They Are Learning: Changes through Teacher Professional Development of Inquiry Curriculum Design and Implementation

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Abstract

The main goal of this High Scope Project centered on analyzing how the targeted vocational high-school teachers disenthralled themselves from the traditional settings to think and act anew during the inquiry curriculum design and implementation process. Ten teachers of a vocational high-school in southern Taiwan participated in this process and worked cooperatively with the theme of “Mechatronic” intelligent robot. A professional development program provided by the university research team was developed based on inquiry framework for equipping these teachers in designing the curriculum. Data were collected qualitatively and then analyzed by immersion and editing analytic techniques. After receiving the one-year professional development, a qualitative analysis on the targeted group of teachers’ inquiry curriculum design process. According to the data analyses, three themes regarding this inquiry curriculum development process were extracted about the progress of their conceptions and actions, where each theme had its own developmental focus: curriculum structure, content design, and instructional design. The findings showed that these teachers progressively moved from more teacher-centered thoughts to student-centered actions incorporating inquiry. They also worked together in designing and implementing an inquiry curriculum leading to a success of disenthralling the traditional standard-based and subject-matter trammels, which truly furnished their students’ learning with an interdisciplinary inquiry environment and obtained admirable outcomes. Implications derived from findings and discussions were proposed for the future study of implementing the designed curriculum and promoting teachers’ continuous growth.

Keywords: Curriculum Design, Inquiry, Teacher Professional Development

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1. Background and Purpose

Scientific inquiry has been emphasized in both the National Science Education Standards (NSES) and the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) as a set of pedagogical methods that represents scientific practices and promotes students to acquire content knowledge through the problem solving process (National Research Council [NRC], 2000). Numerous scholars (e.g., Staer, Goodrum, & Hackling, 1998) indicated that the cultivation of students’ inquiry abilities should be at the center of contemporary science education. Therefore, providing students active opportunities to inquire and receive relevant training during the teaching process becomes an essential instructional activity in all classrooms. In Taiwan, based on the new curriculum standards of senior high-school and vocational education announced in 2006, it was in the hope of providing innovative curriculum and instruction in every high-school classroom in order to furnish students with real-world learning environment and cultivate their capability of solving realistic problems. It also aimed to motivate students’ curiosity toward advanced technology, encourage them to explore actively and solve problems scientifically, and develop their positive attitude toward scientific learning. Correspondently, the “High Scope Project” funded by the National Science Council [NSC] of Taiwan (NSC, 2007) was initiated to reach innovative goals of this reform effort, which mainly intended to design an experimental curriculum with an emphasis of integrating advanced technology into original high-school curriculum by applying an inquiry learning approach. Within this project, a “university research team” and the nearby “secondary school team” worked cooperatively to design and implement the “high scope curriculum” in the targeted high-school. Accordingly, this study was conducted under the second phase of the High Scope Project with duration of three years, which was to design an inquiry curriculum with a theme of “Intelligent Robot” in a vocational high-school (VHS) in southern Taiwan. Supportive by the university team, a professional development (PD) program was provided to equip the VHS teachers with adequate knowledge and ability in working cooperatively to design the curriculum. Three types of activities, i.e. 45-hour workshop, weekly designing and discussion, and monthly reflective exchange, was implemented with three categories of content: inquiry-based instructional model, curriculum and instructional design, and advanced technology of intelligent robot.

Literally, the original curriculum used in VHS, as other vocational high-schools did, came from common textbooks that were designed based on the official standards proved by the Ministry of Education, Taiwan. For a long time, a traditional way of teaching (e.g. lecturing) was employed to implement the curriculum, where students lacked for opportunities to inquire actively, discuss communally, and innovate creatively as well as learning fragmentally in a “subject-matter oriented” environment. However, as stated in “A Framework for K-12 Science Education” (NRC, 2012, p.218), Standards and performance expectations that are aligned to the framework must take into account that students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined.

Therefore, it is time to disenthrall this predicament and furnish our students better learning environment. Moreover, we hope to provide a qualitative analysis on how the targeted teachers freed themselves from the traditional settings to think and act anew during the inquiry curriculum design process of this High Scope Project. It is also expected that the targeted curriculum and its design process are able to be positive leading evidences in supporting this innovative reform, which may lead to further improvements in all Taiwanese vocational high-school classrooms.

2. Research Design

A case study approach was mainly employed in this study for analyzing the design process of the inquiry curriculum. Participants were ten teachers of two departments (“Department of Electrical Engineering [DEE]” and “Department of Mechanical Engineering [DME]”) in VHS. Data were collected through in-depth interviews (formative and summative, individual and group, formal and informal follow-up style), semi-structured observations at all PD events, and field notes and reflection notes in order to obtain the rich and thick data for analyzing this curriculum design process. Based on the theoretical framework of inquiry and indicators of curriculum design and evaluation, the original codes used were centered on two topics for data collection: teachers’ conception of inquiry and their plan of the curriculum design. Immersion and editing analytic techniques (Crabtree & Miller, 1999) were
mainly employed for data analyses. The editing analytic system, applying the organizing code topics mentioned above, was used to make sure that the analyses focused on the curriculum design process. The immersion analytic system was employed because of the exploratory character of this study, discovering the possible changes and sources of the changes in the process of targeted teachers’ curriculum design. The cycle of immersion was repeated till the reported interpretation was reached.

3. Equations Finding (Because of the page limit, only a small part of findings was presented here.)

After receiving the one-year PD program, an analysis on the targeted teachers’ design process of inquiry curriculum on intelligent robot was conducted. According to the data analyses, three themes regarding the curriculum design process were extracted about the progress of their conceptions and actions, where each theme had its own developmental focus: curriculum structure, content design, and instructional design.

3.1 Curriculum structure—从官方学科/部门事项标准到跨学科框架

The focus of the advancing technology used in this study was the design and manufacture of intelligent robots, while “Mechatronic” served as an important learning basis of the targeted curriculum. The original curriculum used in VHS came from common textbooks that were designed based on the official standards proved by the Ministry of Education, Taiwan, associated with the school-based and department-oriented regulations and needs. Currently, the intelligent robots made by VHS students were mostly developed by using the extracurricular time and with teachers’ special guidance. Actually, the prerequisite knowledge and ability these students owned and applied in producing robots were actually fragmented and not integrated. Even though the knowledge and ability they learned separately were embedded in the curriculum of two departments (DEE and DME), they were still not able to apply them in the practical situation. One DME teacher mentioned that at the beginning of the semester, “we taught based on textbooks, we didn’t pay much attention to the content related to manufacture the robot” (110411-T8). Another DEE teacher also mentioned that, “I am responsible for my teaching tasks; I didn’t really think about how my course could be integrated with others” (110111-T6). However, the intervention by prompted these teachers to think closely about the existing curriculum framework. Different from the official subject-matter design, they especially worked on finding out possible relationships among all courses in both departments in order to design the interdisciplinary content effectively. Accordingly, ten teachers together conducted an interdisciplinary integration of the curriculum within two departments, and finally determined the prerequisite core knowledge needed for designing and manufacturing robots. The core knowledge structure included three modules from DME and four from DEE (see figure 2 and 3). These modules were perfectly embedded in the original curriculum in teaching the core concept, while it is also appreciate to be taught as a thematic curriculum separately.

In the design process, most teachers gradually understood how to efficiently integrate the core content of both electrical and mechanical aspects for constructing students’ competence in their future designing and manufacturing capabilities of intelligent robots. One DEE teacher elaborated this understanding:

We never thought about how to merge those scientific and learning concepts together before. What we were doing now, the interdisciplinary integration, were goal-oriented and conducted based on students’ learning needs. We tried to make it more structural and objective-based. Discussions with other teachers exposed me to the attributes of others’ experience and knowledge... (050711-T5)
Intelligent Robot

Interdisciplinary “Mechatronics” Integration

Department of Mechanical Engineering I
(Robot Mechanism)
Mechanism Type and Manufacture

Department of Electrical Engineering
Chip control, Programming
Handheld devices

Department of Mechanical Engineering II
(Robot Drawing)
2- and 3-Dimensional Drawing

Department of Electronics
(Supplementary)

Motion Design
Strength Design

Figure 1  Integrated learning content

Intelligent Robot (Mechatronics)

Department of Mechanical Engineering
Mechanism Design Manufacture

Mechanical Elements Principle Mechanics

Mechanical Processing Practice Electric Works for Machinery

Department of Electrical Engineering
Actuators Drivers Sensors Single Processing

Electronics

Computer Programming

Programmable Logic Control Practice

Department of Electronics (Supplementary)
Intelligent Robot

Figure 2  Structure of interdisciplinary inquiry curriculum
Actually in the reflective notes, many teachers mentioned that there were too many things that students must learn and master. The traditional curriculum design in vocational high-schools was too segmented, because of subject-matter thought, to equip our students to solve real-life problems through applying what they learned in school. Also, this subject-matter model led to the meaningless learning or the memorization of the knowledge in textbooks. However, vocational education in the high school level should be problem-based and practical-oriented. We should appropriately provide practical experiences for students to learn the problem-solving techniques by using an interdisciplinary curriculum to assist them in grasping the core concept. Teacher T3 mentioned,

“Our education system was too subject-oriented, but, in fact, various areas of knowledge were interconnected. As I taught the Curvilinear Motion Sliding Table, it was a great teaching aid that could integrate different learning contents of several subjects together. It could be seen that its concept was linked to how mechanics worked (Mechanics course), to the design of sliding tables (Mechanical Elements Principle course), to the 2D/3D drawings of tables (Mechanical Drawings course), to the manufacture of tables (Mechanical Processing Practice course), and to the application of Mechatronics concept in assembling and testing tables (Electric Works for Machinery course). All these efforts were to construct an intelligent robot, which were truly required the integration of all prerequisite knowledge.” (051511-T3)

In summary, after receiving the PD and went through the curriculum design process, these teachers’ conceptions of the curriculum framework transformed the subject-matter model into an interdisciplinary-oriented model. This major change was beneficial to the overall design of the targeted curriculum.

4. Conclusion

The findings showed that these teachers progressively moved from more teacher-centered thoughts to student-centered actions incorporating inquiry. They also worked together in designing and implementing an inquiry curriculum leading to a success of disenthralling the traditional standard-based and subject-matter trammels, which truly furnished their students’ learning with an interdisciplinary inquiry environment and obtained admirable outcomes. Implications derived from findings and discussions were proposed for the future study of implementing the designed curriculum and promoting teachers’ continuous growth.

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