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Development of a Maker Education Instructional Design Model: Delphi-based Analysis

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Abstract: This study aims to develop a Maker education instructional design model that can improve students' comprehensive ability and creativity. This study constructs a Maker education instructional design model comprising four stages: needs analysis, content selection, process design, and effect evaluation. The model's effectiveness is validated through the development and implementation of Computer Aided Manufacturing for Education (CAME) courses.

Keywords: Maker education instructional design model, Delphi Method, Computer Aided Manufacturing for Education

1. Introduction

Our learning environment has become intelligent learning environment. The combination of the STEAM education with interdisciplinary characteristics and the Maker education instructional design model with the purpose of cultivating creativity is of great help to the cultivation of compound innovative talents.

Researchers had put efforts on the development framework of the Maker education instructional design. Jia et al. (2021) integrated STEAM in engineering design and Maker education into primary school curriculum to promote students' comprehensive capabilities. Combining the 3D technology of Kinesthetic Education Mobile Studio (MAKE) and the mobile maker space platform, to attract novice users from all places to participate in the practical activities of art creation(Jordan et al., 2021) . However, for the practical needs of curriculum development, there is no consensus on an operational development model and development process.

We took Computer Aided Manufacturing for Education (CAME) as an example to build a complete Maker education instructional design model. We hope that these experiences can be used as reference by international peer.

2. Research design and method

This study used the revised Delphi Method to build the relevant indicator system of the Maker education instructional design model, and implements a round of semi-structured interviews and two rounds of questionnaires. Finally, experts reached an agreement and screen out the key indicators of the Maker education instructional design model.

This study constructed a Maker education instructional design model and applied it to develop the Computer Aided Manufacturing for Education course. Using the Delphi Method, 9 experts participated in interviews and 20 in questionnaire surveys. Interviews explored: (1) previous STEAM/maker curriculum development experience, (2) development processes, (3) influencing factors, and (4) evaluation approaches. Round 1 questionnaire: 31 items derived from literature and interviews using 5-point Likert scales. Round 2 questionnaire: 19 retained items rated for importance (1=very unimportant to 5=very important). Round 2 questionnaire: 19 retained items rated for importance (1=very unimportant to 5=very important). Nineteen indicators were identified across three categories: needs analysis (13 indicators), development process (3 indicators), and evaluation (3 indicators). The model was then applied to develop the Computer Aided Manufacturing for Education course.

3. Research Findings

After two rounds of questionnaires, the consensus rate of experts on the second round of questionnaires was 89.47%. It is higher than the data 80% mentioned in study (Kim et al., 2022). This indicates that the experts have reached an agreement, so the investigation was stopped.

3.1 Construction of Maker education instructional design model

Maker education solves real-life problem environments by providing problem-solving methods (Kim et al., 2022). In this study, the Maker education instructional design model was carried out in four stages: needs analysis, content design, process design, and effect evaluation.

The first stage is needs analysis, examining objects from nations, society, schools, to students and teachers. This involves analyzing curriculum standards, students' knowledge base, school educational resources and class hour support. The second stage is content design, matching national curriculum standards of relevant subjects. The knowledge point map covers S, T, E, A, M perspectives, using different marks to show students' acquired knowledge points, their relationships, and target knowledge points. The third stage is process design, including learning activity design and learning path design. This emphasizes students' subjectivity and activities based on student characteristics, followed by collaborative work sharing. The fourth stage is effect evaluation, conducting formative evaluation of course effectiveness through work evaluation and team collaboration ability. Work evaluation focuses on three aspects: innovation, technology and exploration. If results are unsatisfactory, the process returns to the first stage for iterative improvement.

Based on this analysis, the Maker education instructional design model is shown in Figure 1. Solid rectangles represent necessary processes, dotted rectangles represent optional processes.

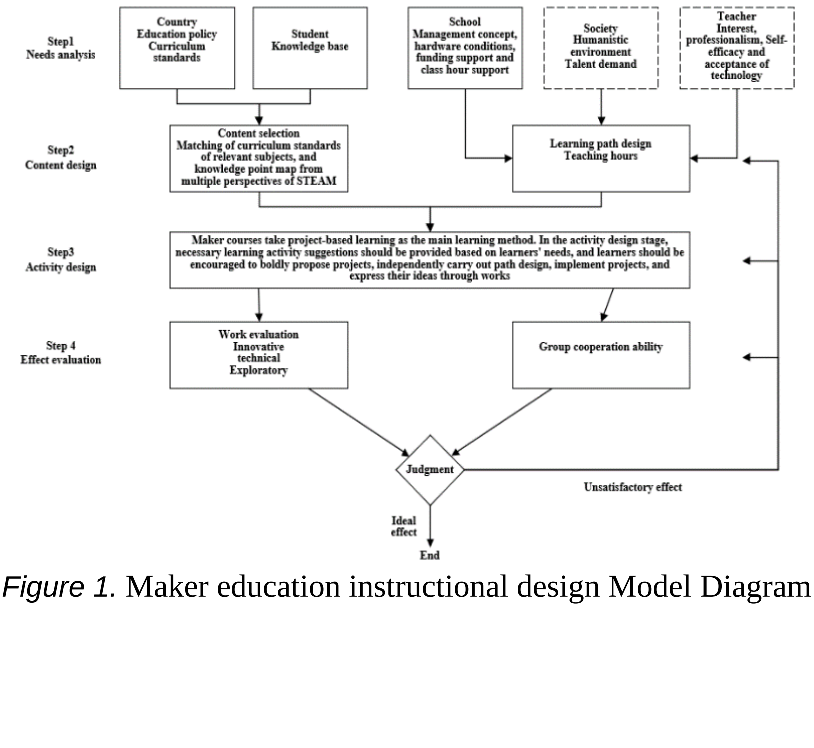

Figure 1. Maker education instructional design Model Diagram.

3.2 Computer Aided Manufacturing for Education (CAME)

The core goal of CAME is to introduce computer-aided manufacturing technology and related equipment into the classroom, and help students express their ideas through works. The content of the textbook is divided into three levels, mainly including the basis of Auto CAD and drawing commands, basic operations of drawing and graphic editing, word games and various object designs. However, the existing textbooks emphasize the operation process too much and how to design and implement scientific knowledge are not clearly reflected.

3.3 Curriculum reconstruction based on this research's curriculum development model

In order to deal with the problems existing in the available curriculum and improve the learning effect of students, we reconstructed the existing curriculum according to the previous Maker education instructional design model.

The needs analysis stage analyzes educational resources and learner characteristics. Schools need maker laboratories and computer rooms with laser cutting machines and class-related materials. The course targets students from fourth grade primary to third grade junior high school. Due to significant differences in cognitive development and independent exploration willingness between elementary and junior high students, two paths are needed: primary and advanced. In content design, knowledge points are extracted based on lesson content and students' existing knowledge base to select learning content. In process design, primary students receive a brief teacher demonstration before independent exploration, whereas junior students work with minimal guidance; typical project-based activities include sketch → CAD → laser-cut → test, with rotating roles to support collaboration. Effect evaluation focuses on artifact quality and team collaboration.

4. Conclusion

Using Delphi method, this study identified 19 indicators and constructed a Maker education instructional design model verified through CAME development.

While expert consensus eliminated some student analysis indicators, practical application revealed their necessity. This highlights that comprehensive needs analysis remains foundational to effective instructional design, even when challenging to implement. The model demonstrates that content selection must align with maker education principles through project-based, collaborative activities.

Future research should empirically verify the model's effectiveness and examine specific indicators' impact on implementation.

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