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Research on Application of Steam Teaching in Primary School Based on Gamification Task Orientation-Taking the Fifth Grade Campus Sandbox as An Example

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Abstract: Steam education integrates multiple disciplines for education and teaching. It is an educational concept and measure for international education to explore talent training in the 21st century. This paper uses the literature analysis method to sort out the current research status and hotspots of the current Steam class design and teaching application. It is also proposed to combine the strengths of gamification teaching, and to drive the project-driven and task-oriented design of the Steam lesson to be closer to the game, whether or not it contains modern technology. Combined with relevant theories, this paper attempts to construct a design model of steam teaching activity based on gamification task orientation, and describes the design and practice process of the successful case of the fifth grade primary school campus sand table. After the course, the questionnaire and interview method will be used to understand the teaching effect of the steam class. The results show that the teaching mode is effective in primary school classroom teaching, which can enhance students' enthusiasm for learning and provide a better learning experience. It is expected that the case in this study will provide a reference for steam education researchers in practical exploration.

Keywords: Steam education; gamification teaching; K-12 field; instructional design

1. Introduction

The training goal of “disciplinary literacy” in China's current steam education has limited its development to some extent. Many international researchers have advocated that core literacy and subject literacy are put into the same position, and carried out some experiments. On the other hand, the gamification education in recent years has faced serious problems of “fragmentation” and “hollowing” due to the lack of physical curriculum. The teaching methods of cultivating the core literacy advocated by gamification teaching, such as fun practice, exploration and innovation, provide a reference for the improvement of steam education. According to the above situation, this paper proposes a steam education model based on gamification task orientation. It shifts its educational goal orientation from a disciplined literacy to a comprehensive literacy that combines discipline and practical collaboration, from general problem-solving ability to creative problem-solving ability.

2. Research Background

2.1 Overview of Research on Steam Teaching Practice at Home and Abroad

STEM education is a national development strategy proposed by the United States to cope with future social challenges [1]. Because it is in line with the direction of education reform, countries around the world have introduced stem or steam education to varying degrees. This paper focuses on the design of classroom examples and teaching practice, and uses the literature analysis method to sort out the current research status and hotspots. The literature is mainly collected through domestic and foreign literature databases, such as CNKI database, Taiwan Huayi database, EBSCO, ERIC, etc. The time is from 2009 to 2019. Keywords include “steam lesson”, “steam class”, “steam practice”, "steam application" and so

on. After screening, 120 articles with higher correlation were obtained, and the keyword co-occurrence network map was drawn, as shown in Fig. 1.

According to Figure 1, the co-word network of the entire keyword is not completely dense, and the secondary nodes are more prominent. The network is centered on steam and stem education, and it is surrounded by relatively obvious secondary node centers such as project learning, curriculum design, self-learning, empirical research, 3D printing lessons, scratch, flipping classrooms, and interdisciplinary integration. There are also three-level nodes based on science, biology, physics, geography, innovative thinking, and case teaching. To a certain extent, this shows that the research on steam education has a certain breadth and depth. The research hotspot is based on the project design research of science, physics, chemistry and other disciplines. On the other hand, it is the curriculum development to train high-level steam ability.

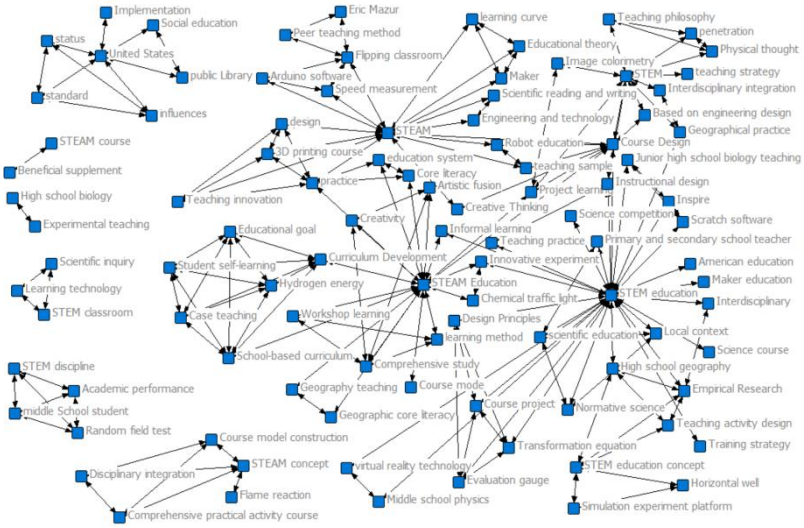

Figure 1. Keyword co-occurrence network diagram

2.2 The Origin of Gamification Teaching and the Integration with Steam Education

In ancient times, the relationship between education, life and games was close, but with the introduction of the class system in Comenius, education and games gradually became opposed [2]. Educational researchers are beginning to seek change. German educator Froebel suggests that early childhood education should be combined with games. Italian educator Montessori believes that games are a necessary stage for early childhood development, and American educator Dewey believes that games should be part of the school curriculum. To sort out the development of gamification education, we find that researchers all over the world agree that games are important in the development of children.

China's steam education is more dependent on a specific subject, and relatively more emphasis on the cultivation of subject quality, it is easy to fall into the trap of the surface steam education. Combined with the above literature analysis, we found that there is a broad application prospect is the task orientation of life and gamification, so the team proposed to design the task of the Steam lesson to be closer to the game, whether or not it contains modern technology. At the same time, combined with the theory of steam teaching design, build a steam teaching activity design pattern.

3. Steam Teaching Design Related Theory

There are three parts of the theoretical thoughts related to steam instructional design. One is the learning theory represented by the theory of generative learning and the theory of learning in practice. Generative learning theory means that learning is mainly influenced by existing knowledge and experience, rather than by external stimulus or reinforcement [3]. The active generation process is different from the simple storage information, which emphasizes the characteristics of the learning subject and cognitive strategies. The theory of learning in practice is the theory put forward by the educator Dewey on the basis of the ideas of “education is life” and “education is the transformation of experience” [4].

The second is the design theory of steam teaching activities based on project-based learning, group cooperative learning, and 6E teaching mode. Project-based learning provides students with the questions they need to solve in real situations, helping to understand science, technology, engineering, and mathematics [5]. Group-based collaborative learning is a mutual-assisted learning in which students have a clear division of labor in order to accomplish common tasks. The 6E learning model divides the STEAM teaching process into attraction, inquiry, interpretation, design, development and evaluation, focusing on integrating the engineering design process into classroom teaching [6]. The third is the idea of gamification teaching, which is very compatible with the characteristics of the mobile Internet, such as diversification, experience, fragmentation and so on. It can stimulate learning motivation, promote cognitive development, and develop high-level steam skills such as problem solving, collaborative learning, and creativity [7].

4. Construction of Steam Activity Design Pattern based on Gamification Task Orientation

The design model of steam teaching activity based on gamification task orientation is constructed by four aspects. The first aspect aims to cultivate a comprehensive quality that combines the discipline and practical cooperation. At present, the focus of the steam education reform in all countries falls on the core literacy. The early European Union proposed the eight literacy of lifelong learning, and the United States proposed the core skills of the 21st century, as shown in Figure 2 [8]. In 2016, China proposed six core literacy: responsibility, practical innovation, humanistic heritage, scientific spirit, learning to learn and healthy living. After the literature and field research, we decided to put the cultivation of basic subjects such as writing, reading and calculation into an important position in combination with the situation of local schools, and at the same time increase core literacy, such as induction, reflection and other learning literacy; classification, spatial imagination, Modeling and other abstract thinking; innovative creativity, etc. The second aspect is to design a reasonable fun game as a task-driven and analyze its rationality. For example, analyzing learners' learning foundations and requirements based on generative learning theory, analyzing specific subject knowledge and core literacy, determining learning objectives from the perspective of three-dimensional goals, and finally analyzing feasibility, such as whether learning space, resources, etc. are sufficient to support the completion of practice.

In the third aspect, the learning style is learned in the practice of group cooperation. First, design teaching context and specific module teaching knowledge in order to ensure each training goal, and then complete the learning bracket design, including designer activities, learning expectations and solutions. In the fourth aspect, the evaluation method is a dynamic evaluation of discussion sharing and creative problem solving orientation. Based on the above, a design pattern of steam teaching activity based on gamification task orientation is drawn, as shown in Figure 3.

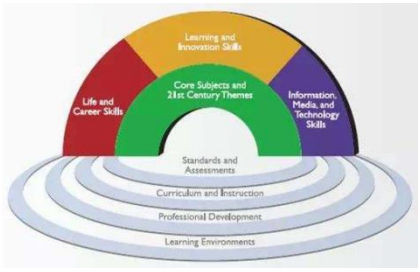

Figure 2. 21st Century Core Skills

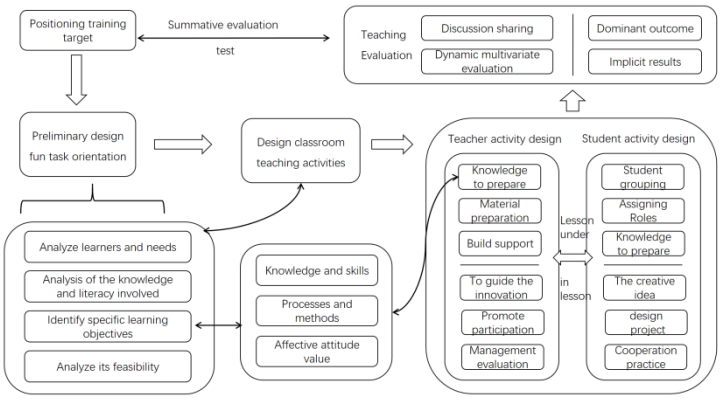

Figure 3. Pattern diagram

5. Steam Teaching Practice

5.1 Research Design and Teaching Process

Based on the established model, we designed four major themed steam classes—observing leaves, garbage sorting, origami art, and campus sandboxes. The course is about 2-3 class hours per week, and a theme class is completed in one month. The first round of practice took four months, targeting five fifth-grade classes in a city in Fujian Province, China. The second round of practice is in progress in Qingdao. The schedule is shown in Table 1. This article selects "Campus Sandbox" to elaborate.

The first lesson is observation and description. First of all, creating a game task situation leads to the theme of this section, inspiring interest and thinking about whether it can make a campus sand table for the alma mater, and then the teacher guides and emphasizes the importance of the project plan. Study the orientation description method through case study to test the learning effect. Finally, leave the after-school activities to draw a floor plan, and use the wrong floor plan to inspire and guide the importance of the ratio. The second lesson is measurement and calculation. First, use the case to explore new knowledge, and introduce the discussion of proportional calculation and application with maps. Then enter the group practice (steam course is based on the teacher's understanding of the classmates to divide the 5-6 heterogeneous study group), the teacher helps the students to divide the "work" of the teaching building, playground, etc., and measure the campus by means of step test. Then summarize and convert to model data.

The third lesson is a hands-on building. After the model data is compared, the construction starts. Each team member should be able to work with others to share work, exchange experience, help each other, evaluate, and solve various production and complex layout problems. Teachers can give advice and reference practices as appropriate. The fourth lesson is communication expansion. Each group displays the works of this group in turn, and evaluates each other whether the image is accurate and beautiful. And recommend students to share their own task list, reflect on defects, give advice. Finally, teachers use onion cells, planetary models, etc. to guide students to understand that from small to very large, modeling is an important idea and method.

Table 1 *schedule of steam experiment*

Phase	Time	Explore content
The first round	September to December 2018	Teaching design and implementation, teaching, activity design model feasibility verification.
The second round	March to June 2019	Model improvement and teaching case improvement.

The problem	Often	Sometimes	Never
1.Do you hope your group's campus sand table works can be exhibited in the class?			
2.In the process of sharing, do you want your works to be praised by your classmates and teachers?			
3.Do you want to be more dexterous?			
4.Do you think your ability to make works will improve if you practice hard?			
5.Do you try to make good work when other students are discouraged?			
6.Do you want to make your work more functional and creative because you want to be praised by the teacher?			
7.Do you work hard and want to be recognized?			
8.Do you want to get good comments in the production of campus sand table works?			
9.Do you want people to admire your work?			
10.Do you want to improve the level of the campus sand table works made by yourself?			
11.When you started making the campus sand table, did you think you could do it well?			
12.Can you overcome all kinds of difficulties in order to complete the work?			

Figure 4. Learning motivation questionnaire

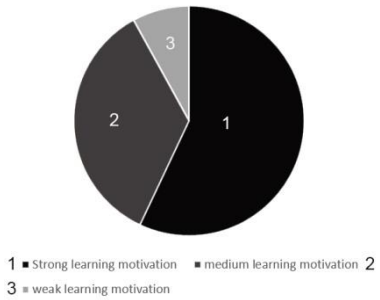

Figure 5. Learning motivation pie chart

5.2 Analysis of the Effect of Teaching Practice

5.2.1 Questionnaire Analysis of Learning Motivation

The Learning Motivation Scale was based on the revised learning motivation test conducted by Zhou BuCheng of East China Normal University in 1991. The modified subscale is shown in Figure 4. After completing the questionnaire online, 102 valid questionnaires were retrieved. The scale has good reliability and validity, and its half-correlation coefficient is 0.83-0.89, and the re-test correlation

coefficient is 0.79-0.86. Questionnaire options are never, sometimes, and often recorded as 1-3 points, so the total score is 12-36 points. The evaluation method below 21 points indicates that the learning motivation is weak, and the higher than 28 points indicates strong. Calculated to have a mean value of 28.1, that is, at a strong level of learning motivation, and draw a fan chart proportionally, as shown in Figure 5, it can be clearly seen that the gamification task drive basically makes the students have a more positive learning attitude, which is good for the steam course and the learning effect.

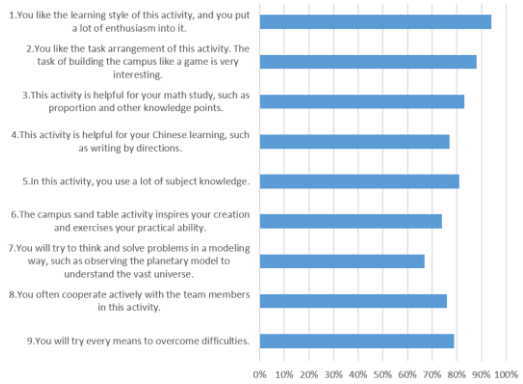

Figure 6. Learning situation summary graph

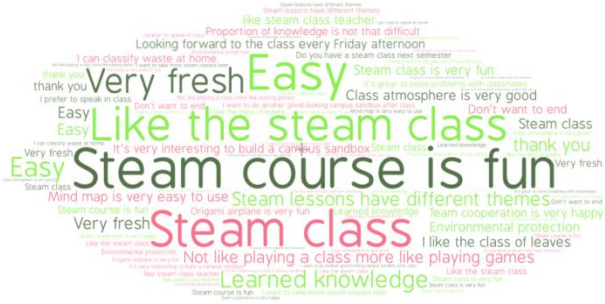

Figure 7. Keyword cloud

5.2.2 Questionnaire Analysis of Learning Situation

The team designed a questionnaire to investigate the student's steam course learning and results, using the Rickett scale to have a positive statement, from completely disagree to very agree with the five options, the score is 1-5 points. After testing, the reliability coefficient is 0.912>0.7, and the validity coefficient KMO 0.902>0.6, so the reliability and validity of the questionnaire is good. Count the percentage of the total number of people in each of the 121 valid questionnaires that reached 4 points and above, as shown in Figure 6. The proportion of consent for most topics reached 75%, indicating that students have a lot of experience and gains in the course, especially in terms of learning interest, participation, learning of subject knowledge, and ability to solve problems. The percentage of the two topics related to whether gamification task orientation can stimulate creative inspiration and develop modeling thinking is relatively low, but it is also close to 70%. It shows that this steam course has played a certain role in the above aspects, but because the cultivation of ability and literacy is a long-term process, it is difficult to show obvious effects in the case. In addition, we conducted interviews with students, and the results are shown in Figure 7, which is mutually validated with the results of the questionnaire.

Evaluators	N	Correlation coefficient	Sig
a&b	64	0. 855	0

Figure 8. Correlation coefficient

group	The design and production have certain innovation	to meet certain needs, solve practical problems	the structure of the work is reasonable and complete	with certain aesthetics	clear ideas, complete content, clear expression	concise and smooth	Reasonable and clear division of labor	Clever design and smooth operation	score
A1	8	7	8	7	6	7	8	7	58
A2	6	8	8	6	8	6	8	6	56
A3	6	7	6	6	7	7	7	6	52
B1	8	9	8	9	8	8	8	7	65
B2	7	7	8	6	6	5	7	5	51
C	10	9	9	9	9	7	6	8	67
D	8	10	9	9	10	8	5	8	67
E	9	10	9	8	8	9	7	7	67
On average	7.75	8.375	8.125	7.5	7.75	7.125	7	6.75	60.375

Figure 9. "Campus Sand Table" works score

5.2.3 Course Work Evaluation

The team invited two graduate students who participated in the steam project as scorers, including the final eight works. Each aspect that can be evaluated is up to 10 points. A paired sample T test was performed on the two sets of data to obtain Fig. 8. The probability value was less than 0.001 and the correlation coefficient was positive, indicating that significant correlation and evaluation were

effective. The average score is taken and rounded off as the final score, as shown in Figure 9. Overall, the team that finished the work scored higher, with an average score of 60 or more (total score of 80), indicating that the completion was good. However, the gap between the groups is large. In combination with the specific teaching situation, most of the groups of 5-6 people complete the work, while the C, D, and E groups are all the whole class to complete a teacher's centralized guidance and gather the whole class, so the score is relatively higher, especially in terms of the integrity, aesthetics and presentation of the work. However, after communicating with the teachers, it was found that there were individuals in the three classes who contributed less to the group's works, which needs to be improved.

6. Reflection and Summary

Both the evaluation of the work and the interviews between teachers and students have verified the effectiveness of the gamification task orientation, but the student base is different, and some hands-on and collaboration skills are not high, so the design needs to be improved. For example, the preparation work should be designed more fully. In addition, regarding the group study, the students took turns to be the team leader, the spokesperson, the disciplinary officer, etc., and basically completed the task. However, it is necessary to pay attention to the targeted, disciplined and underachievers of the group activities. In general, this study focuses on the design and implementation of the steam class case, proposes the advantages of combining gamification teaching, and constructs the design pattern of teaching activities. The "Sandpaper Sandbox" is taken as an example to analyze the implementation process and effect. This is a scientific practice inquiry, including the stages of participation, exploration, sharing, expansion and evaluation, and forms a classroom mode in which groups and classes share, communicate and question. The research results show that the students' interest and experience are good, the classroom teaching effect is obvious, and the cultivation of disciplines and core literacy has achieved initial results. However, there are still shortcomings in the research. For example, only through questionnaires, there is a lack of discussion on deeper cognitive rules. The sample size is small, and long-term verification is needed to promote the improvement of core literacy. In the future, we will continue to explore steam classroom teaching based on gamification task orientation, and hope to contribute to the development of steam education.

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