Design and Application of Maker Education Curriculum Based on Creative Learning Theory

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Abstract. This article explores the design and application of maker education curriculum based on creative learning theory. It introduces a general learning model tailored for maker courses and validates its effectiveness through a teaching experiment conducted on a "Commercial Photography" course.

Keywords: Creative Learning; Maker Education; Course; Learning Model.

1 Introduction

Creative learning is a new form of learning concept widely encouraged in current educational circles. It not only focuses on the memory and mastery of knowledge but also places great emphasis on cultivating learners' ability to explore the unknown world, independent thinking, and innovation. For personal growth and comprehensive social progress, it has very positive value and significance. Creative learning is regarded as the product of two Western psychological theories, one is Bruner's discovery learning, and the second is Gilford's creative thinking.[1] It is rooted in the learning theory of cognitivism. Expressing in a more specific way: "Creative Learning is an educational process that prioritizes the cultivation of learners' creative capacities, encouraging them to think innovatively, solve problems creatively, and produce original ideas through their educational experiences."[2] This kind of learning typically requires implementation in a creative, technical support environment, which can provide opportunities for students to explore, experiment, take risks, and foster their innate curiosity and inventiveness. In different eras, this environment has different contents. In this decade, we can find it to be connected with cyberspace and open-source platforms increasingly which are the basis of the maker movement.

2 From Maker Movement to Maker Education

In 1999, Professor Neil Gershenfeld from MIT initiated the Fab Lab project. This is widely regarded as the starting point of the maker movement. The core concept of Fab Lab is to provide people with a laboratory space equipped with advanced manufacturing tools and enable them to turn their ideas into reality by producing anything they want.

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As he defined in his book “FAB: The Coming Revolution on your Desktop” the maker movement is a contemporary cultural and technological trend that encourages individuals to engage in DIY projects, often with a focus on the use of new technologies such as 3D printing, CNC machining, electronics, and open-source platforms. The movement is characterized by the sharing of knowledge, resources, and tools; collaboration; and the blending of different disciplines to create new and innovative products.[3] It is not only a process of practical creation but also a process of cultivating individual creativity. Subsequently, its contents become richer: “The maker movement is a trend in which individuals or groups create and market products that are recreated and assembled using unused, discarded or broken electronic, plastic, silicon or virtually any raw material and product from a computer-related device."[4]

Chris Anderson, in his book "Makers: The New Industrial Revolution," outlined the three noticeable commonalities of maker movement: (1) People use digital desktop tools to design new products and create model samples; (2) Sharing design achievements and collaborating in open-source communities has become a cultural norm; (3) everyone can transfer a design compliant with generic design document standards to a commercial manufacturing service provider and have it produced in any quantity and scale, or produce it by themselves using desktop tools.[5]

As the maker movement expanded into the educational sphere, the concept of maker education began to take shape. Many researchers, in their discussions of maker education, still emphasized the three elements of the maker movement: manufacturing or production, maker spaces, and makers themselves. They failed to discern the distinctions between maker education and the maker movement.[6]

In our opinion, maker education is the product of combining the concept of creative learning with the methods and tools of the maker movement in the educational process. The reasons are as follows: Firstly, maker education refers to the learning process, which is also a process of discovery and creation accompanied by cultivating human creativity. Secondly, maker education always uses new technologies, cyberspace, and open-source platforms. Thirdly, maker education emphasizes the output of products, which is also a symbol of the maker movement.

By examining some successful examples in America, we have identified some common phenomena: (1) In most cases, maker education occurs within schools. (2) Educators must spend huge amounts of money building complex maker spaces in advance for maker education. (3) Maker education is always performed in activity classes or maker clubs instead of the school's regular curriculum. (4) The objectives of most cases are to cultivate several comprehensive social survival abilities instead of specific academic abilities such as Subject knowledge; Innovation and creativity; Self-cognitive ability; Collaboration ability; Effective communication skills and a Sense of responsibility.[7] The most crucial objective is to cultivate students’ innovation and creativity ability.

Recently, people are no longer satisfied with its small scale, they strongly call for bringing maker education into ordinary classrooms and integrating it into the school curriculum system to benefit more students.[8][9] Consequently, how to integrate maker education with school curriculum emerged as a popular research topic.

3 The Design of a Maker Course Learning Model

We can identify several key distinctions between maker education and traditional educational models. Firstly, the educational goals diverge significantly. While traditional education often focuses on imparting subject-specific knowledge and skills, maker education aspires to a more holistic approach, aiming to develop a range of competencies essential for social survival. Secondly, the qualifications of the teaching staff are markedly different. Educators in maker education settings are expected to have a solid technical background, hands-on expertise, and a broad interdisciplinary knowledge base to guide learners effectively. Thirdly, the curriculum content in maker education is distinctive. It highlights the integration of creative and productive processes as integral parts of the learning experience. Consequently, courses are tailored to align with these processes, often adopting a modular, project-based structure that reflects real-world challenges and innovation. Fourthly, the pedagogical approaches and learning strategies in maker education are unique. These courses are intrinsically linked to open-source platforms and digital technologies, which are not just supplementary tools but essential components of the educational framework. This integration elevates the importance and frequency of online learning and collaborative communication. Simultaneously, offline learning is reimagined to focus on independent, inquiry-based activities and collaborative projects that foster hands-on experience and teamwork. Lastly, the evaluation methods in maker education are designed to reflect its core principles. With creation and production at the heart of the learning process, assessments are tailored to measure these elements. Evaluation strategies such as process review, product critique, group assessments, and self-reflection become the primary means of gauging student progress and course effectiveness.

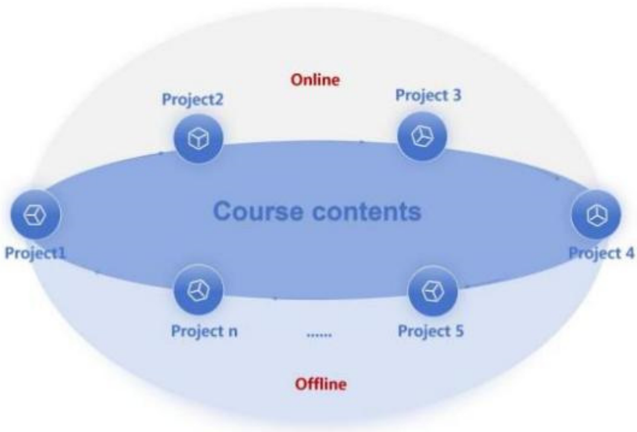

Fig. 1. General learning model of a maker course.

Taking these factors into account, we have crafted a comprehensive learning model tailored for maker education courses. As illustrated in Figure 1, our model seamlessly integrates online and offline environments, ensuring continuous access to resources and technical support. The learning experience is designed to be flexible, allowing for online, offline, or hybrid modalities of instruction. The course content has been thoughtfully restructured into modular learning projects, each focused on a tangible creative task. These projects are intentionally organized in a circular fashion rather than a linear one, which underscores the interconnected and parallel nature of the tasks. The innovative design of each project means that any given project can serve as either an introductory point or the capstone of the course, offering learners the freedom to navigate their educational journey in a non-linear and dynamic manner.

A closer look at the internal structure of each project, as delineated in Figure 2, reveals a spectrum of operations essential for both teachers and students to successfully complete the tasks. Students have the option to tackle these practical tasks either autonomously or through collaborative efforts. Their engagement hinges on four pivotal operations: Learning, Sharing, Creating, and Evaluating. Meanwhile, teachers, in their capacity as architects of the projects and as navigators of the learning journey, are tasked with offering support throughout the educational experience. Their responsibilities are anchored in two principal operations: Instructing and Evaluating.

Fig. 2. Internal structure of a project.

In application, the substance and format of these operations may adapt to meet specific requirements. Fundamentally, they materialize as an array of activities.

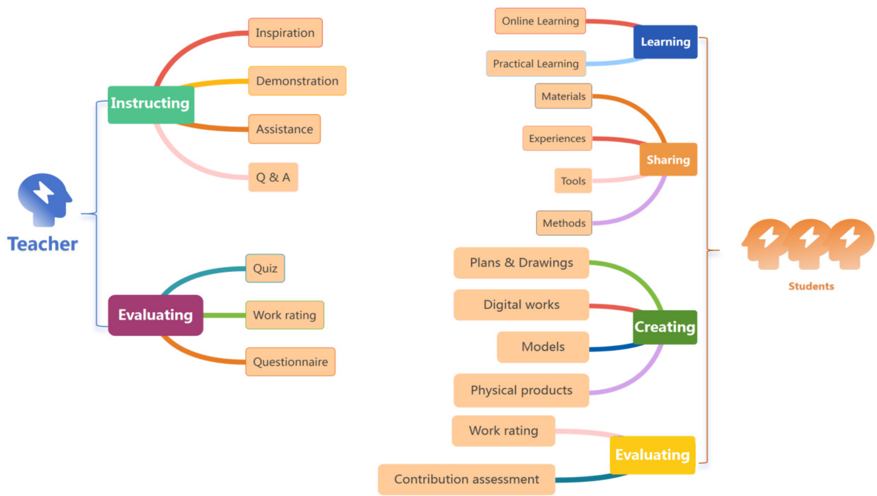

Fig. 3. Typical activities for teacher and students to operate in a project.

As depicted in Figure 3. For example, teachers might employ four distinct instructional strategies within a single project: sparking Inspiration, providing Demonstrations, offering Assistance, and facilitating Q&A sessions. The creative outputs produced by students can encompass from conceptual plans and technical drawings to intricate digital creations, detailed models, and an assortment of tangible products, among others.

4 A Teaching Experiment

In order to assess the feasibility of our model, we conducted a teaching experiment entitled 'Commercial Photography,' selected for its emphasis on bolstering students' creative expression and practical expertise. We conducted a comparative analysis between two classes of identical grade levels, one employing conventional teaching methods and the other utilizing the model-based maker course approach. With a strong focus on fostering teamwork and collaborative spirit, students were encouraged to form voluntary learning teams tasked with accomplishing six project-based tasks.

We developed a MOOC to serve as an integrated online platform dedicated to learning, knowledge sharing, and performance evaluation. Concurrently, we equipped students with offline resources and dedicated workspaces to facilitate practical, hands-on experiences, thereby ensuring a comprehensive educational framework that caters to the diverse needs of the modern learner.

Drawing from a widely accepted view that maker education typically unfolds across four distinct stages—Preparation, Experimentation, Prototype Development, and Integrated Feedback [10], we strategically distributed the learning activities and operations throughout the curriculum. Additionally, we utilized diverse assessment methods to gauge the effectiveness of the experimental class's learning and compared these findings with the outcomes from the control class.

From a process evaluation standpoint, our findings indicated that both the overall attendance rate and the level of course satisfaction among students in the experimental class were significantly higher compared to those in the control class. Furthermore, students in the experimental class exhibited a considerably higher degree of enthusiasm and proactivity in their engagement with the learning process. Shifting to result evaluation, the learning outcomes for the experimental class were primarily assessed through the evaluation of students' project work. To facilitate a comparative analysis, the control class was assigned six tasks, closely aligned with those given to the experimental class. Both classes presented their team projects, with standardized scoring criteria uniformly applied to all submissions to ensure a fair and equitable evaluation process.

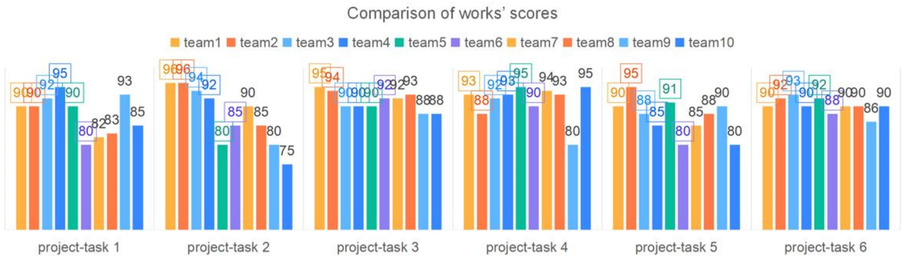

Fig. 4. Comparison of work scores between experimental class and control class.

As depicted in Figure 4, Teams 1 to 5 are part of the experimental class, while Teams 6 to 10 constitute the control class. An observation suggests that the scores for the works are marginally higher for Teams 1 to 5 compared to Teams 6 to 10. To substantiate this finding, we performed a t-test analysis on the scores across all ten teams.

Table 1. T-test for teamwork scores between the experimental class and the control class.

	Class	Number of cases	Mean (Standard Deviation)	t	p	Difference comparison
Scores	Experimental class (Team1-5)	30	91.3 (3.368)	3.875	0	Experimental class > Control class
	Control class (Team6-10)	30	87.0 (5.172)			

Table 1 illustrates a notable disparity in the scores of the students' works between two classes. The t-value stands at 3.875, with a p-value of 0, indicating a statistically significant difference at the 5% level. The experimental class boasts an average score of 91.3, surpassing the control class's average of 87.0. The data demonstrate that the experimental class outperformed the control class regarding scores.

We administered a questionnaire in the experimental class to gauge students' attitudes towards the learning model. To collect relevant feedback, we employed a 5-point Likert scale. The findings revealed that the 44 students in the class offered a positive evaluation of the maker course and the learning model. Specifically, 32 students (71.1%) gave the highest rating of 5, indicating extreme satisfaction, and 12 students (26.7%) rated it 4, reflecting high satisfaction. Only 1 student (2.2%) provided a neutral score of 3.

5 Conclusions

As society's demand for innovative capabilities and technological applications grows, traditional education can no longer meet the needs of the times. Maker education, with its unique teaching objectives, teacher qualification requirements, curriculum design, teaching methods, and evaluation mechanisms, provides students with a brand-new learning environment that stimulates their creativity and practical skills.

By integrating creative learning theory with the methods and tools of the maker movement, maker education not only cultivates students' innovative thinking and problem-solving abilities but also promotes their learning and application of new technologies in practical operations. The promotion and application of this educational model will help cultivate more talents with comprehensive social survival skills, an innovative spirit, and practical skills, thereby driving the overall progress and technological development of society.

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