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Virtual Simulation-enabled Online-Offline Blended Practical Teaching of Biogeography

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Abstract: *In geography education, practical teaching is crucial for cultivating students' comprehensive abilities. With the continuous development of information technology, virtual simulation technology is attracting increasing academic attention. This study aims to explore the integration effects of online and offline teaching in geography practical teaching and changes in student needs. Questionnaire surveys were conducted on geography majors at a certain university in 2022 and 2024, and the data were analysed for correlations. The results indicate that students prefer practical teaching, with increased recognition of online simulation teaching, while the demand for offline teaching persists, and hybrid teaching models are more widely accepted. Overall, online virtual simulation practical teaching and offline concentrated practical teaching each have their advantages, and their organic integration can enhance teaching effectiveness; teachers should optimise teaching methods based on student needs to promote the development of geography practical teaching and provide references for geography practical course reforms.*

Keywords: *Geography Practical Teaching, Online-Offline Blended Teaching, Virtual Simulation Platform, Correlation Analysis, Biogeography*

1. Introduction

Geography, being a highly practical discipline, plays a vital role in cultivating students' practical, problem-solving, and innovation abilities via practical teaching [1,2].Traditional offline practical teaching methods like field internships and experimental operations can create real geographic environments for students to experience actual situations, facilitating the integration of theoretical knowledge with practical applications. Taking the biogeography course as an example, field practice involving plants and animals is a crucial part of its teaching system. It's significant for students to deeply understand core knowledge about organism distribution and ecosystem structure and function. During field internships, students can better grasp key knowledge points by engaging in the natural environment, observing species and their relationships with the surrounding geography. They can also understand plant and animal classification fundamentals, master the relationship between organism distribution and the environment, as well as learn about plant community quantitative characteristics and field investigation methods [3]. However, with the rapid development of information technology, especially the emergence of virtual simulation technology, online virtual simulation practice teaching has increasingly become an important supplementary form to traditional offline practice teaching [4]. The COVID-19 pandemic further emphasized the importance of online teaching, making it a key means to ensure teaching activities' smooth progress. The digitization of education, as a result of integrating educational teaching activities with digital technology, drives educational reform. The wide application of modern information technology provides new impetus and feasible paths for diverse teaching forms like precision teaching, scenario-based teaching, collaborative teaching, and blended teaching [5]. Against this backdrop, geography practical teaching has a new development opportunity. In the biogeography course, the virtual simulation platform is of great significance. The Northeast Tiger and Leopard National Park in China's border area has rich and unique biogeography research resources, with complete and typical wildlife populations in Northeast China's temperate forests [6]. Although it's an ideal place for field internships and in-depth investigations, there are many objective limitations in actual internship organization. Thanks to the support of the national first-class undergraduate program, the university's biogeography course has built a provincial-approved virtual simulation platform. Using advanced technology, it can simulate typical biogeographic scenes, helping students overcome time and space limitations and compensate for offline internship deficiencies.

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Foreign research on virtual simulation technology started early. Its development in overseas colleges and universities has been good, making significant progress in many aspects and showing trends like integrating multiple technologies, interdisciplinary applications, and combining mobile devices with online learning. Foreign universities mainly use methods such as virtual laboratories, remote experiments, gamification teaching, and building virtual learning environments for virtual simulation practice teaching. For example, the Open Science Laboratory of the Open University of the UK can fulfill all laboratory functions online. Students can download virtual instrument software for online experiments or do remote control experiments with the help of remote control instruments and also use shared instruments like virtual microscopes. The virtual laboratory of the National University of Distance Education (UNED) in Spain helps students understand abstract theoretical knowledge by simulating the operation of complex systems. In network communication experiments, students can directly observe the data transmission process to enhance their professional knowledge. The Open University of the UK uses Second Life to build a 3D virtual environment for real-time teacher-student interaction in learning and counseling. Indiana University and Purdue University Indianapolis Unified and other colleges integrate educational resources into online learning environments, adopting peer-led team learning models and workshop collaboration. The Technical University of Manabi in Ecuador has created the Moodle platform for virtual learning environments. It helps teachers create online learning spaces, manage courses, and share resources, and has a discussion forum and instant messaging space to facilitate interactions [7,8,9]. In China, the application of virtual simulation teaching methods started a bit later but has developed rapidly. Although the technological depth is comparable to foreign countries, there's still a gap in popularization and application. Domestic virtual simulation teaching mainly involves constructing centers and platforms, developing systems and courses, and using combined teaching modes. For instance, China Agricultural University has established a relevant teaching center and proposed a specific teaching system. Shandong Agricultural University has built a platform management system and several teaching systems. The University of Science and Technology of China has developed an experimental platform using virtual simulation technology [10].

Based on prior research, this study focuses on regional characteristics and practical integration and innovation. With a teaching support team of teachers from multiple fields and an independently developed provincial virtual simulation platform as the carrier, it creates an immersive learning experience different from existing platforms at home and abroad through high-precision environment modeling, dynamic interaction design, and a task-driven mode combining the real and virtual. Incorporating biodiversity conservation requirements in border areas with educational digital technology, it establishes a hybrid online/offline practical teaching mode based on virtual simulation experiments through hierarchical teaching design, enabling the organic integration of theoretical teaching, virtual experiments, and field operations. This study offers a localized solution for geography practical course reform, especially for addressing the shortage of practical teaching resources in ecologically sensitive and remote areas.

2. Methods

In this study, data was collected via questionnaire surveys on the Questionstar platform. The surveys were conducted at two time points: 2022 (during the epidemic) and 2024 (after the epidemic), targeting two groups of geosciences majors at a certain university. In 2022, 111 students participated, and in 2024, 136 students took part.SPSS AU software was used to conduct in-depth correlation analysis on the questionnaire data. Specifically, the Pearson correlation coefficient was employed to measure the correlation strength between variables. Correlation analyses were carried out across different dimensions for the data collected from students in both years, such as those on the correlation between students' attitudes towards practical teaching activities and their feelings and preferences for different teaching modes. By interpreting the correlation coefficients and their significance changes over the years, we explored the evolution trend of students' perception and demand for practical geography teaching activities reflected in the data, providing solid data support and a quantitative basis for the study's conclusions.

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3. Results

3.1. Analysis of students' attitudes toward practical geography teaching activities and teaching mode preferences

3.1.1. Students' general attitudes towards practical geography-based teaching and learning activities

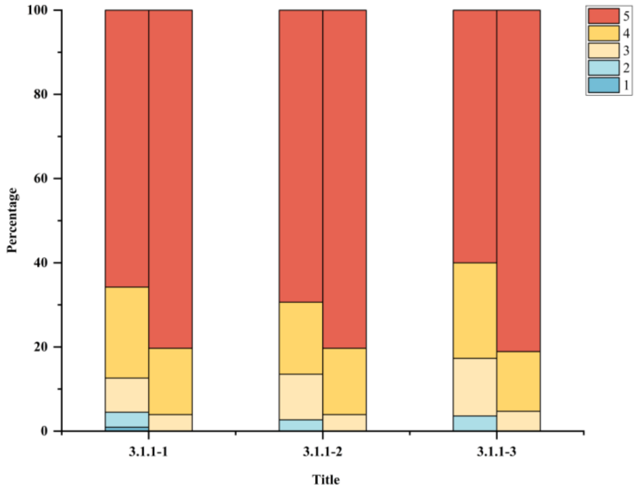

Figure 1: Students' General Attitudes toward Geography Practical Teaching Activities (Note. Variable definitions: 3.1.1-1 = Enjoy participating in geography practical activities; 3.1.1-2 = Practical teaching is necessary; 3.1.1-3 = Prefer multidisciplinary integrated teaching).

The overall attitude of students towards geography practical teaching activities is shown in Figure 1. Students in both 2022 and 2024 were highly enthusiastic about participating in practical geography teaching activities like experiments and field placements, considering them vital for their professional learning. Regarding multidisciplinary integrated practice-based teaching, in 2022, 59.46% of students liked it a lot, 3.6% had a lower preference, and only 0.9% strongly disliked it. By 2024, the situation had changed markedly. 81.1% of students liked it very much, 14.17% had some preference, and 4.72% had a moderate liking. Notably, no student disliked it. This shows that most students have understood such practices better over time, though a few still have a relatively shallow perception.

3.1.2. Students' actual perceptions of online vs. offline instruction

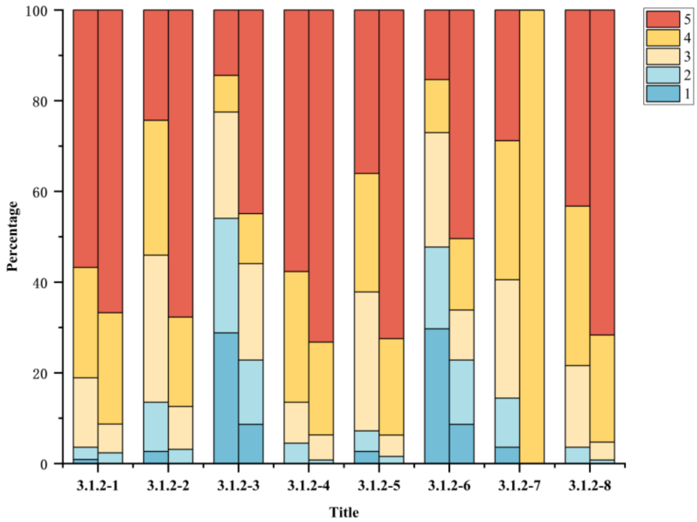

Figure 2: Students' Perceptions of Online and Offline Teaching Effectiveness (Note. 3.1.2-1 = Want offline practice after online simulation; 3.1.2-2 = Online simulation improves practical skills; 3.1.2-3 = Online simulation can replace offline teaching; 3.1.2-4 = Offline teaching improves practical skills; 3.1.2-5 = Online-offline hybrid improves practical skills; 3.1.2-6 = Want to shift offline to online simulation; 3.1.2-7 = Offline decentralized practice is helpful; 3.1.2-8 = Offline centralized practice is helpful).

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Students' perceptions of the effectiveness of online and offline teaching are presented in Figure 2. From 2022 to 2024, students' recognition and acceptance of online virtual simulation practice instruction grew notably. In terms of improving practical skills, the proportion of students considering online teaching helpful rose from 24.32% in 2022 to 67.72% in 2024, while those thinking it unhelpful dropped from 0.9% to 0%. Regarding whether online teaching can replace offline teaching, the share believing it can completely replace offline increased from 14.41% to 44.88%, and those believing it can't replace at all decreased from 28.83% in 2022 to 8.66% in 2024. Meanwhile, the percentage wanting to shift offline practice teaching online grew from 15.32% to 50.39%. These data show students' growing recognition of online teaching and belief in its effectiveness and replacement potential. Questionnaire results also reveal an increased demand for offline practical learning. Comparing 2022 and 2024 data, students in 2024 were more inclined to choose offline practical learning, indicating higher expectations after online experiences. However, over half of students in both years expected offline learning, highlighting its importance. In improving practical skills, most students found offline teaching helpful. The percentage of those finding it completely helpful increased from 57.66% in 2022 to 73.23% in 2024. The combination of online and offline teaching was favored too, with the proportion finding it completely helpful rising from 36.04% in 2022 to 72.44% in 2024, showing its positive role in skill improvement. In short, offline teaching is crucial for skill enhancement, and the combined mode is widely recognized by students. As for the specific forms of offline practice, both decentralized and centralized ones were effective. In 2022, 28.83% of students thought offline decentralized practice was completely helpful for skills improvement, and this rose to 64.57% in 2024. For offline centralized practice, the corresponding percentage increased from 43.24% in 2022 to 71.65% in 2024. In 2024, no students thought these were unhelpful, showing a growing positive perception. Moreover, 66.93% of students in 2024 preferred both forms, indicating broad acceptance. Overall, most students saw positive effects on skills improvement in both forms, and this recognition grew significantly in 2024, underlining the importance of offline practice teaching in learning.

3.1.3. Student Preferences for Instructional Models

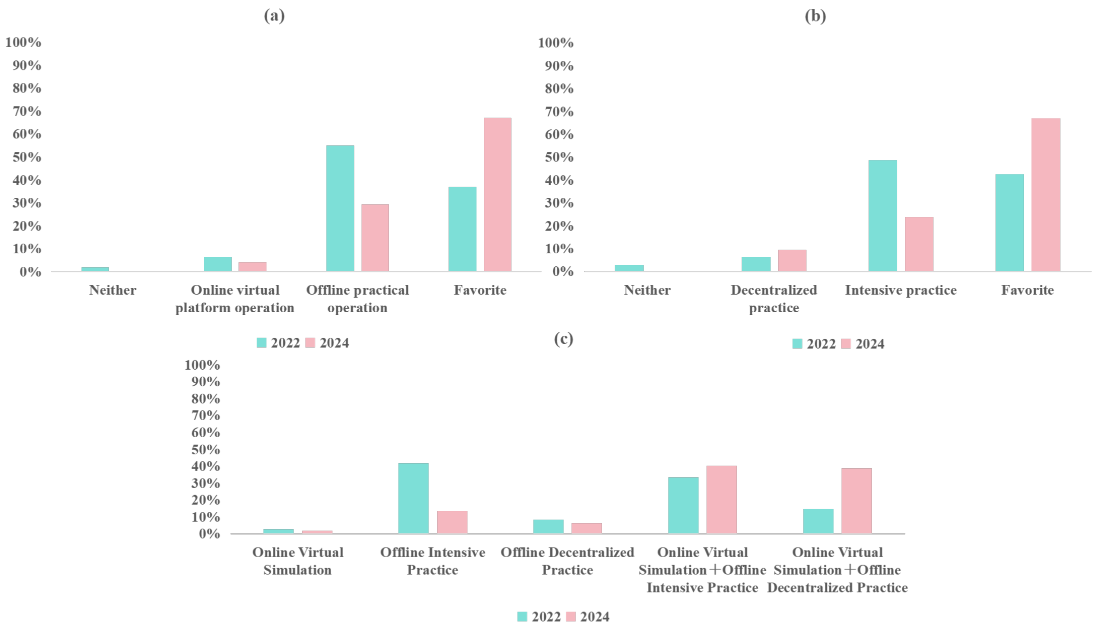

Figure 3: Students' Preferences for Practical Teaching Modes: (a) Which one do you prefer among the two modes of practice teaching, online + offline combined practice teaching mode, which is used in the process of practice teaching due to the new crown epidemic? (b) Which of the two modes, decentralized practice teaching mode and intensive practice teaching mode, do you prefer in the process of offline practice teaching? (c) Which practice teaching mode do you expect more?

Students'preferences for different practical teaching modes are illustrated in Figure 3. From the results of the questionnaire, students' preference for practical teaching modes showed a diversified trend between 2022 and 2024. For the preference of online virtual platform operation and offline practical operation, 54.95% of students preferred offline practical operation in 2022, while this percentage increased to 66.93% in 2024. Meanwhile, students who preferred the combined online + offline mode decreased from 36.94% to 29.13%, while those who preferred online virtual platform operations

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decreased from 6.31% to 3.94%. This indicates that despite the increase in acceptance of online platforms, most students still prefer offline practical operations. In terms of preference for decentralized versus centralized practice teaching modes, 42.34% of students preferred both in 2022, while this increased to 66.93% in 2024. In contrast, students who preferred centralized practice teaching decreased from 48.65% to 23.62%, while those who preferred decentralized practice teaching decreased from 6.31% to 9.45%. This shows that students have become more receptive to the diversity and flexibility of teaching practice modes. As for the teaching mode that students expect to adopt, 44.44% of students prefer offline centralized practice in 2022, while 38.58% of students prefer the mode combining online virtual simulation and offline decentralized practice in 2024, and 40.16% of students prefer the mode combining online virtual simulation and offline centralized practice. This reflects the increased openness of students to the integration of online virtual simulation technology into practice teaching.

3.2. Correlation analysis

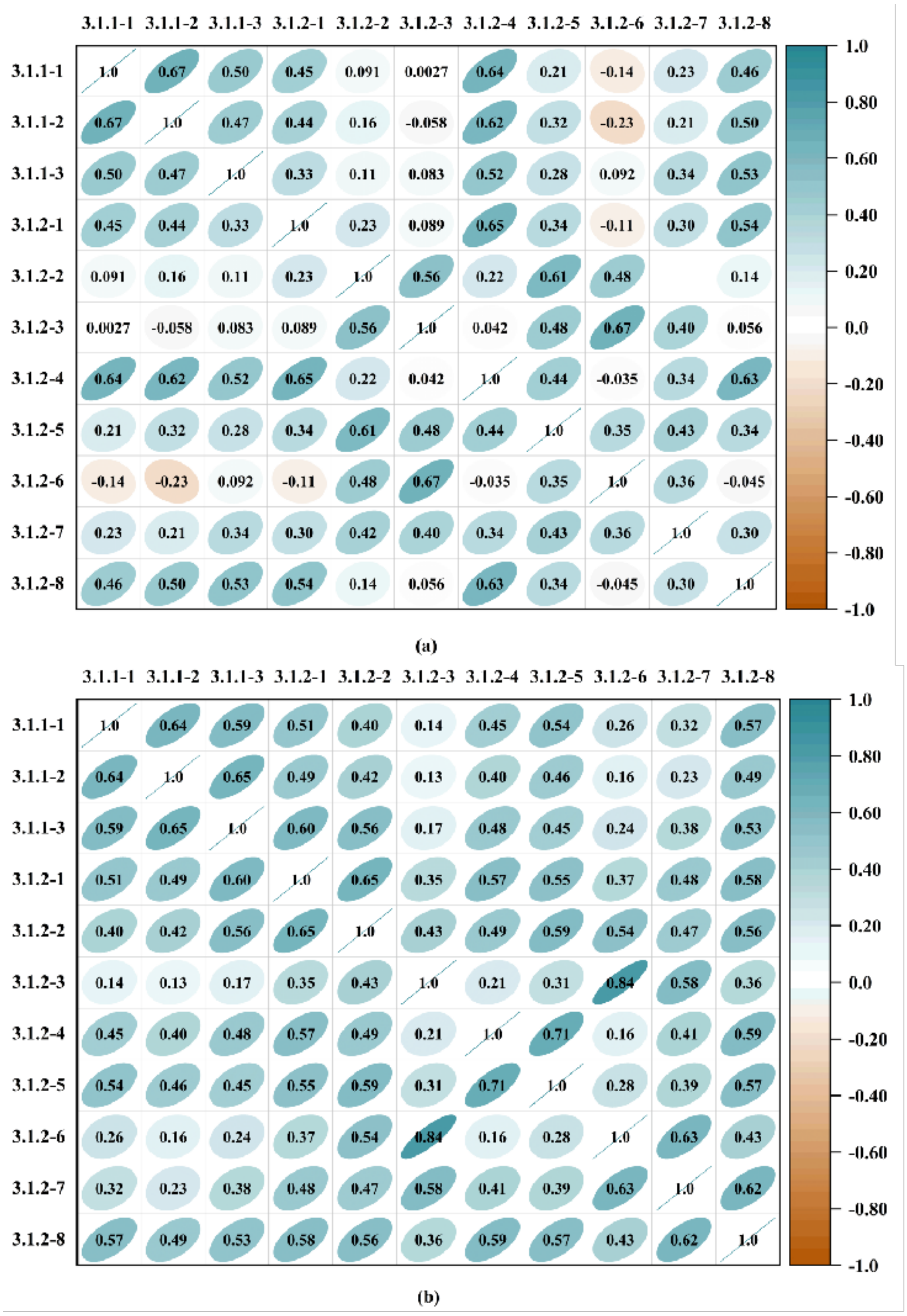

Figure 4: 2022 (a) vs. 2024 (b) Correlation Heat Map

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Table 1: Correlation Analysis of Student Attitudes and Teaching Mode Evaluations (2022 vs. 2024).

	3.1.1-1	3.1.1-2	3.1.1-3	3.1.2-1	3.1.2-2	3.1.2-3	3.1.2-4	3.1.2-5	3.1.2-6	3.1.2-7	3.1.2-8
3.1.1-1	1	0.674** 0.635**	0.496** 0.587**	0.450** 0.513**	0.091 0.402**	0.003 0.143	0.645** 0.447**	0.215* 0.535**	-0.137 0.261**	0.226* 0.318**	0.462** 0.571**
3.1.1-2	0.674** 0.635**	1	0.473** 0.646**	0.437** 0.491**	0.155 0.422**	-0.058 0.132	0.625** 0.397**	0.317** 0.464**	-0.229* 0.161	0.212* 0.232**	0.499** 0.493**
3.1.1-3	0.496** 0.587**	0.473** 0.646**	1	0.329** 0.603**	0.105 0.561**	0.083 0.171	0.515** 0.482**	0.284** 0.450**	0.092 0.243**	0.341** 0.376**	0.534** 0.529**
3.1.2-1	0.450** 0.513**	0.437** 0.491**	0.329** 0.603**	1	0.231* 0.653**	0.089 0.348**	0.647** 0.570**	0.343** 0.546**	-0.115 0.368**	0.301** 0.480**	0.537** 0.576**
3.1.2-2	0.091 0.402**	0.155 0.422**	0.105 0.561**	0.231* 0.653**	1	0.560** 0.433**	0.224* 0.488**	0.613** 0.590**	0.478** 0.542**	0.424** 0.469**	0.137 0.560**
3.1.2-3	0.003 0.143	-0.058 0.132	0.083 0.171	0.089 0.348**	0.560** 0.433**	1	0.042 0.210*	0.479** 0.310**	0.674** 0.843**	0.401** 0.584**	0.056 0.364**
3.1.2-4	0.645** 0.447**	0.625** 0.397**	0.515** 0.482**	0.647** 0.570**	0.224* 0.488**	0.042 0.210*	1	0.441** 0.705**	-0.035 0.161	0.345** 0.410**	0.625** 0.591**
3.1.2-5	0.215* 0.535**	0.317** 0.464**	0.284** 0.450**	0.343** 0.546**	0.613** 0.590**	0.479** 0.310**	0.441** 0.705**	1	0.355** 0.282**	0.426** 0.390**	0.340** 0.572**
3.1.2-6	-0.137 0.261**	-0.229* 0.161	0.092 0.243**	-0.115 0.368**	0.478** 0.542**	0.674** 0.843**	-0.035 0.161	0.355** 0.282**	1	0.357** 0.634**	-0.045 0.426**
3.1.2-7	0.226* 0.318**	0.212* 0.232**	0.341** 0.376**	0.301** 0.480**	0.424** 0.469**	0.401** 0.584**	0.345** 0.410**	0.426** 0.390**	0.357** 0.634**	1	0.297** 0.620**
3.1.2-8	0.462** 0.571**	0.499** 0.493**	0.534** 0.529**	0.537** 0.576**	0.137 0.560**	0.056 0.364**	0.625** 0.591**	0.340** 0.572**	-0.045 0.426**	0.297** 0.620**	1

Note: Variable definitions: 3.1.1-1 = Enjoy participating in geography practical activities; 3.1.1-2 = Practical teaching is necessary; 3.1.1-3 = Prefer multidisciplinary integrated teaching; 3.1.2-1 = Want offline practice after online simulation; 3.1.2-2 = Online simulation improves practical skills; 3.1.2-3 = Online simulation can replace offline teaching; 3.1.2-4 = Offline teaching improves practical skills; 3.1.2-5 = Online-offline hybrid improves practical skills; 3.1.2-6 = Want to shift offline to online simulation; 3.1.2-7 = Offline decentralized practice is helpful; 3.1.2-8 = Offline centralized practice is helpful. Top value = 2022; Bottom value = 2024.

The Pearson correlation coefficient was employed to analyze the correlation strength. The correlation heat maps of each variable in 2022 and 2024 are shown in Figure 4, and the detailed correlation coefficients are listed in Table 1. For the correlation between students' belief in the necessity of practical teaching activities and their belief in the usefulness of offline practical teaching for enhancing practical skills, the coefficients were 0.625 in 2022 and 0.397 in 2024. The 2022 coefficient was significantly higher, indicating that students in 2022 were more aware of offline teaching's prominent role in skill enhancement. Despite the decrease in significance in 2024, there's still a significant positive correlation. Regarding the correlation between whether students like geography practical teaching activities and whether they think the combination of online + offline teaching can improve practical ability, the coefficients were 0.215 in 2022 and 0.535 in 2024. The 2024 significance is much higher, suggesting that the combined teaching mode was more effective and popular among students in 2024 compared to 2022. Taking online virtual simulation practical teaching as an example, the correlation coefficients between students' belief in the necessity of practical teaching activities and their belief in its help for improving practical skills were 0.155 in 2022 and 0.422 in 2024. The significant increase shows that this teaching method was more effective in improving skills in 2024 than in 2022. The correlation coefficients between whether students think offline intensive practice helps improve practical ability and whether they want to transfer more offline teaching to online simulation teaching were -0.045 in 2022 and 0.426 in 2024, changing from a low negative to a high positive correlation. This means that in 2022, students who thought offline practice helped were not eager to transfer it online, but in 2024, more students wanted to

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do so. The correlation coefficient between whether students believe online virtual simulation teaching helps improve skills and whether they think it can completely replace offline teaching changed from 0.089 in 2022 to 0.348 in 2024. The increase indicates that in 2024, many students thought online teaching had a positive effect on skills and had the potential to replace offline teaching in the future. The correlation coefficients between whether students believe online virtual simulation teaching helps improve skills and whether they want to practice the same content offline after using the online platform were 0.231 in 2022 and 0.653 in 2024. The significant increase shows that in 2024, students' willingness to do the same practical learning offline after using the online platform was higher than in 2022.

3.3. Analysis of students' recommendations for practice

Figure 5: Students' Recommendations for Practical Teaching Optimization.

Students' suggestions for the optimization of practical teaching are summarized in Figure 5. Comparing students' suggestions for practical teaching in 2022 and 2024, we found the following shifts: For online virtual simulation practical teaching, students' concerns changed from basic issues like network lag and server capacity (with a highest percentage of 35.14% in 2022) to more detailed practical needs such as better graphics, compatibility with more laptop models, and improved operability (both with a highest percentage of 17.65% in 2024).Regarding offline centralized practice teaching, students generally desired more practice time and richer content in both years. However, in 2024, they emphasized teaching flexibility and location variety more, indicating higher expectations for quality (with the highest share of recommendations at 20.83% in 2024).In offline decentralized practice teaching, students moved from wanting diverse tasks and more practice opportunities (highest percentage 23.08% in 2022) to seeking more flexible arrangements and additional instruction (highest percentage 20% in 2024).In biogeography and geosciences practical teaching, students shifted from suggesting simulation labs and more field studies (highest percentage 68.19% in 2022) to desiring more practice sites and enriched instruction (highest percentage 28.57% in 2024).Overall, students' demand for online teaching experience is growing annually, and their expectations for offline practice teaching are also rising, particularly in terms of practice flexibility and teaching quality.

4. Discussion

In the past, traditional offline practical teaching methods were mainly used in practical teaching. But with the rapid development of information technology in recent years, online virtual simulation technology has emerged and played a more and more important role in practical teaching. However, it's still a challenge in the current teaching reform to integrate online virtual simulation practice teaching with offline centralized practice teaching or other forms of practice teaching organically. This study found that online virtual simulation practice teaching and offline centralized practice teaching have different functions in the teaching process, and their organic combination is likely to improve the teaching effect.

4.1. Importance of offline practical teaching

The study's findings show that students have always been enthusiastic about offline practical teaching and believe it has improved their practical skills. Especially during the 2022 epidemic, students clearly preferred offline practical operations that involved hands-on participation, with the offline centralized practice mode being particularly favored. In 2024, as the online virtual simulation platform was

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continuously optimized, students' preferences for teaching modes became diversified. Their attention was no longer limited to offline practical operations but also included the operation of the online virtual platform. Although the online mode emerged, the overall trend indicates that students' enthusiasm for offline practical teaching remained unchanged before and after the epidemic. Moreover, the value of this teaching mode has been widely recognized and praised by students.

Practice teaching is a crucial part of college teaching, and offline practice teaching plays a vital role in college practice teaching. It's a significant catalyst for the in-depth integration of theory and practice. Firstly, offline practical teaching can provide an immersive learning experience. In face-to-face teaching, teachers can intuitively sense the teaching effect by observing students' expressions and movements, and students can quickly get feedback and corrections from teachers to precisely improve their operational skills. Such an instant feedback mechanism is hard for online teaching to fully replicate, ensuring an efficient and accurate learning process [11]. Secondly, offline practical teaching environments are usually closer to actual geographic situations. By providing real experimental conditions and a natural environment, it enables students to conduct hands-on operations and make direct perceptions in the field, facilitating the integration of theoretical knowledge with practice. This deepens their understanding of theoretical knowledge and sharpens their practical application abilities. The "learning to do, doing to learn" mode is more conducive to cultivating students' abilities to combine theory and practice, solve practical problems, and conduct scientific research and innovation, laying a solid foundation for their future development [12]. For example, during field practice, students can use the methodology of geography field investigation, integrate the observed characteristics of the combined natural and humanistic environment with their own experiences, and summarize them into a report. This enhances students' geography practice abilities and helps them better understand the local natural and humanistic environment [13]. Furthermore, offline practice teaching has remarkable advantages in cultivating students' teamwork, communication, and leadership skills. In teamwork tasks, students need to cooperate to solve problems, assign tasks, and coordinate resources. Through face-to-face communication and cooperation with peers, they can effectively develop these skills. In contrast, online teaching often has difficulty offering the same level of interaction and cooperation opportunities as offline practice teaching [14].

The questionnaire analysis also showed that students in 2022 and 2024 had different attitudes towards offline practice teaching. In 2022, due to the epidemic, offline practice teaching mainly took the form of decentralized practice, but students actually hoped for centralized practice opportunities and thus showed a stronger preference for the offline centralized practice mode.

4.2. Relationship between the quality of virtual simulation experiments and practical teaching

Questionnaire analysis showed that the quality of online virtual simulation practice is a crucial factor affecting teaching effectiveness. Specifically, a high-quality virtual simulation laboratory system can significantly boost teaching effectiveness, while an imperfect one may undermine the overall teaching quality.In 2022, despite the prevalence of online education, students keen on geography practical teaching and learning activities were not eager to shift more offline practical teaching to online virtual simulation practice teaching. However, with the continuous technological and user experience optimization of the online virtual platform by 2024, students' attitudes changed significantly. They recognized the positive role of online virtual simulation practice teaching in improving practical abilities and gradually preferred to move more offline practice teaching activities online. Moreover, in 2022, online virtual simulation practice mainly relied on public courses, and its simulation degree and closeness to real situations were relatively low. In contrast, in 2024, it was mainly conducted through professional courses with practical features, which were more in line with students' professional fields.

Online virtual simulation practice, as an emerging teaching mode, has been widely used in education in recent years and has shown excellent efficacy in enhancing students' learning and practical abilities. In this mode, the quality and application level of online virtual simulation practice are significant factors influencing teaching effectiveness [15]. Firstly, high-quality online virtual simulation practice can present highly realistic environments and scenarios, allowing students to feel like they are in an actual operating environment. This authenticity and immersion can effectively stimulate students' learning interest and increase their participation [16]. When the virtual environment accurately reflects real operation details and processes, it's easier for students to understand and master relevant knowledge, strengthening the teaching effect. Secondly, high-quality online virtual simulation practice platforms usually have abundant interactive functions and instant feedback mechanisms. Students can explore, experiment, and solve problems by interacting with the virtual environment. Such interactivity is vital for cultivating students' practical abilities and innovative thinking. Meanwhile, the instant feedback mechanism helps students

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quickly understand their operation results and identify problems, enabling them to adjust learning strategies and improve learning efficiency [17]. Furthermore, virtual simulation practice closely resembling real scenes can enhance students' sense of reality and immersion. When it aligns well with actual situations in life or professional fields, it's more convenient for students to apply knowledge to real-life circumstances, which also helps cultivate practical abilities and problem-solving skills, allowing them to quickly find solutions when facing real problems [18]. Virtual simulation practice with a high degree of simulation can more accurately mimic geographic processes in real scenes and provide more precise learning information, reducing misunderstandings and confusion during learning and improving learning outcomes. Consequently, both the closeness to real scenes and the simulation level of virtual simulation practice jointly contribute to teaching and learning effectiveness [19]. When both reach a high level, they can create a powerful synergistic effect and significantly enhance students' learning outcomes and practical abilities. Conversely, if they are inadequate, it may lead to abstract, unrealistic, or misleading learning content and undermine the teaching effect.

4.3. Adaptation of different practice teaching models

The questionnaire results show that the appropriate combination of online virtual simulation practice and offline centralized practice can effectively boost the effectiveness of practical teaching (Table 1). In both 2022 and 2024, students generally believed that online virtual simulation teaching, offline centralized practice, and the integration of these two practical teaching modes all achieved remarkable results in significantly improving their practical skills. Clearly, the integration and application of online virtual simulation practice and offline centralized practice play a crucial and decisive role in enhancing the effectiveness of practical teaching.

With the continuous development of Internet technology, new teaching modes have been constantly emerging in higher education. In recent years, virtual simulation platforms and flipped classrooms have gradually become research hotspots in the education field [20]. Especially during the COVID-19 pandemic, their application and significance in education were further emphasized. Take online virtual simulation practice as an example. It's a new experimental mode that has emerged and evolved under the impetus of advanced technologies like virtual reality and multimedia. Through operating simulation equipment, this teaching mode enables students to achieve or even exceed the training effect of completing scheduled experimental projects in a real environment [21]. Firstly, online virtual simulation practice breaks through time and space limitations, broadening the teaching scope [22]. Traditional geography practice teaching is often restricted by time and space. For instance, field trips need a lot of time and resources and are affected by weather and transportation. In contrast, online virtual simulation practice can overcome these constraints. By using virtual technology, it can simulate various geographic environments and phenomena, allowing students to engage in practical learning anytime and anywhere. This flexibility enhances teaching efficiency and expands the teaching scope, exposing students to more diverse geographic knowledge and practical scenarios [23]. Secondly, online virtual simulation practice enhances students' intuition. For example, in 2014, the School of Architecture and Urban Planning of Tongji University was approved to establish the Virtual Simulation Experimental Teaching Center for Architecture, Planning, and Landscape, aiming to conduct virtual simulation research on architectural structures and landscapes and provide students with vivid and accessible experimental environments [24]. Geography is characterized by high spatiality and integration [25,26]. Many geographic phenomena and processes are hard to visualize through text or pictures. However, online virtual simulation practice can present complex geographic phenomena and processes vividly through 3D modeling and animation demonstrations. It can simulate various geographic processes and natural phenomena like earthquakes, floods, etc., and reproduce extreme or disaster scenarios that are difficult to experience in reality, helping students deeply understand the nature, causes, and consequences of natural disasters [27]. Furthermore, online virtual simulation practice promotes students' independent learning and cultivates their innovative abilities. It offers a personalized learning platform that can stimulate students' learning interest and enthusiasm, and foster their independent learning and innovation capabilities. During virtual practice, students need to apply knowledge to solve practical problems, which helps develop their critical thinking and problem-solving skills [28]. Finally, online virtual simulation practice can save teaching costs and achieve sustainable development [29]. Traditional geography practice teaching often requires a lot of teaching equipment and resources, like transportation and accommodation expenses for field trips. In contrast, online virtual simulation practice can significantly reduce these costs, realizing the optimal allocation of teaching resources and sustainable development. Meanwhile, it can also mitigate the impact and damage caused by fieldwork on the natural environment, in line with the concept of green education [30].

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4.4. Strategies for improving practical teaching

The study shows that under different teaching conditions, teachers should optimize their teaching methods according to students' practical needs. It was found that in 2022, students had relatively higher expectations for both online platforms and offline practice teaching. They especially focused on the improvement and refinement of the platforms since the online ones were still in the experimental stage at that time. However, by 2024, students were paying more attention to the frequency of practice sessions and personalized instruction. This indicates differences in students' needs, learning environments, and teaching resources under various teaching circumstances. Thus, teachers need to adjust their teaching strategies flexibly based on students' specific requirements to enhance teaching effectiveness.

Firstly, grasping students' practice needs is extremely important. Effective practice teaching should involve a sense of perception [31]. Students may have diverse requirements at different learning stages, and "meeting the learning needs of various students" has become an inevitable responsibility for every teacher. As a result, differentiated teaching has become the inevitable choice for more educators [32]. For example, when the online virtual simulation platform was first launched in 2022, many students reported issues like numerous bugs on the website, limited server capacity, and frequent lagging. Virtual reality, as a teaching tool and technical means, has advantages such as presence, multi-sensory experience, and interactivity [33]. A high-quality virtual simulation practice platform requires not only comprehensive teaching content and resources but also mature R&D technology. During the collaborative development process, teachers need to contribute appropriate teaching content and have in-depth discussions with the technical team about technical details to determine which technologies and equipment can ensure the system's stability, efficiency, and user-friendliness [34]. Meanwhile, teachers should take the initiative to learn and master relevant technical knowledge in the cooperation to lay a solid foundation for future development and innovation [35]. Therefore, teachers must actively communicate with students to understand their expectations, confusion, and interests, so as to offer them the most suitable teaching methods and content. Secondly, the selection of teaching methods should match the teaching conditions. To conduct geography practice teaching before, during, and after class, teachers implement a real-time interactive teaching mode combining online, offline, and empirical research [36]. There is growing evidence that outdoor teaching and learning in natural environments can bring many benefits when teaching and learning resources are abundant [37]. Conversely, in resource-limited environments, it's necessary to focus more on the effective use of traditional teaching methods (such as blackboard writing, physical demonstrations, etc.).Furthermore, teachers need to constantly reflect on and evaluate their teaching styles. By collecting students' feedback, observing students' learning outcomes, and analyzing teaching effectiveness, teachers can quickly identify problems and deficiencies and make corresponding adjustments and improvements. This continuous optimization process will help teachers continuously improve their teaching standards and provide students with better educational services [38]. Teachers also need to consider students' learning styles, whether they are visual, auditory, or hands-on. By fully exploiting the educational value of typical geographic elements, teachers can provide students with diverse learning paths. For example, they can select some exemplary deeds of individuals and cases of local social and economic sustainable development to illustrate the classic theories in textbooks [39]. In college geography teaching classrooms, teachers should recognize the role transformation from being an indoctrinating transmitter to a knowledge guide, promote cooperation between teachers and students, and improve the quality of college geography teaching in an active learning atmosphere [40].

5. Conclusion

This study investigates the online-offline blended practice teaching of biogeography empowered by virtual simulation among geography science students at a certain university. Key findings include: (1) Students highly recognize the value of practical geography education. From 2022 to 2024, their acceptance of online virtual simulation teaching has significantly increased, while offline teaching remains in demand. The blended teaching model is the most favored approach, with students demonstrating a trend toward diversified teaching mode preferences. (2) Teaching effectiveness is closely related to teaching models and student attitudes. In 2022, students placed greater emphasis on the skill enhancement role of offline practical training, while in 2024, there was higher recognition of the effectiveness of online virtual simulation and blended teaching, with increased willingness to repeat offline practice after online practice. (3) Offline practical teaching provides immersive experiences, promotes the integration of theory and practice, and cultivates diverse competencies; online virtual simulation teaching transcends temporal and spatial limitations, enhances intuitive perception, and its quality directly impacts teaching efficacy. Both approaches possess distinct advantages. (4) Teachers

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should optimize teaching methods and integrate teaching resources based on students' needs and teaching conditions, continuously reflect on and improve teaching practices, pay attention to student differences and enrich learning approaches, and promote efficient teacher-student collaboration.

In conclusion, the organic integration of online virtual simulation and offline centralized practical teaching can enhance the teaching effectiveness of biogeography, providing a reference for the reform of geographical practice courses. Further exploration of the integration pathways between the two is required to meet student needs, improve teaching quality, and address the shortage of practical teaching resources in ecologically sensitive areas and remote regions.

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