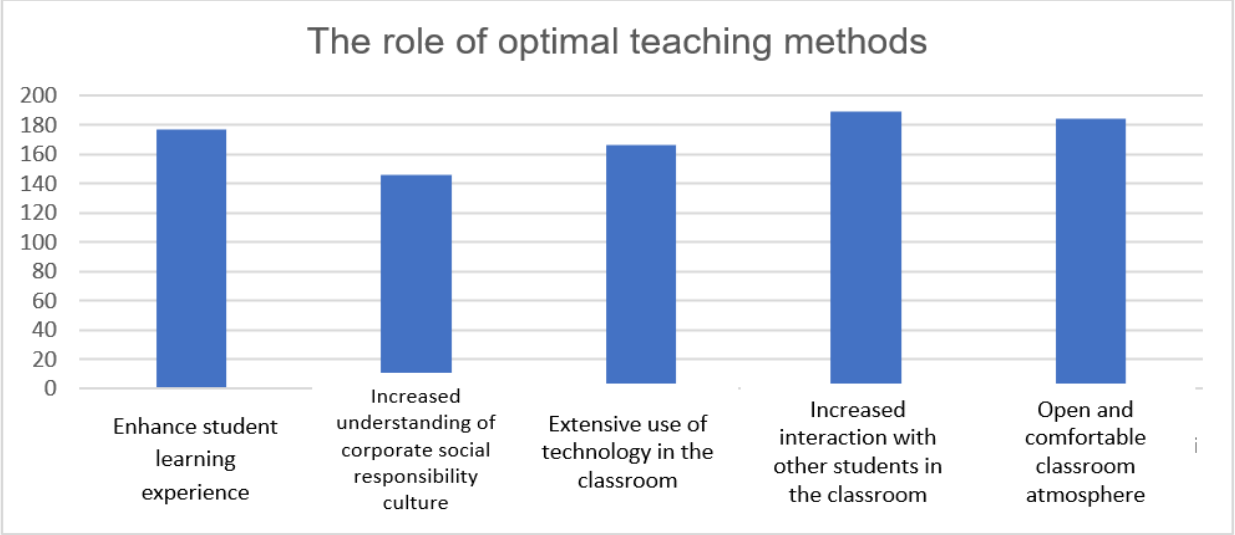

Figure 3. The role of optimal teaching methods

According to the survey results of 200 students majoring in Business Administration, the role of optimal teaching methods is shown in detail in the chart above. In which, the role of: Enhancing students' learning experience, Interacting more with other students in the class or Open, comfortable classroom atmosphere are chosen the most. In addition, the role of Increasing understanding of culture and corporate social responsibility shows that education about culture and social responsibility is necessary. This may be related to preparing students for the modern working environment, where social responsibility and corporate culture are increasingly valued. In addition, the use of technology in teaching is an important factor, helping students access information more easily and creating diverse learning methods. This figure shows that technology is being applied relatively effectively in the classroom.

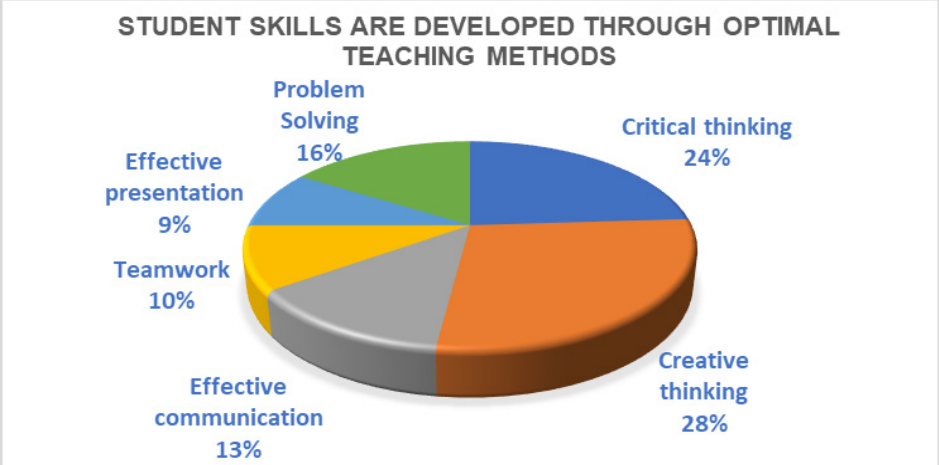

Figure 4. Student skills are developed through optimal teaching methods

From the above analysis, it can be seen that creative and critical thinking and communication skills are considered the most important skills that students are trained in class. Creative thinking skills involve the ability to develop new ideas, find different solutions to problems. Critical thinking skills play a very important role in analyzing information, evaluating arguments and making reasonable decisions. Problem solving skills show that the ability to find solutions to problems is an important factor. Problem solving may involve applying creative and critical thinking to find reasonable solutions. Communication skills affect the way information is shared and the way individuals interact with each other. Teamwork skills and effective presentation skills have a lower selection rate than other skills, but these are still important skills for coordinating, communicating ideas and information clearly and convincingly.

Through the analysis of the technologies that students use in the classroom, Kahoot, Class Dojo and Trello are the most popular and widely used tools. Socrative, Background Noise are the next most used tools, showing the usefulness of these tools in supporting learning and teaching.

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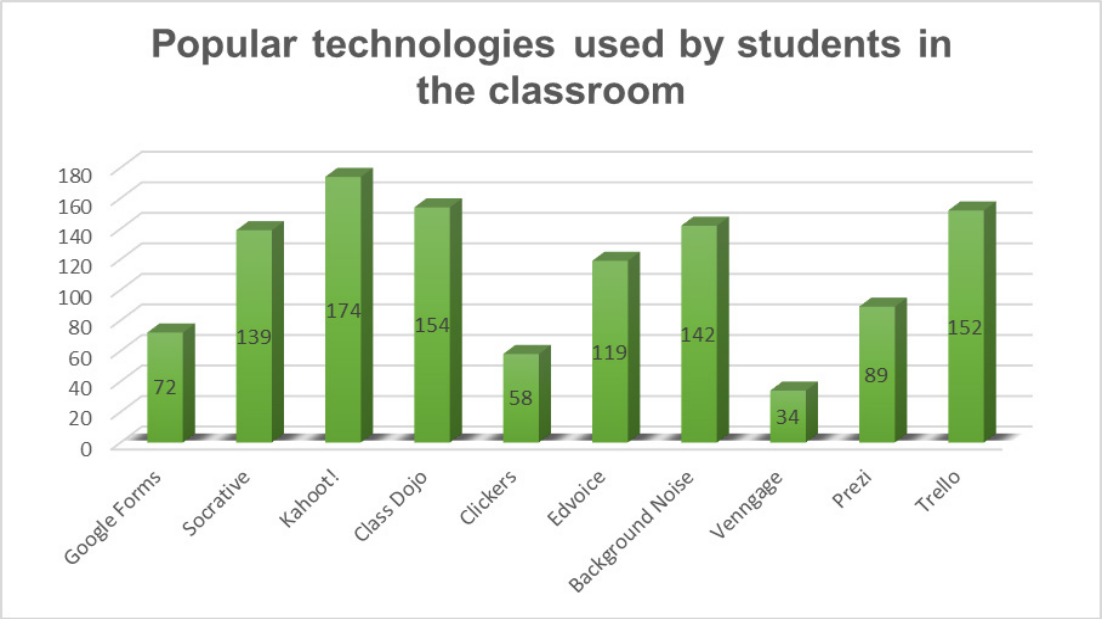

Figure 5. Popular technologies used by students in the classroom

DISCUSSION

The results of the study showed that students had high satisfaction with the PBL method and technology integration. This is consistent with the research theories of Issa and Khataibeh (2021), Marsiti et al. (2023); Zhou and Li (2022) that PBL can increase students' engagement and motivation in learning. The students' autonomy in the learning process and the opportunity to apply knowledge in practice helped them feel more interested and responsible for their learning.

Our study also showed similar results to Marsiti et al. (2023) on the role of technology in enhancing student interaction and collaboration. However, our study focused on the field of sustainability education, while Marsiti et al. (2023) had a broader scope.

One limitation of this study is the small sample size, so the results cannot be generalized to all students. In future studies, we will increase the sample size and diversify the research subjects to obtain more reliable results.

The results of this study show that PBL and technology integration are effective methods to improve the quality of sustainable education. Universities and educational institutions should invest in training teachers in these methods and provide the necessary resources to support the implementation of PBL in classrooms. However, introducing technology into the classroom without a proper educational plan can lead to the same problems we've seen in schools for years (Araújo, 2019).

Findings

The findings of this study revealed several key outcomes:

Enhanced student satisfaction and engagement: students reported high levels of satisfaction and engagement with PBL and technology integration. They appreciated the opportunity to work on real-world projects and apply their knowledge to real-world problems.

Deeper understanding of Corporate Social Responsibility: PBL and technology integration facilitated a deeper understanding of corporate social responsibility. Students were able to connect theoretical concepts with real-world examples and develop a sense of civic responsibility.

Develop Creative Thinking, Problem Solving, Communication Skills: PBL encouraged students to develop critical thinking, problem solving, and collaboration skills. They were able to analyze complex issues, evaluate different perspectives, and work effectively in teams. Enriching learning through technology especially Kahoot, Class Dojo and Trello are the most popular and widely used tools: integrating technology gives students access to diverse information and resources, enhancing their learning experience. They can conduct research, communicate effectively and collaborate with colleagues from all over the world.

CONCLUSIONS

Using both qualitative and quantitative research methods, this study draws on Dewey's (1902) grounded theory, building on the work of Chueh et al. (2024) that found the effectiveness of integrating technology and project-based learning in promoting student satisfaction, engagement, and understanding of corporate social responsibility. By incorporating these innovative pedagogical strategies, educators can create meaningful

learning experiences that equip students with the knowledge and skills necessary to address the challenges of a sustainable future.

RECOMMENDATIONS

The findings of this study have important implications for sustainability education. Educators can incorporate PBL and technology integration into their courses to create more engaging and effective learning environments (Chueh and Kao, 2024). Additionally, institutions can invest in technology infrastructure and professional development to support the implementation of these approaches.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

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