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Research Article

Educational Model and Practice of STEM Education+Creator *

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Abstract

There are few achievements in the research of STEM educational theory and practice in China and there exists a lack of systematic course system, activity design framework and resource support in STEM education, so this study probes into the localization of STEM education based on the present situation in China. In the educational model of "STEM education + creator", this study finds out the model of integrating STEM education into the talent cultivation process by means of creator space. Then through the method of evaluating students' problem-solving ability, this study explores the influence of STEM course on students' problem-solving ability and explores a new way of thinking of reform.

Keywords

STEM Education • STEM Course • Creator • Practice

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STEM Education and Characteristics

STEM education is an interdisciplinary integration of science, technology, engineering, and mathematics, which is an effective integration of discipline accomplishment. It is an organic whole driven by the task of solving real problems, which applies and acquires knowledge in practice and cultivates students' problem solving ability, compound thinking and innovative thinking. (Barrett, Moran, & Woods, 2014) Integration is the most prominent characteristic of STEM education that aims at cultivating the core quality in the 21st century and attaches importance to the cultivation of logical thinking and innovation ability.

Literature Review

The concepts of STEM and creator originate from different fields, both of which have something in common and are different. The literature on the two presents four points of view:

The first viewpoint is "no excuse". This view represents the views of many scholars, holding that for a practical concept, it is not necessary to excuse or argue. Attention should be paid to the practical application, the use of teachers and students, and the breakthrough and innovation of traditional classroom teaching (Clark, & Ernst, 2007). The second viewpoint is the inclusion relation theory (Dilshad, 2017; Bøe, Henriksen, Lyons, & Schreiner, 2011), believing that the creator activities must be included in the STEM activities, and the STEM activities are not necessarily all creator activities. The third viewpoint is the carrier theory (Hinde, 2005; Koedinger, Corbett, & Perfetti, 2012), holding that the creator is the carrier of STEM and STEM is not equal to the creator. The fourth viewpoint is the integration theory (Bryan, Moore, Johnson, & Roehrig, 2015; Buck, Bretz, & Towns, 2008; El-Deghaidy, & Mansour, 2015) that uses the creation process as a way to guide students to apply interdisciplinary knowledge in STEM education to solve problems and cultivate accomplishment and capacity. In theory, STEM education and creator education are conducted a careful comparative analysis from main source, social participation, interdisciplinary, solving real situation problem, student output, use of digital tools, quality of accomplishment, the role of teachers and the role of students. Creator education has a broad and narrow definition (Becker, & Park, 2011; Guzey, Moore, & Harwell, 2016). In most of creator activities, middle school students use open source circuit boards to realize creativity, which involves both interdisciplinary knowledge and creative presentation of some artificial products. It is difficult to make clear whether the nature of the activity belongs to "STEM" or "creator", which brings confusion to the education teaching practice on the front line to a certain extent.

STEM education and creator education have different origins. In practice, the development of STEM education in the K-12 stage in the United States is mature, and has the common theoretical and realistic basis with creator education. Thus, the integration of STEM education into creator education is an effective way to create creator culture. In theory, creator education is divided into two types: school creator education and social creator education (Koedinger, Corbett, & Perfetti, 2012; Clark, & Ernst, 2007). Therefore, STEM education is integrated into the creator teaching (Becker, & Park, 2011). In practice, STEM disciplinary knowledge is taught in the form of informatization and stimulates creativity by relying on the learning space of creator. It is a good way to balance practice and theory by treating the creator education in school as STEM education.

Model and Experiment of STEM Education + Creator Education

Based on the concept of STEM education curriculum design with interdisciplinary integration orientation and under the guidance of constructivism and innovation theory, this study improves and integrates the subject-oriented curriculum design and SCS teaching method. The key points of constructing the teaching model of STEM education + creator are as follows: first, basic knowledge learning of STEM education + creator (Guzey, Moore, & Harwell, 2016; Dilshad, 2017); second, establishment of evaluation standard for the teaching model of STEM education + creator; third, project creation of the teaching model of STEM education + creator (Clark, & Ernst, 2007); fourth, results show and evaluation. To realize STEM education from concept to practice, it is necessary to overcome the inherent consciousness and practice of traditional teaching, carry out STEM course practice research and pay more attention to students' learning needs, learning process and abilities.

Hypothesis and design of study

This study puts forward the following four questions for the effectiveness of STEM course in the field of experimental study. Question 1: Does STEM course affect students' understanding of scientific knowledge? Question 2: Does STEM course have an impact on the cultivation of students' problem solving ability? Question 3: Is there any difference in the understanding of scientific knowledge between STEM course and traditional course? Question 4: Is there any difference between the STEM course and the traditional inquiry course in improving students' problem solving ability? There are two hypotheses in this study: Hypothesis 1: There is difference in the understanding of scientific knowledge and cultivation of problem solving ability between STEM course and traditional course. Hypothesis 2: Compared with the traditional course, STEM course has different understanding of scientific knowledge and problem solving ability. The implementation of the study hypothesis is intended to take the following steps. First of all, pre-test is carried out on all the objects. Secondly, the pre-test data are collected and sorted out, and the level test is conducted on the pre-test data. Thirdly, the experimental group is subjected to STEM course learning, and the control group is subjected to scientific course learning. Then, post-test is carried out on all the objects, and the post-test data are collected and sorted. Finally, the pre-test and post-test data are analyzed, and the experimental conclusion is obtained according to the data.

Design of Experimental Scheme

Object of study: students are selected from University A in Lanzhou with equivalent professional knowledge structure and learning level. Their prerequisite courses are the same and they belong to students of parallel classes. In order to avoid the influence of pre-learning level of the students and the teaching level of the teachers on the experimental result, the teaching level of the teachers is quite similar. There are 200 junior students, including 118 boys and 82 girls. Among them, 100 are in the experimental group for STEM course learning and 100 people are in the control group for traditional course learning.

This experiment study is divided into six steps as follows: 1. Analysis of students. Choose the accounting and basic analysis unit combined with the scientific course standard and take foreign courses for reference to conduct STEM curriculum unit design based on business analysis on the basis of mathematical and computer capabilities. 2. Discuss and analyze with subject experts and science teachers for many times, revise the course content arrangement, perfect the unit teaching design and form the final teaching unit on the basis of science teacher's trial teaching of the course. 3. Decide research issues, prepare pre-test post-test questionnaires for testing, and discuss with subject experts and science teachers for several times to form a first draft of the questionnaire. 4. Select 100 senior students from University A in Lanzhou to complete the questionnaire and collect the data. The questionnaire is tested for reliability and validity, and the questions of the questionnaire are selected and modified according to the results to form the formal draft of the questionnaire before and after test. 5. Select 200 students with the same learning level from University A in Lanzhou as the object of study. 100 are in the experimental group for STEM course learning with 8 class hours and 100 are in the control group for traditional course learning with 8 class hours. 6. Both the control group and the experimental group are tested before and after the course learning, then the data are collected, sorted out and analyzed to obtain experimental study conclusion according to the data analysis result.

Design of test

This experiment is mainly to measure and evaluate the effectiveness of STEM course from two aspects: acquisition of scientific knowledge and development of problem solving ability. (1) In the aspect of knowledge acquisition, the pre-test and post-test results of the control group and the experimental group are measured by paired sample T test of knowledge dimension. (2) In the development of problem solving ability, the pre-test and post-test results of the control group and the experimental group are measured through the paired sample T test of the dimension of the problem solving ability. (3) To compare the difference between the control group and the experimental group, the whole questionnaire, the knowledge dimension and the dimension of problem solving ability are tested independently according to the post-test data. (4) According to the post-test data of the problem solving ability, the differences in the problem solving ability between the control group and the experimental group are compared in detail by carrying out independent sample T test on different kinds of problems.

Reliability and validity test of questionnaire

Based on the discussion with many experts and science teachers, the questionnaire is completed step by step. The contents of the pre-and post-test questionnaire are based on the experimental purpose, including scientific knowledge test questions and problem solving ability test questions. The scientific knowledge test question part is designed according to the scientific curriculum standard. The test questions for comprehensively evaluating students' problem solving ability are designed according to the scientific curriculum standard, the connotation of solving problems and the classification of problems, which are divided into decision-making questions, design and analysis questions, problem exclusion questions.

Reliability analysis: the reliability test of the questionnaire is carried out by measuring the internal consistency of the questionnaire by using the Krenzhehe α coefficient reliability index. The internal consistency coefficient (Cronbacha) refers to the consistency among the questions of the questionnaire. This questionnaire includes two dimensions: knowledge part and problem solving part. Therefore, it is necessary to analyze the internal consistency of knowledge and problem solving ability separately. The analysis result shown in Table 1 shows that Cronbacha > 0.8 of the whole questionnaire, knowledge dimension and problem solving ability dimension, indicating that the reliability of the questionnaire is relatively high.

Table 1
Internal Consistency Coefficient of Questionnaire

	Cronbach'alpha	Standardized Cronbach alpha	Project	Number of people
Whole questionnaire	.812	.846	12	100
Knowledge dimension	.887	.891	6	100
Problem solving ability	.865	.832	6	100

Validity analysis is to mainly evaluate the content validity of the questionnaire. Content validity refers to whether the design topic represents the content or subject to be measured, which often uses a combination of logical analysis and statistical analysis. The questions designed by experts and science teachers in this questionnaire meet the purpose and requirements of measurement. The correlation between single score and total score, test single score and total score of students in the statistical pre-experiment is shown in Table 2.

Table 2
Question Validity of the Questionnaire

	Number of people	Pearson correlation	sig.	Questionnaire evaluation dimension
1	100	.837**	.000	Knowledge dimension
2	100	.848**	.000	
3	100	.827**	.000	
4	100	.886**	.000	
5	100	.716**	.000	
6	100	.799**	.000	Problem solving dimension
7	100	.675**	.000	
8	100	.487**	.000	
9	100	.754**	.000	
10	100	.783**	.000	
11	100	.798**	.000	
12	100	.799*	.000	

Results of study

The pre-test data of the experimental group and the control group are analyzed by normal distribution. The results of the SPSS analysis are shown in Table 3. The progressive significance level of the control group is 0.09 > 0.05, so the pre-test data of the control group show normal distribution at 0.05. The progressive significance level of the experimental group is 0.37 > 0.05, so the pre-test data of the experimental group show normal distribution at 0.05.

Table 3
Shapiro-Wilk Test of Pre-test Single Sample

	Control group	Experimental group
sig.	.09	.37

Under the condition that the scores of both groups show normal distribution, independent sample T test is carried out on the total score, knowledge dimension and problem solving ability dimension of the experimental group and the control group before the course intervention.

Table 4

Independent Sample T Test of Pre-test of Experimental Group and Control Group

	Pre-test total score M(SD)	P	Knowledge dimension M(SD)	P	Problem solving ability dimension M(SD)	P
Control group	42.43(19.26)	.455	16.17(6.74)	.219	26.27(14.87)	.085
Experimental group	43.66(19.21)		16.43(6.39)		27.24(14.13)	

Note. p＞0.05 represents "non-significant"

As can be seen from Table 4, the total score, knowledge dimension and problem solving ability dimension of the experimental group and the control group before the course intervention are $p > 0.05$, and the score between the two groups isn't significant, indicating that the level of the experimental group is similar to that of the control group before the intervention. The post-test data of the experimental group and the control group are analyzed by normal distribution. As can be seen from Table 5, the progressive significance level of the control group is 0.19 > 0.05, so the pre-test data of the control group show normal distribution at the significant level of 0.05; the progressive significance level of the experimental group is 0.35 > 0.05, so the pre-test data of the experimental group show normal distribution at the significant level of 0.05.

Table 5

Shapiro-Wilk Test of Post-test Single Sample

	Control group	Experimental group
Progressive significance (both sides)	.19	.35

On the premise that the pre-test and post-test data of the control group satisfy the normal distribution, the paired sample T test is continued before and after the control group learning, and the test can be carried out from the total score, knowledge dimension and problem solving dimension respectively.

Table 6

Pre-and Post-test Results of the Control Group

	Pre-test total score M(SD)	P	Knowledge dimension M(SD)	P	Problem solving dimension M(SD)	P
Control group	42.43(20.01)	.000**	16.18(6.84)	.000**	26.28(15.86)	.000**
Experimental group	55.69(25.54)		21.04(7.68)		34.65(19.76)	

Note. ** represents p<.01

As can be seen from Table 6, there are significant differences in total score, knowledge dimension and problem solving ability dimension in the control group before and after learning. From the average value, it can be seen that the average score after learning is better than that before learning, indicating that the traditional course can improve students' scientific knowledge level and problem solving ability. The pre-and post-test data of the experimental group meet the normal distribution. A paired sample T test is carried out before and after learning of the experimental group, and the test is carried out from the total score, knowledge dimension and problem solving ability dimension, respectively, as shown in Table 7.

Table 7

Pre-and Post-test Results of the Experimental Group

	Pre-test total score M(SD)	P	Knowledge dimension M(SD)	P	Problem solving dimension M(SD)	P
Pre-test	43.66(19.12)	.000**	16.42(6.39)	.000**	27.24(14.55)	.000**
Post-test	64.72(17.43)		27.24(5.32)		41.59(13.26)	

Note. ** represents p<.01

As can be seen from Table 7, there are significant differences in total score, knowledge dimension and problem solving ability dimension in the experimental group before and after learning. It can be seen from the average value that the average score of the experimental group after learning is better than that before learning, showing that STEM course can improve students' scientific knowledge level and problem solving ability. On the premise of the normal distribution of the post-test data of the experimental group and the control group, the independent sample T test is carried out on the post-test data of the experimental group and the control group, and the test results are shown in Table 8 respectively from the total score, knowledge dimension and problem solving ability dimension.

Table 8.

The Post-test Results in the Experimental Group and Control Group

	Pre-test total score M(SD)	P	Knowledge dimension M(SD)	P	Problem solving ability dimension M(SD)	P
Control group	55.69(25.52)	.000**	21.04(7.72)	.000**	34.65(19.88)	.000**
Experimental group	64.72(17.43)		27.24(5.34)		41.59(13.26)	

There are significant differences in total score, knowledge dimension and problem solving ability dimension between the experimental group and the control group after learning. The average scores of decision-making, design and analysis and problem exclusion in the control group are 9.06, 8.83 and 16.76, and the average scores of decision-making, design and analysis and problem exclusion in the experimental group are 9.05, 11.75 and 20.79. The average score of STEM course is better than that of traditional inquiry course. It can be concluded that STEM course can improve students' knowledge level and problem solving ability better than traditional course.

Table 9

Independent Sample T- Test and Average Score for Three Types of Problems

	Decision-making M(SD)	P	Design and analysis M(SD)	P	Problem exclusion M(SD)	P
Control group	9.12(6.43)	.981	8.85(7.72)	.001**	16.75(10.54)	.002**
Experimental group	9.13(4.72)		11.74(5.43)		20.79(8.54)	

Table 9 shows that there are significant differences between the experimental group and the control group in design and analysis and problem exclusion, but there are no significant differences between the experimental group and the control group in decision-making. It can be seen that the significant difference between the two courses in solving problems is mainly related to the problem exclusion and design and analysis. The average scores of the two courses are almost equal in decision-making, and the average scores of STEM course are better than those of traditional course in design and analysis and problem exclusion.

Conclusion

There are significant differences between the experimental group and the control group in knowledge dimension score and problem solving ability score and the average score of the experimental group is better than that of the control group, showing that the teaching effect of STEM course is better than that of traditional course in improving students' scientific knowledge and problem solving ability. According to the results of pre- and post-test analysis of the experimental group and control group on different types of problems, the difference between STEM course and traditional course mainly lies in problem exclusion and design and analysis, but there is no significant difference in decision-making. This shows that two kinds of courses can enable students to use scientific knowledge to choose the best solution. Compared with traditional course, STEM course can better improve students' ability to analyze and design solutions from complex problem situations, as well as improve students' ability to analyze causes and propose solutions.

References

Barrett, B. S., Moran, A. L., & Woods, J. E. (2014). Meteorology meets engineering: An interdisciplinary STEM module for middle and early secondary school students. *International Journal of STEM Education, 1*(1), 1-6. http://dx.doi.org/10.1186/2196-7822-1-6

Becker, K. H., & Park, K. (2011). Integrative approaches among science, technology, engineering and mathematics (STEM) subjects on students' learning: A meta-analysis. *Journal of STEM.*

Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education: Innovations & Research, 12.* (5/6), 23-37.

Bøe, M. V., Henriksen, E. K., Lyons, T., & Schreiner, C. (2011). Participation in science and technology: Young people's achievement-related choices in late-modern societies. *Studies in Science Education, 47*(1), 37-72. http://dx.doi.org/10.1080/03057267.2011.549621

Buck, L. B., Bretz, S. L., & Towns, M. H. (2008). Characterizing the level of inquiry in the undergraduate laboratory. *Journal of College Science Teaching, 38*(1), 52-58.

Clark, A. C., & Ernst, J. V. (2007). A model for the integration of science, technology, engineering, and mathematics. *Technology Teacher, 66*(4), 24-26. http://dx.doi.org/10.1207/S15327043HUP1504_06

Dilshad, M. N. (2017). Learning theories: Behaviorism, cognitivism, constructivism. *International Education and Research Journal, 3*(9), 64-66.

El-Deghaidy, H., & Mansour, N. (2015). Science teachers' perceptions of STEM education: Possibilities and challenges. *International Journal of Learning and Teaching, 1*(1), 51-54. http://dx.doi.org/10.18178/ijlt.1.1.51-54

Guzey, S. S., Moore, T. J., & Harwell, M. (2016). Building up STEM: An analysis of teacher-developed engineering design-based STEM integration curricular materials. *Journal of Pre-College Engineering Education Research (J-PEER), 6*(1), 2. http://dx.doi.org/10.7771/2157-9288.1129

Hinde, E. T. (2005). Revisiting curriculum integration: A fresh look at an old idea. *The Social Studies, 96*(3), 105-111. http://dx.doi.org/10.3200/TSSS.96.3.105-111

Koedinger, K. R., Corbett, A. T., & Perfetti, C. (2012). The Knowledge-learning-instruction framework: Bridging the science-practice chasm to enhance robust student learning. *Cognitive Science, 36*, 757-798. http://dx.doi.org/10.1111/j.1551-6709.2012.01245.x