Integrating Design Thinking into STEAM Education
The Design of STEAM Education Platform and Course Based on Creativity Elements

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The fast development of artificial intelligence in modern society facilitates the needs of creative education. Design thinking, an innovative thinking frame, is beneficial to cultivate children’s creativity. However, little research has clearly explained how to use design thinking to improve creativity. Therefore, this study aimed at integrating creativity and design thinking into STEAM education (Science, Technology, Engineering, Art and Mathematics), and thereby cultivate students’ problem solving and creative ability. Firstly, 151 school-age children participated in the study and finished the creativity tests. Second, dimensions of creativity (e.g., adventure, curiosity, and flexibility) that were significantly related to academic performance were abstracted as core design elements of the education platform. Third, the STEAM education platform model and curriculum design model were established based on the core design elements abstracted and design thinking. These models contribute to scientific ways of designing a STEAM education curriculum and platform aiming at improving school-age children’s ability of creativity. With the STEAM education platform, students’ practical and problem-solving ability were expected to be improved.

Keywords: design thinking; STEAM education; creativity; education platform; design research

Introduction
The rapid development of Internet technology prompts us live in the world of artificial intelligence, with increasing demand of high-level creative talent. Therefore, creativity education is required to cultivate creative talent. STEAM educational idea, formed by the interdisciplinary integration of Science, Technology, Engineering, Art and Mathematics, focuses on cultivating students’ innovative consciousness and ability (Chang & Zhang, 2018). Oriented towards developing students’ problem-solving abilities, STEAM education is beneficial for students’ creative problem-solving ability. STEAM teaching idea has been applied in the curriculum of primary and secondary schools.

With the development of 5G technology and the spread of global Covid-19 epidemic, online education is steadily recognized by students and parents. However, little research about the design of STEAM online platform exists currently. This article aims to combine the creativity with design thinking to form a design model in the interactive design of education platforms. The research not only helps the spread of STEAM innovative education, but also exercises students’ problem-solving skills while providing an evaluation method for curriculum as well.

In the following sections, we start by discussing the related conceptions of creativity and design thinking in general, followed by discussion of applying creativity dimensions in integrating design thinking into STEAM education, as a model of thinking, through creativity elements not only build an education platform model, but also construct a curriculum design model.
Literature review

Creativity Definition
In the 1950s, psychologist Guilford firstly proposed the concept of creativity. For a narrow definition, Creativity represents the most prominent ability of a creative person, because whether a person can produce creativity depends on his own motivation and temperament characteristics, creativity belongs to a creative personality with personal characteristics from personal perspective (Gulford, 1950). The definition of creativity is not only limited to creative personality. Creative thinking also belongs to creativity research. As a cognitive activity, creative thinking is responsible for producing innovative and practical products (John & Zhou, 1993). Both the creative personality and creative thinking that represent creativity can be measured by behavioral questionnaires in the psychology field. Creativity training is based on creative learning. Academic performance is often used as an important indicator to measure the effect of students’ learning (Wei, 2014). Recent research applied theories of creativity in education design, and it analyzed uses of creativity theory in lessons and projects (Kaplan, 2019). Another article pointed out that more theorists no more focus on dynamic process of creativity but are interested elements of creativity (Mehta & Dahl, 2019).

The Relationship Between Creativity and Academic Performance
Affected by the trend that China encourages the cultivation of creativity, the relationship between creativity and study also aroused attention from some scholars. Some studies took high school students as the test group. These results show the significant positive correlation between learning self-efficacy and academic performance. There is significant difference in the creativity adventure and imagination among students with different self-efficacy. It has been found that adolescents’ creativity adventure, curiosity and imagination levels are significantly correlated with academic performance (Yang et al., 2013). Although these studies were tested in different age groups, they all proved that the dimension of creativity is significantly related to academic performance and learning efficacy. Some researchers used elementary school students as main group and found a significant positive correlation between learning self-efficacy and academic performance (Song, 2019). Some other research also showed that learning efficacy can significantly predict academic performance (Wen, 2016). The above research suggests that a close relationship between learning self-efficacy and academic performance. Hence, the research can be used as a relevant indicator of learning to measure the relationship between creativity and learning. There is a view that intelligence has a greater impact on academic performance than creativity (Wu, 1988), so intelligence should be used as a controlling factor. The core ideology of STEAM education is to cultivate creativity competence, STEAM education also has impact on students’ academic performance.

Creativity and Design Thinking
The researcher pointed out that cultivating creative thinking is considered to be one of the core abilities of future-focused learning and as creativity also includes creative thinking, Conversational Task Models and Visual Representation Task Models were proposed for cultivating creative thinking. Methods of incorporating creativity into learning assessment also was discussed (Rosen et al., 2020). Recently, researcher found that design thinking can promote creativity. The experiment conducted a 3-day training course called Design For Change for 255 middle school students, and conducted divergent thinking tasks and self-confidence tests before and after the training. The final results indicate that Design thinking has significantly improved the fluency and descriptiveness of creativity, and also enhanced the self-confidence of students, but the flexibility and originality of creativity were on average lower than those of the control group (Rao et al., 2021). The above research shows that employing the quantitative method to study design thinking how to applied in education has become a new trend and direction. In fact, Liedtka pointed out that design thinking as a new social technology, many researchers had ignored the potential of design thinking can improve creativity (Liedtka, 2018).

STEAM Education and Design Thinking Applied to Creativity Training
Both STEAM education and design thinking are models of interdisciplinary cooperation and problem-solving, which can promote economic innovation and facilitate the cultivation of skills and entrepreneurship in the 21st century (Jagodzinski, 2012; Kalin, 2019). STEAM education first emerged in the United States. It was originally produced to meet students’ needs of scientific interest training and scientific skills learning. With years of development, STEAM education has become more popular among K-12 schools in the United States. Scholars proposed the diversified education model, believing that the purpose of STEAM education is to integrate
common skills. These common skills include learning empathy and interdisciplinary learning, the skills that can propose creative solutions to problems, and encourage students to do a new attempt (Perignat & Katz, 2019). Chinese researchers divided STEAM education into project completion-oriented learning forms and problem-solving-oriented learning forms by the STEAM education learning form (Yang et al., 2020). In recent years, the content of STEAM courses is apt to programming. Other countries integrate art design and programming into STEAM education. For example, elementary school students accomplish logo design by applying graphic programming while integrating multidisciplinary content during the whole process (Park, 2016).

The Design Thinking model usually includes five processes: empathy, problem definition, conception, prototyping, and testing (Ambrose & Harris, 2010). Based on project-based learning, Design thinking focuses on innovating or solving problems (Henriksen, 2017). STEAM education and Design Thinking may expand the boundary of subject area and create a hybrid way to understand and represent knowledge. STEAM and design thinking’s most argument is that they have cultivated the vital creativity, financial ability, innovation and entrepreneurial spirit in the 21st century (Allina, 2018; Costantino, 2018). The combination of design thinking and STEAM education already has practical application. A teacher from Arizona State University instructed her normal graduate students and design an interdisciplinary STEAM project. She explained how design thinking guides pedagogical STEAM course design and integrate it into the STEAM course’s various elements to design more interdisciplinary and innovative courses (Henriksen, 2017). The design thinking model is appropriate for STEAM courses design refer to the design thinking process at present.

Above all, creativity ability has a significant relationship with students’ academic performance, and STEAM education plays an essential role in improving creativity ability. Therefore, many people use STEAM courses to improve people’s innovation ability and comprehensively improve students’ learning effect. However, creative ability is complicated. Previous studies have not clearly stated which dimensions have effectively improved the overall performance of students. Therefore, the past innovative curriculum platforms lacked pertinence. The present study focuses on those dimensions of innovation that enhance learning, and then design the platform based on these extracted factors.

The previous research has some problems as follow:

- Failed to propose indicators that can estimate the effect of innovation education combine with design thinking.
- Lack of mature and Innovative methodology to apply design thinking into STEAM education well, rare design practice of integrating design thinking into digital education platforms.

To tackle these voids, this paper adopts quantitative analysis methods to build design model for exploring the better application of design thinking into STEAM education. In the research, creativity is proposed as a quantitative indicator to measure the effect of STEAM education platform, and creativity elements as well as are applied in construction to generate two design models. These models propose good strategies and innovative ideas for the application of design thinking in the platform of STEAM education.

**Method**

This research used behavior questionnaires to obtain the elements of creativity related to academic achievements and combined them with design thinking to construct a complete interaction design model of the STEAM education platform. There is the whole methodology flow is shown in Figure 1.

**Participants**

The sample of the behavior questionnaire was 151 students aged between 10 and 12 from a school in Shenzhen, China, among whom 93 were boys and 58 were girls.
Measures

Raven’s Standard Progressive Matrices (R. SPM) was accomplished by Raven in 1938. The Chinese city edition of the matrices, revised by Houcan Zhang, was one of the evaluation tools used in this research to meet the need of the group test for measuring intelligence (Zhang, 1989). The R.SPM has 60 multiple choices, divided into five groups from A to E, which means 12 questions for each group. The difficulty of each group increases by groups’ labels. Participants who answer correctly will get the corresponding score. Next, the raw score of participants converts to a standardized score according to participants’ age. The standardized score considers an intelligence score, which acts as the control variable in statistical analysis.

The Creativity assessment packet (CAP) (Williams, 1980) used for measuring creativity personality tendency was compiled by American psychologist Williams. The Mandarin edition of the CAP was employed for the current study. This test is unmistakable for its standard scoring rules, and it is suitable for group test which aged from 10 to 18. Williams Creativity Propensity Inventory contains 50 questions corresponding to 4 dimensions, including imagination, curiosity, risk-taking, and complexity. The Williams test scoring rules utilize 3-point scoring (Liu et al., 2011) and finally get the total score of creative personality and the score of each dimension, representing the level of creativity personality. A higher score represents higher creativity level.

Academic self-efficacy scale (ASRS) established by Liang and Deng (2018) can be used to measure students’ learning self-efficiency, have good reliability and validity test, and be widely used in China to measure self-efficiency in learning (Liang & Deng, 2018). The questionnaire consists of 22 questions for two dimensions: self-efficacy dimension of learning ability and learning behavior self-efficacy. Each dimension takes 11
questions. The questionnaire uses 5-point scoring, and the total score of 22 questions becomes the final score of the test. A higher final score represents higher academic self-efficacy, while a lower score means academic self-efficacy is relatively low.

Torrance Creative Thinking Test (TTCT) was improved by Torrance based on Guilford’s divergent thinking test and applies to many people, including the range in age from kindergarten to graduate school (Kim, 2010). The test should respond to the given language. The test offers the result from fluency, originality, and flexibility. TTCT is divided into language test and graph test, corresponding to linguistic creativity and graphic creativity. In this study, product improvement questionnaire A in language test was selected for the test. The scoring criteria for language task would be used grading and obtain the score for three dimensions of creativity and the total score.

Procedure
The test acquired permission from the school authority, students’ parents and teachers, them all had signed the informed consent. Students filled in the personal document and finished the Raven’s Standard Progressive Matrices in front of computer, which took about 40 minutes. Then they continued completed the Williams Creativity Propensity Inventory, Academic self-efficacy scale, and Torrance Creative Thinking Test, submitted the questionnaire immediately after completion. Supervisors need to confirm the submission is successful. Computers automatically measured the information from the questionnaire and supervisors checked the relative information to ensure the completeness of participants’ information.

Scoring
The behavior questionnaires received 151 pieces, and one researcher processed all the questionnaires’ data with standardized coding to avoid errors caused by the tester’s inconsistent coding. The questionnaire requiring subjective rating was scored jointly by two researchers, and then calculated the average score of two researchers as the final total score of the subjects. The co-completion of the grade had higher reliability than individual grading. The reliability of this research is between 0.574 to 0.774.

All the tests during this research were completed by online questionnaire. Participants completed the questionnaire in the computer classroom, and researchers downloaded the original data from the online questionnaire website. In the beginning, researchers made the data reduction through Excel and calculated the total score by procession the data into SPSS.19 software. Based on the research problem of the relationship between creativity and study, correlation analysis was conducted first and then proceeded regression analysis and extracted the design elements related to creativity.

Result

The Facilitating Effect of Different Creativity Dimensions on Academic Performance
The creativity in this paper included seven dimensions: curiosity, risk-taking, imagination, challenging, fluency, flexibility and originality belongs to creative thinking. To explore the relationship between different dimensions of creativity learning self-efficacy, and academic achievements, study put these variables in SPSS software to do correlation analysis.

Table 1 provided the score of risk-taking, and curiosity in creative personality was significantly related to learning self-efficacy and academic achievement, while the score of flexibility in creative thinking was notably related to learning self-efficacy and academic achievements.

In order to explore how does the degree of creativity dimension affects learning efficacy and academic achievements, risk-taking, curiosity and flexibility were taken as independent variables, while learning self-efficacy was taken as dependent variables, and the students’ age, gender and intelligence scores were taken as control variables. The software SPSS.19 was used for linear multiple regression analysis.

Under the condition of controlling variables such as age, gender, intelligence etc., the risk-taking and curiosity of creativity still present positively predict learning self-efficacy. The result Table 2 shown the regression analysis result indicated that higher proportion of adventurous and curious in the creative personality led to stronger perceived academic self-efficacy. What is more, the learning efficacy also influenced the study.
Table 1. Correlation Analysis Result of Creativity Dimensions

| Creative variables                  | M     | SD    | Learning self-efficacy | Academic achievements |
|------------------------------------|-------|-------|-------------------------|-----------------------|
| Total score of creative personality| 112.774 | 12.274 | 0.599**                 | 0.175*                |
| Imagination                        | 27.815 | 4.240 | 0.424**                 | 0.077                 |
| Risk-taking                        | 24.205 | 3.297 | 0.537**                 | 0.169*                |
| Curiosity                          | 33.007 | 4.265 | 0.553**                 | 0.181*                |
| Complexity                         | 27.748 | 3.114 | 0.456**                 | 0.156                 |
| Total score of creative thinking   | 8.298  | 4.541 | 0.197*                  | 0.244**               |
| Fluency                            | 4.447  | 2.742 | 0.151                   | 0.193*                |
| Flexibility                        | 3.090  | 1.626 | 0.233**                 | 0.274*                |
| Originality                        | 0.765  | 0.780 | 0.131                   | 0.169*                |

Note. N=151, *p < .05(two-tailed); **p < .01(two-tailed); *** p < .001(two-tailed)

According to the features of risk-taking dimension in creativity, the result indicated that people who have strong creative risk-taking traits are willing to face to failures or criticisms, attempt difficult things and believe in themselves. By doing so they would have a sense of achievement. This may affect their sense of self-efficacy. In addition, they believe in their ability. Even in the face of learning difficulties, tasks can be completed by them. This is just in line with the self-efficacy dimension in learning ability.

Table 2. Regression Analysis Result of Creativity Level in Predicting Learning Self-efficacy

| Independent variables | R²    | △R²  | B     | SE    | Beta   | F     | P     |
|-----------------------|-------|------|-------|-------|--------|-------|-------|
| Age                   | 0.410 | 0.386| -6.509| 2.845 | -0.149 | -2.288| 0.024*|
| Gender                | -1.620| 2.007| -0.055| 0.807 | 0.421  |       |       |
| Intelligence          | 0.050 | 0.037| 0.089 | 1.338 | 0.183  |       |       |
| Curiosity             | 1.153 | 0.294| 0.333 | 3.917 | 0.000**|       |       |
| Risk-taking           | 1.382 | 0.372| 0.308 | 3.710 | 0.000**|       |       |
| Flexibility           | 0.720 | 0.633| 0.079 | 1.138 | 0.257  |       |       |

Note. N=151, *p < .05(two-tailed); **p < .01(two-tailed); *** p < .001(two-tailed)

According to the features of the dimension of creativity curiosity, the result reflected that people with strong personality traits of creativity curiosity are always inquisitive, curious about things. What is more, they are keen on exploring things and willing to think thoroughly about things, and they may have a lot of ideas and are eager to achieve goals. Altogether, this is in line with self-efficacy of learning behavior in learning efficacy. They can make appropriate learning plans and then achieve those goals.

Then, academic achievements were taken as dependent variables, and the multiple linear regression analysis was carried out by software SPSS.19.

Under the condition of controlling variables such as age, gender, intelligence etc., creativity flexibility was still significantly positive in predicting academic performance, which indicated that the better the performance of creativity flexibility, the better the academic performance could be. Flexibility usually meant that one may possess lots of ideas while facing a single object. The result Table 3 shows the regression analysis result indicated that students with variable ideas and flexible thinking were usually more likely to achieve better results in learning.

Analysis Conclusion

It was found through the data analysis that there was a significant positive correlation between creativity risk-taking and learning efficacy, and a significant positive correlation between creativity curiosity, flexibility and academic achievements. The dimensions of creativity that could positively predict academic achievements learning or learning efficacy include three features: adventure, curiosity and flexibility. Improving creativity can
positively affect learning efficiency. Finally, elements of creativity, risk-taking, curiosity and flexibility were selecting in the design.

Table 3. Regression Analysis Result of Creativity Level in Predicting Academic Achievements

| Independent variables | R²  | Δ R² | B     | SE  | Beta  | F       | P       |
|-----------------------|-----|------|-------|-----|-------|---------|---------|
| Age                   | 0.140 | 0.104 | -0.192 | 0.248 | -0.061 | -0.775  | 0.440   |
| Gender                |     |      | -0.021 | 0.175 | -0.010 | -0.122  | 0.903   |
| Intelligence          | 0.008 | 0.003 | 0.206   | 2.578 | 0.011* |         |         |
| Curiosity             | 0.009 | 0.026 | 0.034   | 0.335 | 0.738  |         |         |
| Risk-taking           | 0.030 | 0.032 | 0.093   | 0.931 | 0.353  |         |         |
| Flexibility           | 0.138 | 0.055 | 0.210   | 2.501 | 0.014* |         |         |

Note. N=151, *p < .05(two-tailed); **p < .01(two-tailed); *** p < .001(two-tailed)

Construct interactive design model
There are three dimensions of creativity, which are curiosity, flexibility and risk-taking. Each of them is corresponded to different dimension features. According to the features of the dimension, study constructs a creative element design model of STEAM educational platform can be seen in Figure 2, which is expanded from designing strategy to guide platform flow, content and operation design etc.

The first design strategy is to keep users interested in exploring freely and then to keep a positive attitude towards learning. The platform is designed from the perspective of cultivating students’ creativity and curiosity, giving students the space to explore freely, trying to let students find problems independently. What is more, the process of exploring problems keeps student being curious about science world all the time. In this way, students have strong ability to explore and solve problems. Searching for courses on this platform is also an exploration of learning things for students.

The second design strategy is to provide users with multiple choices and then stimulate them to do multidimensional thinking. This platform is designed to improve students’ creativity and flexibility by giving them as many choices as possible, such as plentiful courses and course contents. At the same time, paying attention to diversify the interactive design, adopt a variety of interactive ways and then let students learn in the positive interaction of learning content. Students should also be inspired to born more ideas on a same problem. Because it facilitates them thinking deeply and imagining freely. Meanwhile, appropriate tips and help are given in this process if them have trouble in thinking ideas.

The third design strategy is to encourage users to challenge difficulty. This platform is designed from the perspective of cultivating users’ creativity and risk-taking. It aims to set difficult challenge tasks to form “learning + training” pattern and to encourage students to try them. During the process of learning, some time-limited tasks or small tests are set up to help students review the learned content. After finishing the work, they would explain and evaluate their own works and other users’ work to promote mutual learning.

Curriculum Design Model Combined with Design Thinking
The STEAM education platform provides STEAM project-based courses for school-age children aged from 10 to 12, and creativity assessment before and after class. Combining design strategy and design thinking, taking the current mainstream programming project as an example. The platform structured into 3 functional modules, 4 course stages, and 4 lessons learning as shown in Figure 3.

According to the design strategy, the STEAM education platform sets up three main functional modules:
Flexible founding, Curious learning and Adventurous testing. The Flexible founding module includes four functions: course search, course screening, course recommendation, and course reservation. As the entrance to course learning of education platform, curious learning includes two important functions: content learning and course management. The course content learning also includes four course stages: discover problems, discuss the plan, make prototype and evaluate works; course management assists in management courses in different states (course reserved, course uncompleted, course completed). The Adventurous testing includes task test and scale test, test instructions, test results report. It is an effective assessment for course that measure the change of the creativity by the platform.
The combination of creative elements and design thinking forms a course design model can be seen in Figure 4. The final education platform courses include curiosity inquiry, flexible thinking, adventurous attempt and mutual rating four course stages. The STEAM education platform contains multiple courses, and each course is also a project, focusing on programming learning. After each course is finally completed, a virtual work will be generated. This study applied the course model in design project example called Animal Lamp.
STEAM education platform courses are mainly in the form of online project-based learning, and the content includes interdisciplinary knowledge of science, technology, engineering, art and mathematics. The curriculum design model emphasizes the integration of design thinking and STEAM course stages, and at the same time applies creativity elements to different stages of design thinking, and finally forms different course stages. The empathy and problem definition in design thinking are consistent with the problems of the STEAM course to form a curiosity inquiry content stage, which aims to cultivate children's curiosity and adventurous characteristics. The conception in design thinking is integrated with the discus- sion plan of the STEAM course to form a flexible thinking content stage, which aims to cultivate children's flexibility and curiosity characteristics. The prototype design in design thinking is integrated with the prototype work of the STEAM course to form an adventure content stage, which aims to cultivate children's adventurousness and flexibility characteristics. And finally combines the testing and work evaluation stages to form mutual evaluation content stage, which aims to cultivate children's characteristics of adventurousness and flexibility.

Curious Inquiry
The content of the learning module of Curious inquiry is mainly to cultivate users' curiosity and adventurousness can be seen in Figure 5. Through scene reproduction and scene exploration, users can find problems in the provided scenes, mainly through personalized interaction. In the process of the whole scene reproduction, the users can explore the scene, choose to interact with the environment and give relevant prompts They can also choose to interact with the task, which means having a dialogue with the task in the picture. These design meet characteristics of letting users be full of investigation spirit and willing to contact with confused and uncertain situations. After the users discovers the problem through scene reproduction and scene exploration, they also need to guess the problem, input the problem, and determine whether the input problem is correct according to the keywords. Enter the correct key words to enter the next learning content.
Flexible Thinking
Flexible thinking requires users to think about potential solutions related to problems and topics can be seen in Figure 6. In order to train users to have flexible and changeable thinking logic about the same thing, the design gives users more freedom and allows students to try to discuss and think with other people. The interaction of people inspires new ideas, and finally comes out a solution. The main activity in this content stage is online group discussion: according to the questions discovered by the previous curious questions, you can enter a group of 3 discussion tables for free discussion according to the matching of the questions, or you can freely choose a discussion table with vacant seats. During the discussion, users can communicate by voice. If you have any questions during the discussion, you can ask the robot assistant, who can help users solve some of the problems through human-machine communication.

Adventurous Attempt
Adventurous attempt is the process of prototyping, using a pattern of “learning + training” can be seen in Figure 7. All platform projects are programming related projects, because programming learning came into educators’ attention in recent years. Users need to learn how to use electronic modules and programming platforms, as well as basic graphical programming principles and operations. Taking risks is the key point in the content of the platform. In order to facilitate students’ understanding and learning abilities, the content is systematically formed into four class hours, and the content will be adjusted according to the project. The four
class hours belong to the basic learning and each project will be matched accordingly. Among them, the knowledge of the programming platform in the second class is the content of general learning. If students have learned in the previous project, they can skip this part, but students cannot skip the other learning contents of the past project. They should study them in order.

| Stage              | Content                        | Personality Interaction          | Sociality Interaction                                    | Animal Lamp Project                                                                 |
|--------------------|--------------------------------|---------------------------------|----------------------------------------------------------|----------------------------------------------------------------------------------|
| Adventurous attempt| Electronic module learning     | Interact with the different components of the module | barrage and simultaneous users Ask each other questions and answer each other | Learning of the main control module and LED light screen module                    |
|                    | Programming Platform Learning  | Interact with different areas of the programming platform |                                                                         | General knowledge of programming and programming platform                          |
|                    | Programming Learning           | Interact with programming blocks |                                                                         | Lighting programming learning                                                    |
|                    | Modeling Design Complete Assembly | Interaction with the module, personalized painting design |                                                                         | Comprehensive study, animal appearance art design                                   |

*Figure 7. Adventurous attempt stage design*

**Mutual Rating**

After completing the production and testing the prototype, users entered the stage of mutual comment on works can be seen in Figure 8. The stage of mutual evaluation includes transferring works. Users are required to name their own virtual works, and then upload the works to the course portfolio; to evaluate others works and view comments on their own works, each user needs to evaluate at least two works. The purpose of the design at this stage is to make sure that users can exercise adventurous defense on their own opinions and have flexible characteristics and flexible ideas for treating the same things in flexibility.

| Stage     | Content                  | Personality Interaction | Sociality Interaction | Animal Lamp Project                      |
|-----------|--------------------------|-------------------------|-----------------------|------------------------------------------|
| Mutual rating | Send work                  | Edit the title and introduction of the work | Comment on other people’s work | Upload your own animal lamp works       |
|           | Mutual comment            |                          | View and reply to other people’s comments on your work | Choose other animal lamp works          |
|           | View and reply to comments |                          |                       | Enter my work page to operate           |

*Figure 8. Mutual rating stage design model*

**Discussion**

**Conclusion**

STEAM education aims to improve students' innovative ability and at the same time cultivate students’ creative problem-solving ability. Design thinking is also a way of thinking that exercises creativity. So, creativity, as an important element, can promote the further integration of STEAM education and design thinking. According to the results and the practice of design, we can conclude three conclusions. Firstly, the article found creative elements that have an impact on learning through quantitative analysis. These elements as well as have an impact on STEAM education. These creative elements are representative and therefore more suitable for education-related design. Secondly, the design practice of the platform proved that these design models can well integrate design thinking and STEAM education. The characteristics of creative elements play important roles on better guiding the design of the STEAM education platform. Thirdly, design models can well overcome the problems of no breakthrough point and difficulty in quantitative evaluation when design thinking is integrated with STEAM education. Through the creativity test, it can further verify the effect of design thinking on STEAM education. This paper proposes an innovative method for later design thinking to solve the challenge of education integration. Creativity can be as evaluation indicators to assess course effect before and after the course.
Limitation
Some limitations need to be acknowledged and further work needs to be conducted to address them. Firstly, the STEAM education platform model and curriculum design model request more design practice to check them validity but we only employed them into one course case. Because course development requires a long period, the number of courses developed using model practice design is limited. In the future study, we can apply it in multiple courses to design STEAM education platform and curriculum. Secondly, the small sample size of this study prevents us from generalizing the findings to a broader population, and as well as ignored the comparison measurement of children’s creativity change before and after the course. Thirdly, since ways are diversity which design thinking can be applied to innovation education, this article only explored creativity elements related study how to help design thinking integrated into STEAM education. Other key points of STEAM education are also worthy of our in-depth thinking and exploration. A further study is also proposed to complete this study.

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