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Research on Innovation Capability Cultivation Oriented Design-Based Learning: Model and Case of Junior High School Information Technology Curriculum

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ABSTRACT [1]

The cultivation of innovative talents is an important development strategy in China. Especially in the stage of basic education, there is an urgent need for specific instructional strategies for cultivating innovative capability. Based on the theories of "Hands-On Inquiry learning" and Constructionism and teaching practice, this study put forward an innovation capability cultivation oriented design-based learning model in junior high school information technology curriculum. The model has three characteristics: simple teaching links, reverse teaching design and equal teacher-student relationship. It is hoped to provide guidance on teaching operation level for front-line information technology classroom teaching, or for other disciplines ' , and to provide a reference for international scholars to do the research about constructing instructional models for skill cultivation in the 21st century.

Keywords: Maker Education, Innovation Capability, Design-Based Learning Model, Junior High School, Information Technology Teaching.

1. INTRODUCTION

With the advent of the fourth industrial revolution driven by technologies such as big data and the Internet of Things, China's comprehensive national strength determines that it will play a crucial role in this wave. Innovation is the first driving force for technological development, but the cultivation of students' innovative capabilities have not been given due attention in China under the long-term examination-oriented education system. However, the current issue of young talent training is not limited to China. UNESCO, a global leader in education, published *Reimagining Our Futures Together* [1] in 2021, which mentioned secondary education rarely unleashes the precious potential of young people in a perspective of possibility. Therefore, the study aims to develop the teaching model for stimulating potential, especially innovative capabilities.

Maker education, as a new educational concept that encourages learners to make things by means of information technology, has entered the field of vision of educational technology researchers in China in 2014. The concept of maker education originated in the United States, which is the integration of maker movement and education [2]. In the 2014 Horizon Report on Basic Education, "Makerspaces" are considered to promote learning revolution in basic education [3]. Chinese experts and scholars indicated, maker education can achieve the goal, which is to train innovative young talents with innovative awareness, innovative thinking and innovative ability based on Chinese educational conditions.

From the perspective of the current teaching model oriented the cultivation of innovation capabilities, the construction of teaching models under the concept of maker education has become the mainstream of research in China. The researchers mainly use the literature research method and the quasi-experimental research method to construct the corresponding teaching models based on the relevant theories, and test them in the teaching practice. Most of them used the *Williams Creativity Tendency Scale* for pre- and post-tests, and a few used controlled experiments and self-made scales, combined with student works and interview results, to verify the effectiveness of the model in cultivating students' innovative ability. However, the teaching models of research design generally has problems such as long teaching links and single teaching ideas; and the data obtained through the results of a single group of pre- and post-tests cannot prove the superiority of the constructed teaching models. Even in the traditional teaching model, students' innovative capability can be improved to a certain extent. Some researchers under the self-made questionnaire did not test the reliability and validity of the questionnaire, so the rigor of the measurement tool is questionable. The design-based learning model that stands out and shows unique advantages in the cultivation of 21st century skills such as creativity and computational thinking can be used as the basic model for improving the teaching model.

In the next part, the research will be based on the concept of maker education, combined with *hands-on* inquiry learning and constructivism theory, to construct a design-based learning model for the cultivation of innovative capacities, and to test the teaching model through the results of teaching quasi-experiment in junior high school information technology classrooms in China. It will enrich the research on teaching models for the cultivation of innovative capacities, provide reference for the teaching practice of front-line teachers, and guide a feasible path for the cultivation of innovative talents in international basic education.

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2. QUASI-EXPERIMENTAL DESIGN

Test Subject

The teaching quasi-experiment selected two classes, Class 1 and Class 4, Grade 8, Q Middle School, District G, F City. The ratio of male to female students in each class was close to 1:1, and the total number of students was equal. Before the teaching practice, they were both taught by the same IT teacher. It is known that the students' learning foundations are not very different, and their knowledge and cognition levels are similar, so they are suitable as test objects. The study set the Grade 8 Class 1 as the experimental group, using the constructed teaching model to carry out teaching, and the Grade 8 Class 4 as the control group, using the traditional teaching model for teaching. The 3rd and 4th lessons are the teaching content. There is one lesson per week with 45 minutes of class time. The teaching tasks of each lesson are equivalent, so as to control irrelevant variables.

Experimental Tool

Based on the training objectives of innovation capacities and knowledge and skills, this research uses a self-made scale to design from two dimensions: innovation capacity and learning situation, which are used for post-test of teaching practice. Based on the interpretation of Zhang Baochen [4] and other scholars, the research believes that understanding the connotation of innovative capacity should start from the purpose of creating new things. Students must first have innovative ideas, that is, innovative awareness. Awareness drives students to think about problems. The process of thinking about problems is reflected in innovative thinking, and finally implementing ideas to achieve the creation of new things, that is, innovative behavior. That is to say, innovation capacity includes three sub-dimensions of innovation awareness, innovative thinking and innovative behavior. Innovation awareness mainly focuses on detecting students' awareness of seeking new and different ideas. Innovative thinking mainly examines its core thinking - divergent thinking. Innovative behavior mainly explores the willingness of students to put innovative ideas into practice. The students' learning detection mainly selects the mastery of the representative "imitation stamp tool" application skills and "filter" effect skills in the third and fourth lessons taught in the teaching practice process.

Experimental Procedure

The whole teaching quasi-experiment process is divided into four stages.

1) Current Situation Research and Theoretical Analysis, using the literature research method, through reading literature, understanding the research status and existing problems of the teaching models aiming at the cultivation of innovation capacities, analyzing the connotation and types of the design learning models from the theoretical level, and using them as the theoretical basis for model construction.
2) Teaching Model Construction, based on the previous research experience and deficiencies, combined with the current teaching status of information technology subjects in junior high schools, and constructing a design-based learning model for the cultivation of innovation capacities.
3) Implementation of the Teaching Quasi-Experiment, focusing on the teaching content of the junior high school information technology course, making instructional design with the constructed teaching model and the traditional teaching model, using them to carry out teaching practice in the experimental group and the control group, distributing the questionnaires after the teaching practice, and collecting the questionnaire data.
4) Application Effect Analysis, using SPSS software to organize and analyze the questionnaire data collected at the end of the experiment, comparing the innovation capabilities and learning situation of the experimental subjects in the control group and the experimental group through the independent sample T test, and drawing experimental conclusions to test the application effect of the model.

3. PATTERN BUILDING

Design-Based Learning

Design-based learning, abbreviated as DBL or LBD, refers to allowing learners to learn to acquire knowledge and skills in the design process. Design-based learning was first established by American scholar Doreen Nielsen, and has been continuously praised for its remarkable teaching effect applied to K12 education. Scholars define design-based learning mainly into the following three types. One is that design-based learning is similar to project-based learning, and both are based on a project to start learning and inquiry [5]; the other is to pay attention to the process of students' hands-on iterative design in teaching, emphasizing that there must be certain design achievements [6]; the third is to learn design as the goal, to cultivate students' design thinking and design ability [7]. Professor Wang Youmei of Wenzhou University pointed out that design-based learning can enable learners to experience a sense of design, engage in meaningful learning, participate in the iterative learning process, and produce the results of learning. The model can exercise learners' design thinking, critical thinking, innovation capacity, hands-on practice ability and practical problem-solving ability, etc.

Theoretical Basis

Inspired by the French *hands-on* inquiry learning program, this research follows the following three basic principles when constructing a design-based learning model. First, it is student-oriented, but the guiding role of teachers cannot be ignored. In the design process, students only need to participate in the parts that are strongly related to the learning objectives of the course, and teachers make corresponding teaching design preparations and learning resources assistance for students to complete the complete design works. The second is to attach importance to cultivating students' innovative capacities in the learning process. The completion of the design work should not be the main purpose, the important thing is the students' skill acquisition and spiritual cultivation in the design process. The third is to pay attention to the students' hand-brain combination in the teaching process, which can inspire students to think through observation, questioning, etc. , to give students ample practice time for students to carry out hands-on activities.

At the same time, based on the learning theory of constructivism, in the process of constructing a design-based learning, the author will firstly attach importance to the sharing of works in the teaching process, not only limited to the description and display of works, but also to guide students to describe and express the construction process, form ideas [8]. Secondly, in the complete teaching process, it is necessary to form an organic unity between the internalization and transfer of knowledge and the hands-on design of works through corresponding means [9]. Finally, pay attention to the stage of thinking formation, focus on the cultivation of innovative capacity mentioned in this article, refer to the four stages of preparation stage, gestation stage, clear stage and verification stage proposed by an American psychologist.

Information Technology Design-based Learning Model

Based on *hands-on* inquiry learning and constructivism theory, the author tries to construct information technology design-based learning with simplified teaching links, reversed teaching design and equal teacher-student relationship in junior high school information technology teaching. The basic learning process is shown in Figure 1 shows the process model.

Teacher Activities: Teachers, as designers of teaching links and helpers of student activities, play an important role in the teaching process.

1) As designers, teachers should follow the inverse nature of instructional design [10]. Firstly, according to the teaching content, design examples of works that students can realize after learning the content, and the works need to have practical significance, conform to the real situation, and can reflect a certain social value. For example, in the theme of building a 3D solid model, a keychain with the Chinese character "Fu" is designed as an example of the work, which not only covers a variety of different modeling commands, but also creates a situation close to life. Secondly, according to the knowledge and skills to be mastered, the work formation process is divided into 2~3 stages, unnecessary work production links are deleted, and the work examples are simplified according to the students' ability level. For example, in the lesson "Processing Graphic Design Materials", with the theme of school logo design, the two steps of forming a silhouette effect and synthesizing pictures can be used as the basis for the splitting of the work formation process. That is to take the breakthroughs in teaching difficult points as the basis for the decomposition of the work production steps, and design the number of activities according to the actual teaching needs. The activities range from simple to complex, from simple tasks to case imitation, and finally form personalized works. Then, simulate the difficulties that students may have in designing, and prepare learning tools that can solve students' difficulties in advance, such as task planners or process memos and other tools; look for resources that can stimulate students' inspiration and creativity, such as showing design topics related to the theme, preparing various design materials, or even opening the Internet to allow students to freely search for the resources they need when students are more self-conscious and self-control. Finally, optimize the details of each link, design evaluation criteria, and form a complete teaching design.
2) As helpers, teachers mainly play an organizational and auxiliary role in the teaching process. It is embodied in the following three aspects. First, at the beginning of the activities, create a vivid situation and describe the case to help students quickly understand the situation. It can be elicited by foreshadowing related questions, or interesting small videos that are close to students' lives. For example, making a small animation recording the whole process of making a work, accompanied by the popular Tik Tok music, to create a relaxed learning atmosphere, and at the same time to stimulate students' awareness of seeking novelties and differences. The second is to provide necessary resources support during the activities, carefully observe the difficulties or obstacles that students have in the production process, provide timely and corresponding guidance, and help students successfully complete the staged tasks. The third is to organize various links, especially the sharing and evaluation links in the activities, to choose more personalized student works are displayed, and students are guided to share their own design process and can conduct self-evaluation and other evaluations according to the evaluation standards. After the teaching, teachers can conduct teaching reflection in time to accumulate experience for the next instructional design.

Student Activities: Students, as the main body of the classroom, are the explorers, practitioners and reflectors of the whole design process. In the process of exploration, students should understand the created situation and the works to be produced, strengthen their understanding and construction of new concepts while observing the case, and complete the simple task designed by the teacher based on this, which is not necessarily concrete. In the process of practice, students should learn to use the resources provided by teachers or actively use the Internet to search for resources, and carry out practical production according to the guidance of teachers' activities. If there are difficulties in the process of practice, they can communicate and discuss with teachers or peers, refer to the information provided by teachers again, and then carry out practice test, exchange and discuss again, until the activity task is realized and the case imitation is completed. In the process of reflection, students follow the guidance of teachers to revise the technical problems existing in the works, integrate their own innovative ideas, share the works after improving them, reflect and improve after obtaining evaluations, until they form personalized works.

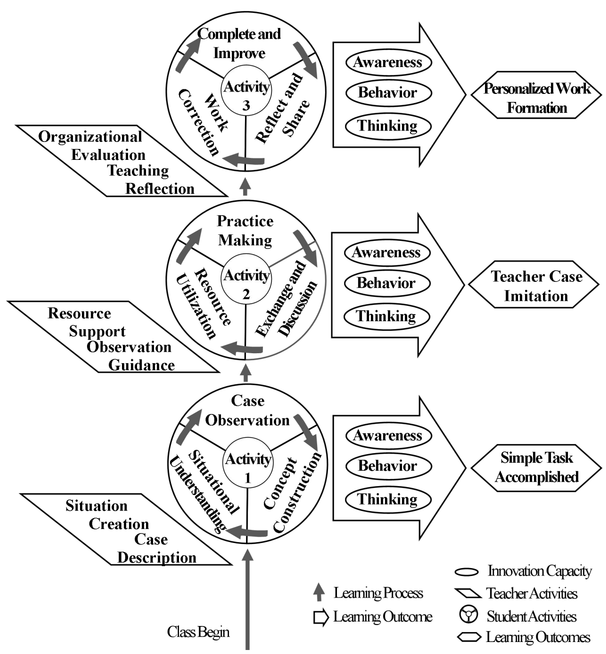

Figure 1.

Cultivation of Innovative Ability: As the main training goal, innovation capacity is distributed between "Student activities" and "Learning results". Teachers subtly guide students to generate innovative awareness by designing interesting teaching situations, practical work cases and changing teaching activities. Four stages of innovative thinking cultivation are covered in the three activities of student activities. The first activity is the preparatory stage to develop the knowledge and skills required for designing works, and the second activity is the gestation stage of subconsciously generating ideas in practical production. The third activity is the verification phase of improving the work through repeated revisions and reflections. Finally, the learning results generated in each activity are realized to form innovative behaviors. It can be seen that the innovative awareness, innovative thinking and innovative behavior that constitute the innovative capacity have been realized in this model.

4. TEACHING PRACTICE

In order to test the effectiveness of the design-based learning model for the cultivation of innovation capacity constructed above, the author carried out a one-month teaching practice research in Q Middle School, District G, F city. Due to the limited space of the article, the author takes the teaching of "Clipping Mask Command of Photo Shop Software" in Lesson 4 "Creating Special Effects of Graphic Design Materials" as an example to show the teaching cases designed based on the technology information design-based learning model, such as shown in Figure 2.

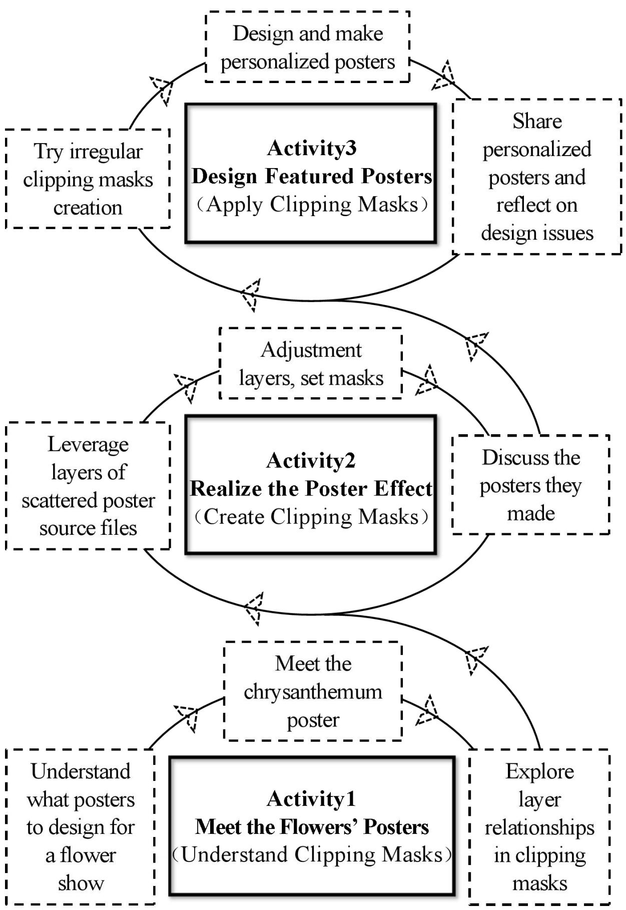

Figure 2.

The whole teaching process revolves around three activities. According to the school's teaching arrangement of once a week and 45 minutes of class time and the current situation that students' computer foundation is relatively weak, the activity process is designed as follows.

Activity 1 ***Meet the Flowers' Posters***: Learners participate in the flower exhibition poster design situation created by teachers, and think about the questions raised by teachers about chrysanthemum posters. From picture elements, to the number of layers, to layer effects, learners can Through observation, comparison, and repetition, gradually explore the layer relationship of clipping masks, and understand the principle and function of clipping masks. Through the learning of this activity, students can burst out innovative awareness from creative posters, learn innovative behaviors of observation and inquiry, and realize the concept construction of clipping masks in the process, paving the way for subsequent work design.

Activity 2 ***Realize the Poster Effect***: Learners use the scattered poster source file provided by the teacher, operate the demonstration process according to the teacher's brief clipping mask command of the poster, adjust the file layer, set the clipping mask, and expand the poster practice Production, actively communicate with peers and teachers to discuss difficulties encountered, obtain effective feedback, suggestions or help, practice production again, and then communicate again until a simple imitation of the case is achieved. Through this learning activity, students can not only consolidate the layer relationship and principle function of clipping masks, but also master the use of clipping masks in poster design, and subconsciously breed innovative ideas in the process of imitating the teacher's case.

Activity 3 ***Designing Featured Posters***: Learners find irregular-shaped materials in the learning resources provided by teachers, and create clipping masks of irregular shapes. During this process, learners apply the skills they have mastered and combine the teachers' cases to revise the work, incorporate its own innovative ideas, enhance the uniqueness of the work. After the work is completed, share the mental process of the work construction, receive comments from teachers and classmates, and continue to improve it. In this way, with the permission of the class, the final personalized work is formed. Through this learning activity, students learn to apply clipping masks to create posters with their own characteristics, implement and test innovative ideas, and finally realize the formation of innovative thinking, resulting in innovative behaviors of personalized work design.

5. VALIDATION AND RESULTS

After the teaching practice, the "Measurement Form after Teaching Practice" was distributed to the experimental group and the control group. The two classes received a total of 67 questionnaires, excluding 1 incomplete questionnaire and 2 invalid questionnaires, and obtained 64 valid questionnaires . In order to ensure that the questionnaire of this research can reflect the real situation of students' innovation ability and learning situation, the author tests the reliability and validity of the questionnaire. The research used Cronbach's alpha coefficient and split-half reliability to test the internal reliability of the scale in the questionnaire. The alpha value of the scale is 0.801, which is greater than 0.8, indicating that the reliability of the questionnaire is relatively good. Through the Bartlett test, the KMO value of the scale is 0.76, which is greater than 0.6, indicating that the questionnaire data is suitable for factor analysis; the significance value is 0.000, which is less than 0.05, and the questionnaire data is considered valid. Then, factor analysis was carried out on 8 factors by orthogonal rotation method. In the factor analysis mode, select principal component analysis, set the number of factors to be extracted to 4, and extract common factors. The four factors in the factor matrix behind the revolving axis correspond to innovative awareness, innovative thinking, skills and innovative behavior, and each factor contains two variables. It is proved that the scale has good structural reliability and is suitable for data analysis.

Innovation Capacity

In order to explore the differences in the innovation capacity of the experimental group and the control group after teaching practice, this study converted the metric of "class" into numerical values, 1 corresponds to "Grade 8 Class 1", 2 corresponds to "Grade 8 Class 4", and the independent sample T-test is used to obtain Figure 3.

Test variables	Grade 8 Class 1 （n=34）	Grade 8 Class 4 （n=30）	t	P
	Mean ± Standard Deviation			
Innovation Awareness	6.9118±.75348	6.2000±1.37465	2.521	0.015
Innovative Thinking	5.2353±1.07475	3.3333±1.49328	5.897	0.000
Innovative Behavior	6.4118±1.15778	5.1000±1.44676	4.025	0.000

Figure 3.

From Figure 3, we can see that the p-values of "Innovative Awareness", "Innovative Thinking" and "Innovative Behavior" are all less than 0.05, indicating that there is a significant difference between Class 1 and Class 4 in There is a significant difference in the development of innovation ability between Class 1 and Class 4.

Based on the means of the statistics in Figure 3, two decimal places were retained to create a cluster bar graph (see Figure 4) to compare the high and low innovation ability of Class 1 and Class 4.

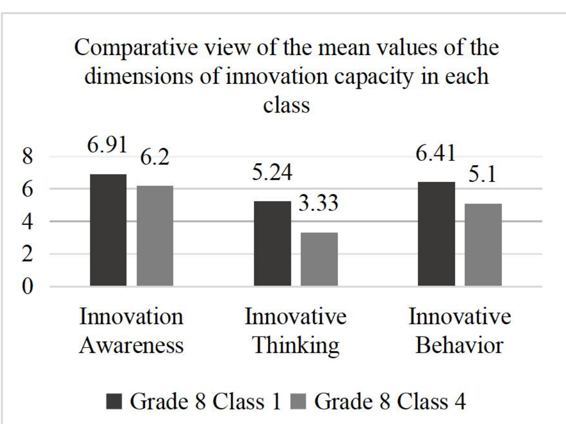

Figure 4.

As shown in Figure 4, the mean values of all dimensions of "Innovative Capacity" of Class 1 are higher than those of Class 4, which means that the innovative capacity of Class 1 is higher than that of Class 4. From the difference of the mean values, the largest dimension is "Innovative Thinking", followed by "Innovative Behavior" and finally "Innovative Awareness", which indicates that the teaching model constructed in this study can significantly This indicates that the teaching model constructed in this study can significantly cultivate students' innovative ability, especially innovative thinking. In terms of the mean value, the mean value of all dimensions in Class 1 reached above 5, while the mean value of "Innovative Thinking" in Class 1 under the traditional teaching model was below 4, indicating that the traditional teaching model did not significantly cultivate students' innovative thinking, and might even hinder the development of students' innovative thinking. The mean value of "Innovative Awareness", which has the smallest difference between the two classes and the largest mean value in each class, is above 6, indicating that the innovative awareness of both classes is high, and the traditional teaching model can effectively cultivate students' innovative awareness, but it also reflects the drawback that the traditional teaching model only cultivates awareness but not forms thinking and implements behavior.

Learning Situation

In order to investigate the differences about learning situation between the experimental group and the control group after the teaching practice, an independent sample T-test is used to obtain Figure 5 in the "Skills" dimension.

Test variables	Grade 8 Class 1 （n=34）	Grade 8 Class 4 （n=30）	t	P
	Mean ± standard deviation			
Skills	7.3235±1.03633	6.3333±1.37297	3.279	0.002

Figure 5.

As we can see from Figure 5, the p-value of the "Skills" dimension is less than 0.05, which means that there is a significant difference between Class 1 and Class 4 in terms of the degree of skills mastery. In terms of the mean value, both of them are above 6, which means that both the traditional teaching model and the model constructed by the study can achieve the goal of students' knowledge and skills development, which is consistent with the objective facts. It shows that the technology information design-based learning model can also promote students' knowledge and skills mastery, and bring better teaching effects than the traditional teaching model.

6. FUTHER WORK

In the future research, we hope to overcome the problem of short teaching practice time, carry out multiple rounds of action research and test in different types of schools; to ensure the rigor of the conclusion, the experiment should be pre-tested; meanwhile, the dimensions of both innovation awareness and innovative thinking will continue to be developed in depth in the design of the questionnaire to test the effectiveness of the teaching model, so as to improve and optimize the current teaching model. Furthermore, we can build the teaching models of innovation capabilities cultivation in other subjects based on the construction approach of teaching model oriented design-based learning by drawing inferences from one another. Other 21st century skills can also be developed in design-based learning, where researchers can further design teaching models for them.

7. CONCLUSIONS

Based on the *hands-on* inquiry learning and constructionism theory, this study, combined with the current situation of junior high school IT teaching, constructs a design-based learning model for the cultivation of innovation capabilities, solving the problems of lengthy teaching links and single-mindedness in the teaching model designed by the previous authors, and forming a new teaching model with concise teaching links, reverse teaching design, and equal teacher-student relationship. The research adopts the quasi-experimental research method, designs teaching cases based on this model, conducts comparative experiments in teaching practice, and makes post-measurement tables to verify the significant advantages of this model in the cultivation of innovation capabilities and the improvement of knowledge and skills compared with the traditional teaching model.

In view of the way of discipline allocation in China, the subject of information technology is firstly selected for research. For western countries such as the United States, subject classification is different, but the development of design-based learning model in all disciplines have the same research ideas. China's experience shows that design-based learning model can effectively integrate disciplines and promote the cultivation of students' innovation capabilities. With regard to other countries, the same idea can be used to study the improvement and upgrading of design-based learning model that integrates specific disciplines and orients 21st century skills.

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