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Article

Research on the innovative atmosphere of online collaborative learning classrooms for football training courses from a biomechanical perspective

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Abstract: With the rapid evolution of educational technology, teaching methods have transcended traditional face-to-face instruction. Beyond physical classrooms, learners now benefit from the flexibility and accessibility of online learning environments. This research examines the innovative dynamics within online collaborative learning classrooms for football training courses, analyzed through a biomechanical lens. Utilizing an action research methodology, the study investigates strategies to cultivate creativity and innovation in virtual football training courses, with a focus on biomechanical principles such as motion analysis, kinetic chain efficiency, and neuromuscular coordination. Key approaches are highlighted: fostering an engaging and innovative classroom atmosphere as a cornerstone for enhancing students' creativity and biomechanical understanding; ensuring learners have access to appropriate personal equipment, such as motion capture devices or wearable sensors, to facilitate accurate biomechanical data collection and analysis during online participation; leveraging course platforms to document and facilitate interactions between learners and instructors, particularly in the context of movement optimization and injury prevention; and addressing the specific requirements of biomechanics-oriented online teaching. Furthermore, the integration of "collaborative learning" and "problem-oriented learning" emerges as the most impactful approach to nurturing creativity and biomechanical proficiency among learners in this context. This study highlights the potential of combining biomechanical principles with online collaborative learning to enhance the quality and innovation of football training education.

Keywords: online teaching; classroom innovation; online collaborative learning; biomechanics; football training courses

1. Introduction

Physical education (PE) and sports science education have undergone significant transformations in recent years, driven by innovations in technology and pedagogical strategies. The integration of biomechanics in PE education is a crucial area of development, aiming to enhance both understanding and application of physical principles. Stiles and Katene emphasize the importance of peer collaboration in improving physical education student teachers' biomechanical knowledge, which has proven to be an effective method for fostering deeper understanding and skill application in this field [1]. Nunes and Wilcox highlight how bridging theory and practice through collaborative platforms, such as the Chat Club, can significantly influence Football Studies education [2].

Recent studies underscore the role of game-based activities in promoting the learning of biomechanical concepts. Keogh, Moro, and Knudson suggest that incorporating game-based learning can effectively support biomechanical education by making complex concepts more accessible and engaging [3]. Likewise, Numbers identifies several innovations in the teaching of physical education, suggesting that creative teaching models can address emerging educational needs [4].

Chen and Chen explore online cooperative teaching modes that leverage self-direction theory to enhance sport science research methods, suggesting that digital platforms can play a pivotal role in modern education [5]. Similarly, Hu examines how virtual reality-based cooperative learning can enhance both physical performance and motivation among students [6]. The integration of technology is further discussed by Shi and Li, who argue for the effectiveness of cooperative learning in college football courses as a way to improve students' teamwork and tactical understanding [7].

Montesinos et al. emphasize the expansion of learning environments using wearable devices and cloud-based programming tools to enhance educational experiences in biomedical engineering, illustrating the broad potential for similar approaches in PE and sports education [8]. Hu and Liu provide insights into the use of multimedia and three-dimensional reconstruction technologies for evaluating teaching effectiveness in physical education, underlining the importance of technological integration in improving educational outcomes [9].

The impact of the COVID-19 pandemic on physical education has also led to new approaches in teaching. Anas et al. compare the effects of online and in-person team-based learning in endocrinology teaching, providing valuable insights into how blended learning strategies can be applied in PE [10]. Ajithkumar et al. highlight the integration of engineering concepts into physical education, proposing a collective approach to transforming teaching methodologies [11].

The alignment of coaching with digital tools has also been a focus of recent research. Bennett and Szedlak discuss novel perspectives on online and remote coaching, exploring how digital innovations can improve coaching effectiveness [12]. Yang and Feng suggest that computer-aided technologies, such as graph sampling and aggregate attention networks, can optimize soccer teaching and training, showing the potential for AI and big data in sports education [13].

Small group and individual learning with technology has been extensively researched, with Lou et al. providing a meta-analysis that outlines the benefits of these learning methods in educational settings [14]. Brink et al. reflect on the evolution of biomechanics scholarship, proposing future directions for the field and emphasizing the importance of interdisciplinary learning [15]. Vaughan et al. take this further by identifying the development of creativity in sports as a critical aspect of enhancing human potential, thus underscoring the value of creative educational methods [16].

Serious games and gamification are increasingly recognized for their role in the Education 4.0 paradigm. Almeida and Simoes examine how these tools, along with industry 4.0 technologies, contribute to an innovative educational framework [17]. Cope et al. explore the perspectives of Saudi Arabian sport coaches on coaching effectiveness, emphasizing the need for continuous professional development in sports coaching [18].

The exploration of coaching effectiveness continues with Solomons et al., who provide insights into the perspectives of coaches and players in South African women's rugby, offering valuable lessons for global coaching strategies [19]. Wang and Wang provide a comprehensive review of artificial intelligence in physical education, proposing future teacher training strategies to incorporate AI into PE pedagogy [20].

Recent developments in teaching models are also captured in Ayubovna, who investigates various teaching methodologies tailored for physical education [21]. Zengaro and Zengaro advocate for inclusive physical literacy, urging the adoption of innovative teaching strategies that embrace diverse abilities in physical education [22]. Quintero et al. contribute by analyzing the integration of the Internet of Things (IoT) in physical education, with a focus on its application in higher education [23].

Finally, advancements in biomedical engineering and computational sciences continue to influence physical education, with Murdivien and Um exploring deep reinforcement learning for solving complex logistical problems, an approach that may have future applications in educational technologies [24]. Akhtar also delves into the intersections of biomedical engineering and regenerative medicine, offering insights into how these fields can contribute to the future of sports education [25].

2. Research methods

2.1. Research design

(1) Teaching Experiment Design

This study employs a non-synchronous online teaching approach to assist football training courses, allowing students to use network tools and features for extended learning, both individually and in groups, beyond traditional class hours. The course integrates biomechanical principles into football training through collaborative learning activities and virtual scenarios. Students are required to participate in a virtual football competition, where they can practice skills related to strategy, biomechanics, team coordination, and performance analysis. Although the competition occurs in a simulated environment, it provides students with opportunities to hone their practical understanding of movement mechanics, performance evaluation, and collaborative problem-solving. Scenario-based teaching is employed to simulate real-world football training and competition settings, enabling students to engage in collaborative tasks such as game planning, movement analysis, and biomechanical assessments.

(2) Teaching Experiment Environment

The experimental teaching takes place in a virtual collaborative learning environment designed specifically for biomechanical principles in football training. This environment, established on the XOOP platform, provides a practical and interactive teaching setup. Based on literature reviews and the needs of the teaching experiment, the platform includes specific cooperative learning features tailored to biomechanics and football training. Users are categorized into various roles, such as trainers, team coordinators, players, and observers, to simulate realistic football team dynamics.

The XOOP platform system serves as the primary system, structured to support collaborative learning through areas like a general workspace, group discussion forums, virtual training zones, and a conference information hub. These areas enable students to collaborate on tasks such as analyzing football movements, designing training regimens, and applying biomechanical concepts. **Figure 1** illustrates the collaborative learning process and the division of functional areas within the platform.

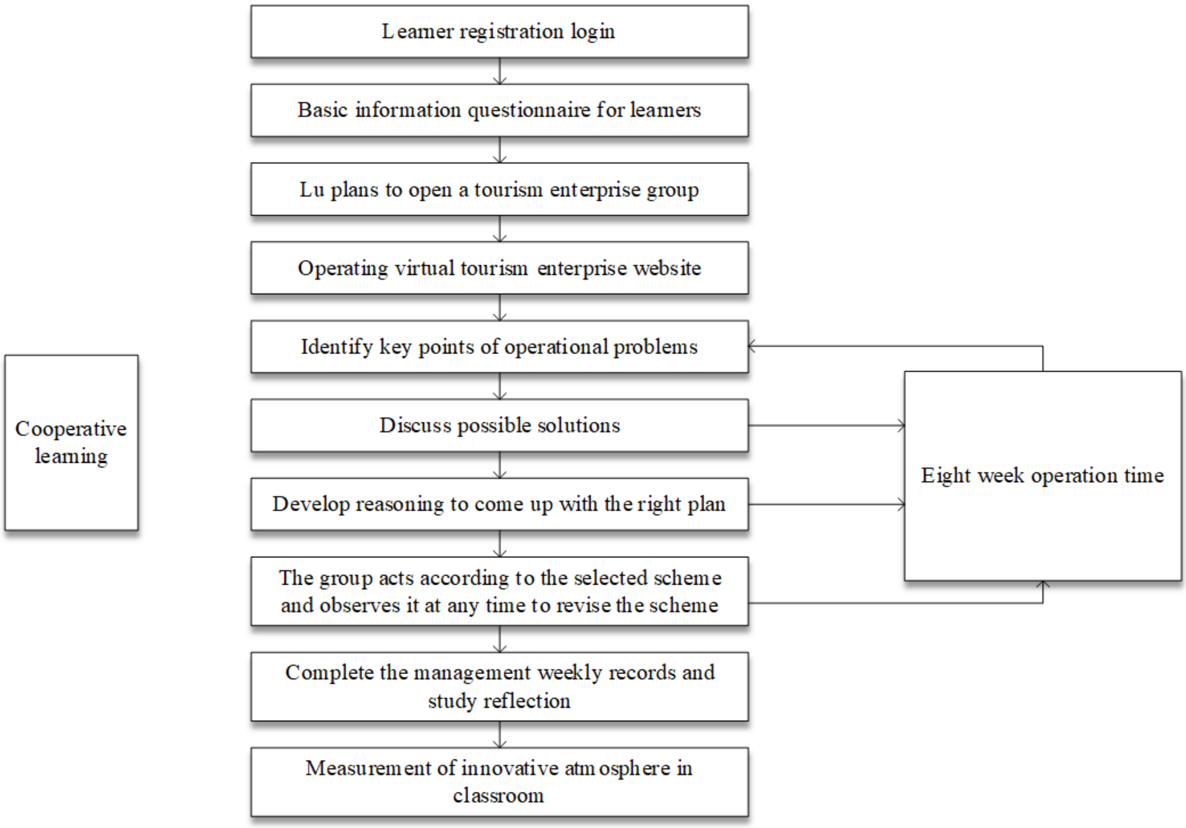

Figure 1. Teaching experiment process.

2.2. Research object

The research focuses on 107 students enrolled in three sections of a sports training course within the physical education department at a technical college. The virtual football training environment, designed on the XOOP platform, was used to observe and analyze the students' systematic behavior and learning processes. The study collected data on students' collaborative learning behaviors, their application of biomechanical principles, and the development of creativity and problem-solving skills in football training scenarios. The research employed methods such as observation of learning activities and statistical analysis to evaluate the effectiveness of the virtual environment and teaching strategies, as shown in **Table 1**.

Table 1. Allocation Tab of the number of subjects in each class.

class	Num	%
A	35	32.72%
B	36	33.64%
C	36	33.64%
total	107	100%

The number of participants in this course was distributed as follows: Class A consisted of 35 students, Class B had 36 students, and Class C included 36 students, totaling 107 participants. The virtual football training environment, developed on the XOOP platform, was employed to implement the teaching design, enabling learners to engage in football training courses collaboratively with a focus on biomechanics and team dynamics.

Before the experimental teaching commenced, two pre-experiment questionnaires were administered: one to collect basic demographic information and the other to assess computer self-efficacy. Learners were then asked to form groups independently, resulting in a total of 17 groups with sizes ranging from 4 to 9 members. These groups participated in the network-based collaborative teaching experiments, where they applied biomechanical principles in football-related tasks and problem-solving scenarios.

3. Research tools

3.1. Basic information questionnaire

The basic information questionnaire collected data on the participants' demographic characteristics and Internet usage habits. The content included the participant's gender, primary Internet access location, average time spent online, and the duration of continuous Internet use during each session.

3.2. Classroom innovation climate scale

The Classroom Innovation Climate Scale was adapted from the campus innovation atmosphere scale developed by Wang. This scale aimed to evaluate the impact of the contextual teaching atmosphere on students' creativity development. The cultivation and practice of creativity within the education system rely heavily on creating an environment that encourages innovative thinking. This environment impacts the creative teaching process and curriculum design, ultimately enhancing students' abilities to think creatively, solve problems, and apply appropriate strategies in learning situations.

This scale evaluates the situational teaching atmosphere in the classroom from the perspective of individual students. Classroom atmosphere reflects the shared perceptions and descriptions of the learning environment by students. Drawing from Schneider's concept of organizational atmosphere, classroom atmosphere can be seen as a manifestation of the organization's social perception. It is the result of personal perception rather than evaluation or attitude, encompassing multiple constructs, including content, procedures, and systems of reinforcement within the classroom.

Research on organizational atmosphere has long been significant in the field of organizational behavior as it reflects the underlying culture and directly influences the attitudes, behaviors, and cognition of individuals within the organization. Similarly, this scale measures how the classroom atmosphere influences individual and group learning behavior through personal perception and interpretation. The scale's purpose is to assess the strength of the classroom atmosphere in promoting innovation and creativity.

The measurement employs a paper-and-pencil test completed by students during class. It evaluates their perceptions of factors that affect classroom performance, with higher scores indicating a stronger innovation climate in the classroom. The scale includes seven dimensions, with some items being reverse-scored and others forward-scored. Higher scores reflect a more positive perception of the classroom innovation atmosphere. The dimensions are as follows:

Teaching Efficiency: Evaluates the teacher's leadership and its impact on fostering creativity, including factors such as the leader's ability and attitude.

Curriculum Design Concept: Measures how curriculum content design encourages creative expression, emphasizing the value of talent development and openness to exploratory attempts.

Group Team Operation: Assesses the effectiveness of team collaboration and creativity within classroom activities, including group consensus and communication efficiency.

Personal Learning Style: Examines individual task approaches and styles that contribute to creative learning, such as autonomy in task work and manageable workload.

Resource Acquisition and Utilization: Evaluates the availability and effective use of resources within the course, including access to professional knowledge, equipment, and support.

Learning and Growth Activities: Measures opportunities provided by the classroom for learning, discussion, and innovation, such as mutual observation and exchange of ideas.

Internet Environment Atmosphere: Assesses the overall online learning environment and its conduciveness to creativity, including aspects like flexibility and comfort in the virtual learning setting.

The scale's purpose is to provide insights into the factors that foster a creative and innovative classroom atmosphere, helping educators refine their teaching methods and curriculum design to support students' creativity and problem-solving skills. **Table 2** includes a detailed comparison table of the scale's factors and associated topics.

Table 2. Names of factors and sample questions of classroom innovation climate scale.

Factor name	**Number of questions**	**Subject content**
Lesson E Design Concept	7	This course emphasizes *R* students and encourages innovative thinking
Personal learning style	4	When I need it, I can study independently without interference
Resource acquisition and utilization	5	I can obtain sufficient data and information for my study
Group team operation	7	My classmates and group partners have a good consensus
Educator leadership effectiveness	6	The teacher can respect and support my creativity in work
Learning and growth activities	5	This course provides sufficient learning opportunities and encourages participation in learning activities
Internet atmosphere	5	My internet environment can make me more creative and creative

The usage of this scale involves summing up the scores of all questions associated with each factor and dividing the total by the number of questions to calculate an index score, which represents the average score for each factor. This approach provides each test subject with a personal total score, reflecting their perception of the intensity of the classroom innovation atmosphere, as well as individual scores on the seven-point scale (corresponding to the seven indicators). The interpretation of these scores is based on a standardized norm, enabling the conversion of each subject's results into a relative status score, either individually or for each class.

In this research, the data analysis was conducted using SPSS (The Statistics Package for Social Science). The statistical methods applied include frequency analysis, percentage calculations, mean score computation, factor analysis, and reliability analysis. These analyses are intended to assess the internal consistency of the scale, evaluate the distribution of responses, and identify underlying patterns related to the classroom innovation atmosphere.

4. Results and discussion

4.1. Basic data analysis

In the pre-test questionnaire, a total of 91 responses were collected. Among these, 5 questionnaires were deemed invalid due to issues such as illegible handwriting and incomplete basic data. Consequently, 86 valid questionnaires were retained for analysis, resulting in a response rate of 80.37%. The valid sample included 37 boys and 49 girls.

Regarding the main locations for Internet access, the majority of respondents indicated "surfing the Internet at home," accounting for 77.9% of the 86 participants. This was followed by workplace access (41.9%), school (9.3%), Internet cafes (7.0%), and other locations (1.2%).

As for the primary method of Internet access, the highest number of participants (66 out of 86, or 76.7%) reported using broadband connections. This was followed by local area networks (23.2%), dial-up connections (11.6%), and other methods (0%).

In terms of time spent on the Internet, the largest group reported two to three years of Internet usage, accounting for 27.9%. This was followed by one to two years (25.6%), five years or more (20.9%), three to four years (9.3%), and four to five years (9.3%). The smallest group, making up 7.0% of participants, had been exposed to the Internet for less than one year. These findings are illustrated in **Figure 2**.

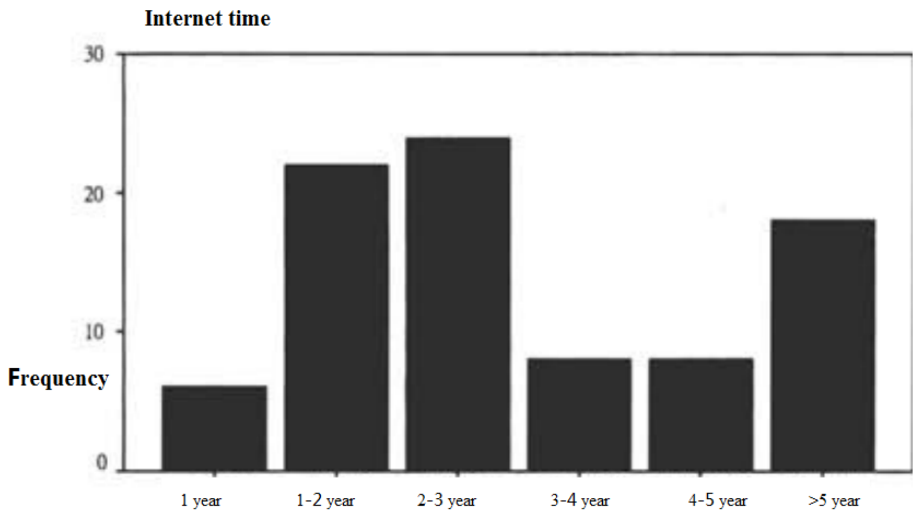

Figure 2. Distribution diagram of the time owed in contact with the network.

In terms of the amount of time spent on the Internet each week, the majority of participants reported spending less than 10 h, accounting for 43.0% of the respondents. This was followed by those spending 10–20 h (20.9%), 20–30 h (11.6%), 30–40 h (9.3%), and 40–50 h (8.1%). Only 7.0% of participants reported spending more than 50 h per week online. These findings are presented in **Figure 3**.

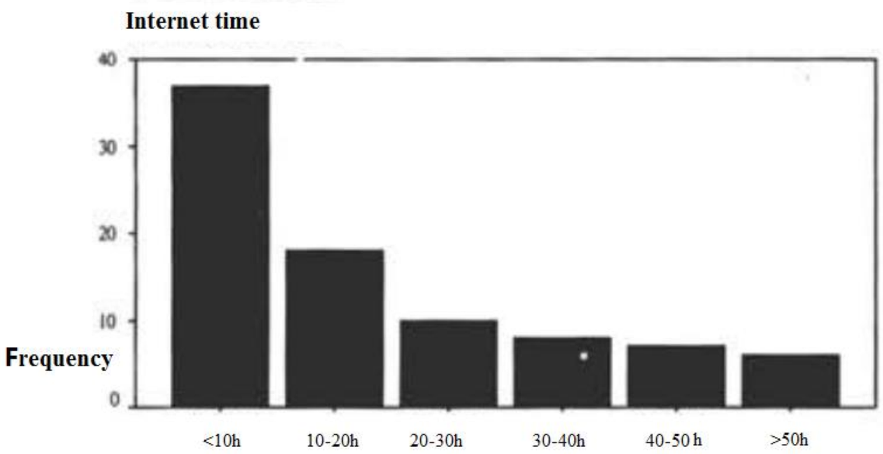

Figure 3. The distribution diagram of the number of times the internet is used for each selection.

4.2. Analysis of the results of classroom innovation atmosphere

The classroom innovation atmosphere scale was administered within one week after the course experiment for this study. This scale was adapted from Wang's classroom innovation atmosphere scale in the online learning report. Among the 86 questionnaires collected, 64 participants scored 75 or higher on the scale for e-commerce learning effectiveness. The questionnaire was conducted in a paper-and-pencil format, with responses provided by students during the class. After excluding 10 questionnaires with missing values, 54 valid responses were used for analysis.

4.2.1. Reliability analysis

(1) Internal Consistency Coefficient

Reliability analysis was conducted to evaluate the internal consistency of each subscale. The Cronbach's alpha coefficient for the full scale, which included 40 items, was 0.91, indicating a high level of internal consistency. The subscales, which measured dimensions such as curriculum design philosophy, personal learning style, resource acquisition and utilization, group team operation, teacher leadership effectiveness, learning growth activities, and network environment atmosphere, also demonstrated good reliability. The Cronbach's alpha coefficients for these subscales were 0.9044, 0.9069, 0.9058, 0.9051, 0.8989, 0.9033, and 0.9041, respectively. These results suggest that the scale is reliable and consistent across its various components (**Table 3**).

Table 3. Cronbach's a coefficient of reliability of classroom innovation qi scale.

Factor name	Number of questions	Whole sample
Curriculum Design Concept	7	0.9044
Personal learning style	4	0.9069
Resource acquisition and utilization	5	0.9058
Group team operation	7	0.9051
Educator leadership effectiveness	6	0.8989
Learning and growth activities	6	0.9033
Internet atmosphere	5	0.9041
Whole wheat	40	0.91

(2) Factor Analysis

The scale underwent principal component analysis to test its structure, with orthogonal axis rotation applied to simplify the structure. Seven factors were identified: curriculum design philosophy, personal learning style, resource acquisition and utilization, group team operation, teacher leadership effectiveness, learning growth activities, and network environment atmosphere. Together, these factors explained 69.17% of the total variance. After orthogonal rotation, the variance explained by each factor was distributed as follows: 28.06%, 14.18%, 8.19%, 6.70%, 4.24%, 4.03%, and 3.73%.

(3) Result Analysis

Based on the intensity of the innovation atmosphere, the total average score for the 40 questions was 4.42, with individual averages ranging between 4.14 and 4.49, indicating an acceptable classroom innovation environment. However, as questions 3, 6, 22, and 29 were reverse-scored, the adjusted average for the 40 forward-scored questions was 4.61. According to the innovation atmosphere intensity scale, an average score between 4.5 and 4.99 reflects a good classroom innovation environment.

Observations of the classroom teaching atmosphere and cooperative learning records in the virtual enterprise environment demonstrated that the scale provided robust reliability and validity support. Moreover, the innovation atmosphere influenced learners' creativity and highlighted individual differences in achieving business success.

4.2.2. Results of virtual tourism business website operations

To evaluate the impact of the teaching approach on business outcomes, five leisure travel enterprise groups were observed. The findings revealed that the integration of website design and marketing activities with Internet-based information significantly influenced business performance. Learners who effectively engaged with the XOOP platform's virtual enterprise teaching environment—utilizing features such as the general workspace, group discussion area, virtual enterprise webpage, and conference information hub—demonstrated greater operational continuity compared to those without online discussion records. These results highlight the critical role of collaborative learning in enhancing learners' performance and engagement within virtual business environments.

4.2.3. Online teaching strategy analysis

A statistical analysis of demographic data and the innovative classroom atmosphere underscored the profound influence of Internet-based cooperative learning on this course's learning environment. Learning inherently requires interaction between teaching and learning processes. Thematic and practical courses progress through the collaboration between learners and instructors in cooperative settings, enabling knowledge construction and the achievement of learning objectives.

The implementation of cooperative learning process files allowed learners to systematically organize data, reflect on their growth, and document their progress. These records not only served as a means to evaluate learners' actual performance, progress, and development but also provided a foundation for setting future learning goals. By integrating cooperative learning with online teaching strategies, this approach not only supported learners in meeting course objectives but also encouraged reflective practices essential for fostering long-term skill development and creativity.

5. Conclusions and recommendations

5.1. Conclusions

This study underscores the critical role of a positive classroom atmosphere in fostering students' creativity. A supportive learning environment enhances interpersonal communication between teachers and students during cooperative learning, leading to improved learning outcomes. The classroom innovation atmosphere scale developed in this research serves as a valuable tool for evaluating whether participants in online cooperative learning understand their roles and tasks, providing actionable insights for online course design.

The findings also highlight the necessity of adequate personal network peripherals for effective online teaching. Most students expressed a preference for completing assignments on personal computers at home, citing the limited comfort and convenience of school-provided network environments. This underscores the importance of ensuring that every learner has access to personal devices and comprehensive online resources to facilitate learning.

Furthermore, this study emphasizes the value of documenting teacher-learner interactions as an integral part of the online learning process. Such records not only guide future curriculum design but also enrich learners' professional skills. Cooperative learning, supported by these interactions, enables knowledge construction and goal attainment, thereby strengthening the synergy between teaching and learning in online settings.

For courses in the leisure industry, particularly those involving e-commerce, marketing, finance, and management, specialized knowledge integration is essential. This equips learners with the skills to make informed decisions and address challenges effectively in individual and group settings. Combining cooperative learning with problem-based learning (PBL) emerges as the most effective strategy for nurturing creativity. By focusing on real-world problems as primary learning objectives, students are encouraged to engage in critical thinking, collaboratively evaluate diverse solutions, and experience a sense of accomplishment. This approach enhances their ability to confidently apply creative thinking in problem-solving contexts.

5.2. Recommendations

To build on these findings, the study recommends expanding the sample size and diversity in future research. The current study's focus on specific schools, courses, and student demographics limits the generalizability of its results. Including a broader and more diverse sample would improve the reliability and validity of future studies. Additionally, simplifying the 40-question Classroom Innovation Climate Scale to 20 questions could make it more user-friendly without diminishing its effectiveness.

The study also suggests broadening the scope of online learning by encouraging inter-school collaborations and diversifying the range of courses offered. Such initiatives could enrich the learning experience and help students view knowledge as a shared resource, reinforcing the idea that learning and knowledge-sharing are collective endeavors that empower educational outcomes.

These conclusions and recommendations provide valuable guidance for enhancing online teaching practices, with particular emphasis on fostering creativity and creating dynamic, collaborative learning environments.

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