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A study of flipped classrooms in higher education

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Abstract: With the continuous innovation of educational concepts and the rapid development of information technology, the field of higher education is actively exploring innovative teaching modes to improve the quality of teaching and student learning. This study focuses on the application of the flipped classroom in higher education, aiming to analyze its application status, advantages, challenges, and strategies. By combining the relevant research results from home and abroad through the literature research method, the research results show that the flipped classroom is effective in stimulating students' interest in learning, improving independent learning ability, and enhancing teamwork skills, among other benefits. However, in the process of implementation, it also faces challenges such as the uneven independent learning abilities of students, difficulties in changing teachers' teaching concepts, and insufficient construction of teaching resources. Based on this, the future development direction and other targeted strategies are proposed to promote the more effective application of the flipped classroom in higher education and to advance the teaching reform of higher education to a deeper level.

Keywords: *Applied research, Flipped classroom, Higher education.*

1. Introduction

The rise of the digital age has driven innovations in pedagogy, changed student expectations of the learning experience, and led to an increasingly competitive university environment [1]. The flipped classroom, an innovative pedagogical model, has gained traction in higher education in recent years. The model aims to increase students' self-directed learning and classroom engagement by moving the knowledge transfer component of the traditional classroom outside the classroom and using classroom time for in-depth interaction and practice [2]. Changes in the structure of the flipped classroom have affected the traditional roles of students, many of whom have become accustomed to sitting in a classroom and listening to experts deliver content while attempting to record what is being said verbatim. After class, students are required to repeat the thinking and problem-solving demonstrated in class, often without timely feedback or guidance. This passive approach perpetuates surface-level learning and results in students cramming as much information as possible into their brains in the hopes of successfully 'data dumping' on a test. The flipped classroom transforms students from cognitive apprentices from passive participants to active learners who will be required to take ownership of their learning, become active members of a community of learners within the programme, and think like experts. By 'shifting' instruction and classroom activities, classroom time traditionally used for passive instruction can be used for active learning [3].

Flipped classroom is a teaching model whose core idea is to swap the roles of traditional classroom learning between classroom lectures and after-school learning, and to change the time and place of learning activities through the use of technology and learning resources in order to improve students' learning effectiveness and engagement, and one of the main features of the flipped classroom is to put the students at the centre of learning Weinhandl, et al. [4]. Bergmann and Sams [5]are the pioneers in

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the study of flipped classroom, who started to explore the flipped classroom teaching model, successfully implemented it, and formally introduced the concept of 'flipped classroom' in 2012 [6]. In order to make classroom time more conducive to professional learning, some elements of the flipped classroom learning process, such as theoretical presentation or developmental level interpretation, will take place outside of the classroom [7].

Surveys have shown that most students are interested in pre-class activities, which are beneficial for student engagement and concentration in class [8]. Teachers use class time for more learning projects such as discussions, exercises, interactions, and activities [9]. In this case, teachers can better understand students' learning needs and difficulties and provide targeted guidance and support, and teachers can help students strengthen their connections with their peers [10]. At the same time, students can also promote each other's learning through co-operative learning and interactive exchanges, and group activities using classroom time have received positive feedback from students [11]. This makes the flipped classroom a teaching method with great potential for teachers [12].

With the rapid development of educational technology, the effects and challenges of the application of flipped classroom in higher education have become a hot research topic. This paper summarises the theoretical foundation of flipped classroom, the implementation mode, the effect research and the challenges it faces by reviewing the relevant literature in recent years, and proposes the direction of future research.

2. Theoretical Foundation

The theoretical foundations of the flipped classroom are mainly derived from constructivism and self-determination theory. Constructivism emphasises students' initiative and ability to construct knowledge in the learning process, while flipped classrooms provide students with more opportunities to construct knowledge through independent learning before class [2]. Self-determination theory, on the other hand, explains the impact of the flipped classroom on students' motivation from a psychological perspective. Zainuddin and Perera [13] study showed that the flipped classroom meets students' needs for competence, autonomy, and relevance, which in turn increases their motivation and engagement. These theories provide solid theoretical support for the design and implementation of flipped classrooms. In addition, the theory of social constructivism also provides theoretical support for the flipped classroom. Social constructivism emphasises that learning is a socialisation process where students construct knowledge through interaction with others [14]. Flipped classrooms provide students with more socialised learning opportunities through group discussions and collaborative learning in the classroom [15]. These theories provide a solid theoretical foundation for the design and implementation of the flipped classroom.

Cognitive load theory was first proposed by Sweller [16]. Cognitive load is a multidimensional structure of a load that is placed on a learner's cognitive system when carrying out a specific learning task, and can be classified into three types: intrinsic cognitive load, germane cognitive load,, and extraneous cognitive load Sweller, et al. [17] that are interacting with each other [18]. Cognitive load theory provides a framework for instructional design in the flipped classroom, where learner load can be reduced through instructional design Sweller [16] by avoiding unnecessary cognitive load and increasing cognitive load that is useful for learning. Cognitive load theory assumes that working memory (WM) and longterm memory make up the human cognitive structure. Information is stored in Long-term memory only after it has been attended to and processed in working memory. The irrelevant cognitive load of novice learners can be reduced by interactive e-tutorials [19]. Lectures and videos recorded in advance can reduce the cognitive load of students and help in learning in a flipped classroom environment [20]. Flipped classroom, a student-centered teaching method, plays an important role in reducing students' external cognitive load and optimizing the educational function, teacher-student relationship, curriculum and educational system [21]. Students can actively develop knowledge and concepts when solving a problem, which they solve and share the information gained from the instructional video before class [22].

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Active Learning is the process of engaging students in activities such as reading, writing, discussing, or problem solving to facilitate the analysis, synthesis, and evaluation of classroom content, and is broad in scope [23]. Fundamentally Active Learning is about keeping students interested and motivated when learning [7]. During Active Learning, students must actively participate and engage in higher-order thinking tasks such as analysing, synthesising and evaluating, and students engage in Active Learning when they are carrying out something other than passive listening [24]. Active learning requires teachers to invest a certain amount of time prior to classroom instruction.

Harvard professor Eric Mazur founded Peer Instruction (PI) in 1991 and began to gradually promote this evidence-based, interactive approach to teaching and learning [25]. It is a student-centered approach that provides students with rich opportunities to learn from each other through collaborative classroom activities such as group discussions and projects [26]. Teachers and students are encouraged to learn interactively and provide immediate feedback on information [27]. The model is based on conceptual test questions, which is a method of teaching and learning that enables classroom teacher-student interaction and student-student interactive style. Students are engaged in the classroom through a variety of activities that require each student to apply the core concepts taught and later explain them to their peers [28]. The peer teaching method requires students to do pre-teaching before class, and during the formal class, the teacher will divide the classroom content into different parts based on the core concepts, which can be taught out of the order of the textbook, with a shorter classroom lecture, and conceptual test questions will be given to the students, and based on the feedback, the teacher will adopt the appropriate teaching methods. The pre-teaching portion of the PI is the Just-in-time- teaching (JiTT), and the main components of PI include group discussions and writing tasks [26]. Knowledge is built through peer interaction, not passively through lecturing students [29]. Flipped classrooms using Peer Instruction have a significant effect on critical thinking skills Kaviza [30] and Peer Instruction encourages critical thinking, conceptual understanding, and problem solving skills [31]. As more and more student-centred in-class engagement takes place, the teacher's lecture is no longer central, and teachers seek ways to engage students in increasingly Peer Instruction-like interactions outside the classroom [32].

3. Implementation Modes of the Flipped Classroom

The implementation modes of the flipped classroom have diverse characteristics, and researchers have proposed a variety of practice paths from different dimensions. Based on the integration and analysis of the literature, they can be summarized into the following six typical models.

3.1. Flipped Classroom Model Based on Online Video

The core feature of this model is to use online video as the knowledge carrier, and reconstruct the teaching process through 'independent learning before class + in-depth interaction in class' [33]. Teachers break down the course knowledge points into 5-15 minutes units, students complete the pre-study through the online platform, and the classroom time is used for higher-order cognitive activities such as case studies and problem solving, solving difficult problems, as well as applying and expanding the knowledge, so as to achieve the internalization of knowledge.

This model has had a positive impact, in the field of engineering education, where it has led to improved student performance in experimental groups Bhat, et al. [33] and in medical education, where anatomy courses have led to increased efficiency in classroom operations through video previews [8].

This model puts the initiative of learning more in the hands of students. Students can independently choose when and how many times to watch the videos according to their learning pace, study habits, and schedule. For the more difficult to understand content, they can pause and replay to ensure mastery of the basics, which meets the individual learning needs of different students. However, there are some limitations, some students have the problem of insufficient completion of pre-reading tasks, which is significantly associated with self-regulated learning ability [34]. If students lack self-regulation, they may not be able to complete the pre-class video learning tasks on time, resulting in failure to keep up

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with classroom learning. This requires teachers to strengthen the supervision and management of students' learning process, such as setting learning reminders and regularly checking learning progress.

The key to the implementation of this model is the need to follow the principle of 'segmented presentation + interactive embedding' Gómez-Tejedor, et al. [35] in the design of the course, and the need to set up a mechanism to monitor the pre-study, e.g. by embedding formative quizzes [36]. Teachers need to spend a lot of time and effort to design and produce high-quality instructional videos, prepare learning task sheets and class discussion materials. In addition, it is a test of teachers' energy and time management skills to pay attention to and give guidance to each group's discussion in class, and to provide timely feedback on students' learning after class.

3.2. Project-Driven Flipped Classroom Model

This model integrates PBL (Problem-Based Learning) with the flipped classroom to form a three-phase model of 'Knowledge Input-Project Practice-Results Presentation' [37]. For example, in a software engineering course, students learn algorithmic theory before class and spend class time developing real-world projects and receiving iterative instruction.

The results in real-world teaching and learning significantly improve complex problem solving skills, especially in engineering courses Lo and Hew [15] promote interdisciplinary skill integration, and in marketing courses, the commercial viability of the project outcomes is increased [38]. It is important to note that the complexity of the project needs to be matched to the cognitive level of the learners [37]. matching Gren [37] and also the use of a multidimensional assessment system including process assessment, peer-to-peer assessment and final defense [39].

Teachers need to design projects that are in line with the teaching objectives as well as being operable and interesting, taking into account the difficulty of the projects and the actual abilities of the students, which requires a high degree of professionalism and teaching experience on the part of the teachers. In group projects, the phenomenon of individual students 'free-riding' may occur, and problems such as poor communication and unreasonable division of labour within the group may also affect the progress and quality of the project. Teachers need to strengthen the management and guidance of group collaboration, and establish an effective incentive mechanism and evaluation mechanism to ensure that every student can actively participate in the project. As various problems may be encountered during the implementation of the project, it is difficult to control the progress of the project and time constraints may easily occur. Teachers need to reasonably arrange the teaching time to ensure the smooth progress of teaching tasks while ensuring the quality of project completion.

3.3. Hybrid Flipped Classroom Model

A blended architecture combining online asynchronous learning with offline synchronous activities Rasheed, et al. [40] with a typical configuration of online learning + discussion forum interaction, and offline group collaboration + teacher guidance. Blended learning strategies significantly reduce the amount of time students spend face-to-face with their teachers Ahmad, et al. [41] and one of the main findings is that in language teaching, the blended model leads to significant improvement in writing proficiency Abedi, et al. [42] there is a need to control the online and offline time ration with an optimal ratio of 1:1 [43]. The knowledge transfer session is done through online teaching resources, such as instructional videos and e-documents, for students to complete on their own before class. Classroom time is then used for knowledge internalization with activities such as group discussions, case studies, and project presentations to promote students' understanding and application of knowledge.

Hybrid flipped classroom teaching expands the boundaries of teaching resources and can fully integrate online and offline resources. Online there are massive digital resources, such as open classes of famous universities, videos of academic lectures in professional fields, etc. These resources enrich the teaching content and expose students to a wider range of knowledge. Offline, there are face-to-face guidance from teachers, paper materials in libraries and practical equipment in laboratories. Taking chemistry courses as an example, online students can watch professional chemistry experiment

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demonstration videos to understand the principles and steps of the experiments; offline hands-on operation in the laboratory combines theoretical knowledge with practice to deepen their understanding of chemistry knowledge. It meets the diversified learning needs of different students with different learning styles and rhythms. Blended learning gives students more choices. Visual learners can master knowledge by watching online videos, auditory learners can make use of online audio materials to assist their learning, and students who like to practice can give full play to their strengths in interactive classroom sessions. In English learning, some students are good at listening to English radio to improve their listening skills, while others prefer to read original English books to enhance their reading comprehension. Blended Learning meets these diversified needs and enhances the learning effect. Teaching flexibility has been strengthened. Teachers can flexibly adjust their teaching methods according to the teaching objectives and students' learning situation. For basic knowledge points, students can be arranged to learn independently online; for key difficulties, in-depth explanations and group discussions are conducted in class. For example, in the economics course, basic economic concepts can be studied online before class, and group discussions and analyses can be conducted in class for hot economic cases to cultivate students' analytical and application abilities, so that the teaching can be more in line with the actual situation of students.

3.4. Gamified Flipped Classroom Model

When designing the elements, a three-tier structure of game mechanics is integrated. On the surface level, mainly points, medals and leaderboards, on the middle level, task levels as well as role-playing, and on the deeper level, narrative context and emotional connection. In terms of implementation effects, in teacher training, gamification led to increased motivation to learn and knowledge retention [11].

In physics laboratory courses gamification design through virtual labs is effective in reducing operational error rates [35]. It is important to note that it is important to avoid excessive gamification leading to cognitive overload Parra-González, et al. [44] there is a need to balance competitive and cooperative mechanisms [45].

The game model stimulates learning. Games are naturally interesting and challenging, and can break the dullness of traditional teaching. Taking puzzle games as an example, knowledge is integrated into puzzles, and students will take the initiative to explore knowledge in order to solve the puzzles, changing from passive acceptance to active learning. This transformation can greatly stimulate students' curiosity and desire for knowledge, allowing students to start their learning journey in a relaxed and enjoyable atmosphere. Knowledge mastery can be enhanced, the game mode prompts students to apply knowledge in practice to solve problems and visualize abstract knowledge. In the competition game, students need to quickly mobilize the knowledge they have learned to answer and analyse, which not only deepens their understanding of knowledge, but also strengthens their memory. Through repeated use, knowledge is consolidated, and students' mastery of knowledge and ability to apply it will be significantly improved. Cultivate comprehensive ability enhancement, different types of games cultivate different comprehensive ability. Role-playing games exercise students' communication skills, adaptability and critical thinking. In the simulation scene, students need to communicate and interact according to the role settings, react to various emergencies, and at the same time think deeply and analyse the roles and situations they play. The group competition game focuses on cultivating teamwork ability and competitive awareness, where students divide the work in the team, work together for victory, and constantly surpass themselves in competition. Enhancing learning motivation, the reward mechanism in the game, such as points, grades, honours, etc., can give students immediate feedback and a sense of achievement. When students complete game tasks or achieve excellent results, the rewards they receive will motivate them to continue to study hard. This positive incentive can continuously enhance students' learning motivation, so that they can maintain a positive learning attitude and actively engage in learning.

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3.5. Discipline Differentiation Model

Differentiation of teaching is based on different types of disciplines, knowledge characteristics and flipping focus, with engineering paying attention to virtual simulation manipulation of procedural knowledge Hadgraft and Kolmos [46] in medicine, declarative knowledge and clinical case base building Chen and Reeves [47] and in languages, attention to skill-based knowledge and immersive conversational scenarios [48].

In science and technology subjects, such as physics and mathematics, the knowledge system is logical and more focused on principle derivation and experimental manipulation. Therefore, the teaching video of flipped classroom needs to clearly show the derivation process and experimental steps, and the classroom interaction can focus on solving complex theoretical and practical problems, and organizing students to conduct experimental design and analysis and discussion. Liberal arts disciplines, like literature and history, emphasise the understanding and perception of knowledge, critical thinking and the cultivation of expression ability. This requires online resources to provide rich reading materials and diversified viewpoints, and more activities such as group discussions and keynote speeches in the classroom to encourage students to express their opinions.

3.6. Intelligent Technology Support Model

AI applications are able to push personalized resources based on learning profiles with intelligent recommender systems Carstens, et al. [49] big data analytics can predict knowledge weaknesses in learning behavioral data Zheng, et al. [36] and spatial cognitive efficiency is enhanced by AR anatomical models through XR technology [8]. AI technology is able to accurately analyse students' learning characteristics and needs based on their past learning data, including learning progress, knowledge mastery, and question answering. With the help of machine learning algorithms, personalized learning resources can be tailored for each student. For example, for students with a weak foundation in mathematics, the AI system can push more videos explaining basic knowledge points, targeted practice questions and related tutorials; while for students with more learning capacity, it will provide extended learning content, such as analyses of mathematical competitions, and introductions of cutting-edge research results in mathematics. Through this personalized delivery, we can meet the learning needs of different students and improve the efficiency and effectiveness of independent learning. In the classroom interaction, AI technology can play a variety of auxiliary roles. On the one hand, the intelligent voice recognition system can record students‘ speeches in real time and convert them into text, which is convenient for teachers and students to review the discussion process, and also helps teachers to quickly understand the students’ viewpoints and thoughts. On the other hand, the AI intelligent question answering system can instantly evaluate and provide feedback on students' answers, point out the problems and provide suggestions for improvement. For example, in the language classroom, after students answer reading comprehension questions, the AI system can analyse and evaluate their answers in terms of accuracy, completeness, language expression, etc., and help students improve their question-answering skills. In addition, AI can also assist teachers in classroom management, by analysing students‘ classroom behavior data, such as the degree of attention, participation, etc., timely detection of students’ learning status problems, and provide reference for teachers to adjust teaching strategies. After class, the AI intelligent tutoring system can provide students with around-the-clock Q&A services. When students encounter problems during homework or revision, they only need to input their questions into the system, and the AI will be able to understand the questions with the help of natural language processing technology and extract relevant information from a huge knowledge base to provide students with detailed answers and guidance. At the same time, the AI can also automatically generate personalized revision plans and extended learning suggestions based on the student's learning situation. In terms of assessment, AI can comprehensively analyse students‘ learning data, including not only traditional indicators such as homework completion and test scores, but also behavioural data and engagement in the learning process, generating multi-dimensional learning reports to provide teachers with a comprehensive understanding of students’ learning, so that

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they can formulate more targeted teaching plans and counselling strategies. In flipped classrooms in higher education, smart technologies are playing a key role in reshaping the teaching mode and enhancing the learning experience. In the pre-course independent learning phase, AI-driven learning platforms accurately push personalized learning resources based on students' past learning data [50]. With pre-recorded videos, students can pause, review and reflect at will before class. For example, for students taking computer programming courses, the platform pushes targeted teaching videos, code samples and practice questions based on their mastery of different programming languages, which meets students' differentiated learning needs and improves the efficiency of independent learning.

Smart technology is equally indispensable for classroom interaction. Intelligent question-answering systems and real-time feedback tools allow teachers to quickly understand the degree of students' understanding of knowledge. Teachers release questions through tablets or intelligent teaching devices, students instantly answer, the system quickly counts the results and analyses the students‘ answer ideas, the teacher accordingly adjusts the pace of teaching, focusing on explaining the content of the students' general confusion. During group discussions, intelligent collaboration tools assist students to communicate efficiently, share documents in real time, collaborative editing, break the time and space limitations, promote the collision of ideas, and enhance the ability of teamwork.

After class, the intelligent tutoring system provides students with around-the-clock Q&A services. When students encounter problems during homework or revision, the intelligent tutoring system understands the problems with the help of natural language processing technology and provides detailed answers and guidance. In addition, big data analysis comprehensively evaluates students' learning performance, from learning progress, knowledge mastery to active participation in classroom interactions, and generates a multi-dimensional learning report, which provides data support for teachers to formulate personalized teaching strategies, realize tailored teaching, and help colleges and universities significantly improve the quality of flipped classroom teaching.

However, the smart technology divide is significant across institutions, with well-resourced institutions having much higher rates of technology use than the average school, and faculty technology acceptance being positively correlated with implementation effectiveness [2].

4. Research on the Effectiveness of the Flipped Classroom

The effectiveness of flipped classrooms in higher education has been widely studied. Carstens, et al. [49] found through empirical research that flipped classrooms can significantly improve students‘ academic performance and motivation, but there is a risk of distraction due to improper use of the technology. Zainuddin and Perera [13] study further showed that flipped classrooms can enhance students' 's self-directed learning and classroom engagement, but it requires more support and guidance from teachers. In addition, the flipped classroom puts new demands on teachers‘ roles. González-Zamar [2] pointed out that teachers need to change from knowledge transmitters to learning guides and facilitators in the flipped classroom, which puts higher demands on teachers' instructional design and classroom management skills.

In terms of student learning outcomes, flipped classrooms can significantly improve students' academic performance and motivation [15]. For example, a study by Martínez-Jiménez and Ruiz-Jiménez [51] found that flipped classrooms can significantly improve student satisfaction and learning performance. In addition, flipped classrooms were able to increase students' independent learning and classroom engagement. However, the effectiveness of the flipped classroom is also affected by students' self-directed learning skills and technological literacy. Students' knowledge acquisition is more solid. In the flipped classroom, students' knowledge learning process is more independent and deeper. Before the class, students initially learn the basic knowledge at their own pace with the help of teaching videos and rich electronic materials carefully prepared by teachers. In this process, students can flexibly adjust their learning progress according to their own understanding of knowledge, watch the content that is difficult to understand repeatedly or consult more information, so as to form a preliminary understanding of knowledge.

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Upon entering the classroom, teachers provide targeted explanations for students' queries arising from independent learning. At the same time, the organization of students to carry out group discussions, case studies, project practice and other activities. In the group discussion, students express their views, ideas collide with each other, from different perspectives to understand the knowledge; case study allows students to apply the abstract knowledge to practical situations, deepen the understanding of knowledge; project practice is to require students to comprehensively apply the knowledge they have learnt to solve complex practical problems. For example, in the mathematics course, students learn the basic concepts, properties and formulas of functions before class, and then work together in the classroom to solve all kinds of function application problems, such as using function models to solve economic problems, physical problems and so on. This learning mode of independent study, followed by in-depth investigation, so that students will be closely linked to the new knowledge and existing knowledge system, to build a more complete and solid knowledge framework, the degree of mastery of knowledge far exceeds the traditional teaching mode of rote memorization.

Students' learning ability is significantly improved. Flipped classroom will return the initiative of learning to the students, requiring students to arrange their own learning time, make learning plans, and complete the initial learning of knowledge on their own. In this process, students need to learn self-management, self-monitoring, and gradually develop good independent learning habits. From initially relying on teachers 'guidance to being able to independently plan their learning paths, students' independent learning ability has been greatly honed and improved. This ability not only helps students to achieve better results in their current course of study, but is also a key ability necessary for their future lifelong learning.

Interactive communication sessions in the classroom provide a broad space for the cultivation of students' critical thinking. In group discussions, classroom debates and other activities, students need to analyse and evaluate different views and insights, learn to question and reflect, and not blindly accept ready-made conclusions. For example, in the course of literature appreciation, students may have different understanding and interpretation of the same work. Through mutual communication and debate, students learn to examine the work from multiple angles, analyse the reasonableness and limitations of other people's viewpoints, so as to form their own unique insights, and enhance their critical thinking ability effectively.

Flipped classroom emphasises the use of knowledge to solve problems in practice. Whether it is a group project or an actual case study, students will face a variety of complex problem situations. In the process of problem solving, students need to apply what they have learnt, flexibly choose appropriate methods and strategies, and keep trying and exploring. For example, in the physics experiment course, students may encounter experimental results do not match the expected situation, at this time they need to analyse all aspects of the experimental process, find the root cause of the problem, and put forward solutions. This continuous problem-solving process not only improves students' problem-solving ability, but also stimulates their innovative thinking, prompts students to try to solve problems with new methods and new ideas, and develops innovative ability.

Under the traditional teaching mode, students are often in a passive state of accepting knowledge, the learning process is more boring, and learning enthusiasm is generally not high. The flipped classroom gives students more initiative, and students become the main body of learning. They can choose the learning content and learning mode according to their own interest and learning rhythm, and this sense of autonomy and participation greatly stimulates students' interest in learning.

Students have changed from the previous 'want me to learn' to 'I want to learn', and their attitude to learning has undergone a fundamental change. In the independent learning stage before class, students take the initiative to explore knowledge and their curiosity is fully mobilised; in the classroom, they actively participate in interactive exchanges, discuss problems with teachers and classmates, and enjoy the fun of learning. For example, in the history course, students gained a deeper understanding of historical events and figures through independent access to information and watching historical documentaries, no longer feeling that history is a boring heap of time and events, but full of stories and

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wisdom. This positive attitude towards learning provides a constant impetus to students' learning, making them more actively engaged in their studies and pursuing higher learning goals.

Teamwork ability is enhanced, and most of the classroom interaction sessions in the flipped classroom are carried out in the form of groups, such as group discussion and project cooperation. In group activities, students need to communicate closely with group members, reasonably divide the work and co-operate to complete the learning tasks together. In this process, students learn to listen to the opinions and suggestions of others, respect the ideas and views of others, and play to their respective strengths to achieve resource sharing and complementary advantages.

For example, in the group project of marketing course, students are responsible for market research, product positioning, marketing strategy development, marketing programmed implementation and other tasks. Students responsible for market research need to go deep into the market to collect data and information; students responsible for product positioning need to analyse the target customer groups and market positioning of the product according to the research results; students responsible for marketing strategy development need to combine the characteristics of the product and the market demand, and develop a practical marketing strategy. Through group collaboration, the students not only completed their learning tasks, but more importantly, cultivated the spirit of teamwork and improved their communication and teamwork skills, laying a solid foundation for their future participation in team work in the society.

The comprehensive quality of students develops in an all-round way, and the flipped classroom teaching model focuses not only on the cultivation of students' knowledge and abilities, but also on the development of students in terms of their emotional attitudes and values. In the process of independent learning and teamwork, students cultivate the spirit of independent thinking and exploration, and when facing difficulties and challenges, they are able to maintain a positive and optimistic mindset, endeavour to overcome difficulties, and enhance their self-confidence and sense of responsibility.

At the same time, in the communication and cooperation with others, students learn to respect and understand others, and improve their interpersonal skills and social adaptability. For example, in group discussions, students may encounter students with different views from their own, and through communication and negotiation, they learn to think from others‘ perspectives and understand others’ positions, thus promoting the harmonious development of interpersonal relationships. In addition, in project practice, students need to be responsible for the outcomes and impacts of the project, which develops their sense of responsibility and commitment. Through flipped classroom teaching, students develop comprehensively in many aspects, such as knowledge, ability and emotional attitude, and become innovative talents with comprehensive qualities.

To sum up, the flipped classroom teaching mode, with its unique teaching method, has achieved remarkable teaching effects in terms of knowledge mastery, learning ability enhancement, learning attitude change, teamwork ability cultivation and comprehensive quality development. With the continuous development of educational technology and the constant updating of educational concepts, the flipped classroom is expected to play a greater role in the field of education, and make greater contributions to the cultivation of high-quality talents to meet the needs of the times.

In terms of teachers‘ role transformation, the flipped classroom puts higher demands on teachers’ instructional design and classroom management skills [2]. The shift in the role of the teacher, from a teacher-centered to a student-centered approach to teaching and learning, can lead to problems of discomfort for some teachers, and a lack of subjective willingness to undergo training, which may interfere with their own teacher competencies. Teachers need to carefully design pre-course learning materials and classroom activities, as well as provide additional support and guidance. In addition, teachers need to be competent in the use of technology in order to cope with the technological challenges in the flipped classroom. Lecturers need to take into account that not all students are computer literate and therefore must provide appropriate resources for students who need extra help [52]. There are some organizations that do not support or value teachers for pedagogical innovation [27]. Teachers in higher education contexts may not have much training or experience in teaching

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[53]. The need for teachers to spend a lot of extra time preparing lessons and developing materials needed for the flipped classroom is a huge test of teacher competence.

5. Challenges and Factors Affecting the Flipped Classroom

Although the flipped classroom shows great potential in higher education, it still faces many challenges in its implementation. Firstly, students' self-directed learning ability and technological literacy are important factors affecting the effectiveness of the flipped classroom. Zainuddin and Perera [13] study found that some students have difficulties in adapting to the learning mode of the flipped classroom due to their lack of self-directed learning ability. Secondly, teachers' instructional design skills and technology application skills are also crucial for the successful implementation of flipped classroom [2]. In addition, the technical support and resource conditions of the school are also important factors affecting the implementation of the flipped classroom. Carstens, et al. [49] stated that insufficient technological resources may lead to a significant reduction in the effectiveness of the flipped classroom.

In terms of student factors, students' self-directed learning ability and technological literacy are important factors affecting the effectiveness of the flipped classroom [13]. Some students have difficulties in adapting to the learning mode of flipped classroom due to lack of independent learning ability [49]. In addition, students' technological literacy can affect the effectiveness of the flipped classroom. For example, some students may be unfamiliar with the use of online learning platforms, resulting in poor learning outcomes [34]. Students are passive in traditional teaching and some active student learning methods cannot be applied [54]. The most obvious disadvantage is that a uniform approach to teaching all students does not adequately cater for individual differences in student learning and the development of creativity, but the teaching process must constantly adapt to individual differences in student learning [2]. In a flipped classroom, students have more initiative, which may increase the pressure of time management for students, and it is a great challenge for them to be motivated enough to learn actively and to keep students focused in the classroom [55]. The biggest problem with active learning in the classroom is the length of class time [56]. Sometimes, students are reluctant to accept new methods [57]. Outside of the classroom a portion of students learn the course content but may have difficulty in completing assignments.

In a flipped classroom, there are physical differences between students, but the problem of too much difference in student groups cannot be directly solved [58]. The focus is on how to fully engage students in collaborative learning and address issues such as communication, rational division of labour, and disagreement. The ability of flipped classrooms to allow students to regulate their learning time at their own pace demonstrates that learning can become personalized [52]. In some cases, students have expressed distress, feeling uncomfortable being in a group with classmates they do not know, and feeling forced when participating in collaborative group learning [59].

In the flipped classroom, the learning process consists of three parts: before, during and after class, and finding a balance is a crucial issue. Problem counselling and in-depth inquiry to address the difficulties students encounter in the learning process are crucial and require an organic combination of the three teaching sessions before, during and after class, where students increase their understanding of key concepts before and during the class [60]. It is crucial to structure the content for extracurricular activities through careful scheduling, constructing new portfolios, orchestrating a new order of instructional management, and designing a reasonably ordered model of instructional activity design for the flipped classroom model [58]. It is important to encourage training and development of specialized knowledge adapted to the needs of the times [61].

To eliminate the formalization and mechanization of the flipped classroom, it is important to promote deeper learning, develop students' interests, hobbies, personalities , creative development, and higher-order thinking skills, which can have a positive impact on learning outcomes. Research has proven that flipped classrooms can improve student achievement [15]. Research on teaching strategies

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and implementation resources becomes necessary to enable students to properly integrate this learning method [51].

In terms of teacher factors, teachers' instructional design skills and ability to use technology are crucial for the successful implementation of the flipped classroom [2]. Teachers need to carefully design pre-course learning materials and classroom activities, as well as provide additional support and guidance [13]. In addition, teachers need to be competent in the use of technology to cope with the technological challenges in the flipped classroom [49].

In terms of school factors, the condition of technology support and resources in schools is also an important factor that affects the implementation of flipped classroom [49]. Inadequate technological resources may lead to a significant reduction in the effectiveness of the flipped classroom. For example, some schools may lack the necessary technical support, which leads to the ineffective implementation of the flipped classroom [34].

6. Directions for Future Research

Future research could further deepen the exploration of the flipped classroom in the following ways.

6.1. Differential Research on Disciplinary Applications

The need for and the effectiveness of implementing flipped classrooms may vary across disciplines. Chen and Reeves [47] suggest that future research should incorporate disciplinary characteristics to explore the effectiveness of flipped classroom applications in fields such as medicine and engineering.

In the study of disciplinary differentiation of the flipped classroom, different disciplines show unique adaptations. Science and engineering disciplines, such as physics, mathematics, computer science, etc., have a strict logical and systematic knowledge system, emphasising formula derivation, experimental operation and algorithm application. In the flipped classroom, the teaching video needs to focus on showing the complex derivation process, experimental steps and code writing ideas, so that students can clearly understand the basic knowledge before class. Classroom interaction can be focused on solving practical problems, organizing students to carry out experimental design, algorithm optimization and other practical activities to cultivate students' hands-on ability and logical thinking. For example, in the physics experiment course, students watch the video of experimental principles and operation specifications before class, conduct experiments in groups in class, analyse experimental data together and solve problems in the experiment.

Arts subjects, like literature, history and philosophy, place more emphasis on intellectual understanding, perception and the development of critical thinking. Online learning resources should provide rich reading materials, diversified academic views and cultural background information to help students broaden their knowledge. In the classroom, more activities such as group discussions, keynote speeches and case studies should be conducted to encourage students to express their opinions and develop their critical thinking and language skills. In literature courses, for example, students read literary works and related critical articles before class, and then have in-depth discussions in class on the themes, characterization and writing styles of the works, so as to enhance their understanding of literary works and their ability to appreciate them.

Business subjects, such as marketing and business administration, emphasise the combination of theory and practice, focusing on cultivating students' ability to solve practical business problems and decision-making skills. The teaching video of the flipped classroom can introduce a large number of real business cases, explaining the theoretical applications and analysis methods in the cases. In the classroom, students are organized to carry out practical activities such as business simulation and project planning, so that they can apply what they have learnt in the simulated business environment and enhance their teamwork and practical problem solving abilities. For example, in the marketing course, students learn market research, marketing strategy and other theoretical knowledge before class, and then work in groups in class to develop a marketing plan for a product and carry out

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simulated promotion, so as to deepen their understanding and application of knowledge through practice.

Through the research on the differentiation of different disciplines in the implementation of flipped classroom, teachers are able to optimize the teaching content and activity design according to the characteristics of the disciplines, better utilize the advantages of the flipped classroom, improve the quality of teaching and meet the learning needs of students of different disciplines.

6.2. Follow-Up Research on Long-Term Effects

Existing studies have mostly focused on the short-term effects of the flipped classroom, while fewer studies have been conducted on its long-term effects (e.g., on students' career development). Future research can assess the sustained effects of the flipped classroom through long-term tracking. If flipped classroom teaching is to be tracked in the long term, it can be done in the following ways. In terms of tracking indicators, in addition to focusing on students‘ academic performance, we should also focus on the changes in students’ learning attitudes, such as classroom participation and the number of active questions; the development of independent learning ability, including the time for independent learning, and the development and implementation of learning plans; and the ability of teamwork, such as the degree of contribution in the group project, and the frequency and effectiveness of communication with group members. In terms of tracking tools, smart technologies are fully utilised. Record students' learning trajectories with the help of a learning management system, such as data on the length of course video viewing, completion of online tests, and time of homework submission. Use online questionnaires to regularly collect students' satisfaction with flipped classroom teaching, difficulties encountered and suggestions for improvement. Meanwhile, the classroom observation tool is used to analyse teachers‘ teaching behaviour and students’ classroom performance. The tracking points vary for different teaching stages. In the pre-classroom stage, students' use of online learning resources is tracked, including the number of resource views and the number of repetitions, so as to judge the attractiveness and effectiveness of the resources. In the classroom, we observe the activity of group discussions, the quality of students' speeches, and the timeliness and effectiveness of the teacher's guidance. After class, continuous attention is paid to the quality of students' homework completion and problems encountered, as well as the frequency of use of the intelligent tutoring system and the effectiveness of problem solving. Through long-term and comprehensive tracking, we continuously optimize the flipped classroom teaching and improve the teaching effect.

6.3. Research on Optimization of Technology Support

With the development of AI and Big Data technologies, future research could explore how these technologies can be used to optimize the design and implementation of the flipped classroom [49]. To further optimize the technical support for flipped classrooms, the following key aspects can be addressed. In terms of hardware facilities, colleges and universities should invest more to ensure that the campus network is high-speed and stable to meet the needs of a large number of students learning online at the same time. Equipped with advanced intelligent teaching equipment, such as high-definition projectors and interactive whiteboards, to provide a good hardware foundation for classroom interaction. At the same time, guarantee the diversity and compatibility of devices on the students' side, whether they are computers, tablets or mobile phones, to access learning resources smoothly.

As for the software platform, we continue to optimize the learning management system to enhance its stability and ease of use. Enhance the data analysis function of the system, which not only counts the data of students' learning behaviours, but also digs deeper into the learning patterns and knowledge mastery behind the data, providing a more accurate basis for personalized teaching. Introducing intelligent teaching support software, such as automatic homework correction tools and intelligent lesson planning systems, to reduce teachers' workload and improve teaching efficiency.

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6.4. Teacher Training and Support

The successful implementation of the flipped classroom cannot be achieved without teacher support. Future research could explore how training can enhance teachers' instructional design and technology application skills [2]. The flipped classroom shifts the focus of the teacher to the student, and the learning process shifts from the teacher to the student, who is responsible for his or her own learning.

The curriculum must evolve to teach learners how to critically evaluate digital media [62]. The emergence of new pedagogical approaches, technologies and learning needs, along with changes in individual student circumstances, will continue to challenge the requirement for learning environments that provide appropriate learning facilities and support [63]. Continued in-depth research is essential, and it is important for teachers to base their practice on scientific evidence in order to find the most effective methods to inform teaching and learning [64].

7. Reach A Verdict

Flipped classroom as a student-centered teaching model Stenberg, et al. [65] an innovative teaching model, shows great potential in higher education. By reviewing the relevant literature in recent years, this paper summarizes the theoretical foundations of the flipped classroom, its implementation model, effectiveness studies and the challenges it faces. Research shows that flipped classroom can improve students' academic performance, motivation and classroom participation, but its implementation still faces challenges such as insufficient independent learning ability of students, difficulty in changing the role of teachers and insufficient technical support. The flipped classroom style does not take the place of the teacher; on the contrary, it enables teachers to work more closely with learners [66]. Future flipped classroom research should combine the characteristics of disciplines, explore the differentiated application of flipped classroom, and make use of emerging technologies to optimise its design and implementation. To deepen research and practice, the flipped classroom can play a greater role in higher education.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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