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Vitalizing creative learning in science and technology through an extracurricular club: A perspective based on activity theory

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ABSTRACT

A case study was undertaken in a junior high school that had won the highest award of the National PowerTech Contest in Taiwan. In the contest, students were required to create their own wooden robot (mechatronics project) in the morning and compete in the afternoon, in order to better avoid the intervention of parents and teachers in the process. The aim of the study was to realize how the after-school club operated to promote the motivation and skills in hands-on creation to win a national competition while advancing learning in science and technology. As a transition model of development, activity theory was used to examine how these developmental processes were structured. In particular, results showed that four major domain strategies were used in the science and technology club (STC): (1) to promote student engagement, (2) to transfer parents' attitudes, (3) to promote peer collaboration, and (4) to enhance expansive learning and creativity.

1. Introduction

Among the various theories about learning, activity theory focuses on the interactions of participants known as actors, as well as their interactions with the surroundings by using tools through activities. Originally proposed by Vygotsky (1978) and others, an activity system is a process system of ongoing, object-directed, historically conditioned, dialectically structured, and tool-mediated human interactions (Leont'ev, 1981a, 1981b; Russell, 1997).

An activity is regarded as a system of human “doing,” whereby actors work on a program or project to achieve a desired outcome. In this sense, a hands-on creation program called the science and technology club (STC) was developed to challenge the PowerTech contest in a junior high school, and the transformation of students in the STC was examined. According to the program, students were engaged in various tool-mediated human interactions, as well as various “object-subject” actions. As such, based on the activity theory, the problems and influences on students and parents in extracurricular clubs, and in process improvement, were examined in this study.

2. Research background

2.1. Activity setting: the science and technology club (STC)

Ashman (1997) and Stamp (1993) define informal learning as that embedded in a social context, meaning that social cues are highly relevant and that students engage in cooperative learning activities. These socially situated learning activities are loosely structured, learner directed, and mediated by peers who often share the same values, attitudes, interests, and

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beliefs. Darkenwald and Merriam (1982) considered any purposeful, systematic, and sustained learning activity that is not sponsored, planned, or directed by an organization as "highly informal." The activities in the STC can be considered as highly informal science and creativity learning in school.

The main theoretical trends underpinning the STC are Communities of Practice (Wenger & Snyder, 2000). Wenger (1998) elaborates many of the ways that identification of the learning activities can be engaged in practice, such as in a science classroom, out-of-school clubs, children's homes and teacher inquiry groups, and are focused in different cultural productions of subjectivity (Williams, Davis, & Black, 2007). In order to create the opportunities for students to practice the designing of PowerTech projects and to allow them to master problem-solving in the process of making a wooden robot, the principal of CM junior high school decided to organize the STC.

From the perspective of activity theory, programs cannot only constitute the formation of organizational identity, but also serve as problem-solving mechanisms (Hernes & Weik, 2007). In the STC, a hands-on creation and learning program called PowerTech design was used as an exemplary activity. The program requires participants to utilize their knowledge and experience in science and technology to assemble a robot. In this mechatronics project, students are required to assemble robots with their team members by using a fixed set of parts, including a motor, battery pack and wires, driving gears, wooden ice pop stickers, and nuts and bolts. During the process, they need to apply techniques and materials to build the robot, delegate and coordinate tasks, and test and modify their designs. Later in the regional and national PowerTech competitions, students are asked to assemble the robot in the allocated hours in the morning and compete in the speed race and tug-of-war in the afternoon. In the finals, students are required to use the same material to create robots based on the theme of the year, such as crawling bugs or jumping ducks.

PowerTech design activity was the major program of the club. Consisting of chains of design actions, the program provides a framework to study what happens when an idea emerges and transforms the design object. The activity purposes of the extra-curricular STC can be described as follows:

(1) Catalyze the emergence of new ways of thinking by facilitating new ways of learning;
(2) Expand the notion of education by creating the conditions for transformation and learning in order to empower individuals and groups to respond to the PowerTech challenges;
(3) Explore unlimited possibilities by developing human potential and creative ways to complete a project;
(4) Design new artifacts through which people can experience self-empowerment and the integration of learning, work, and enjoyment; and,
(5) Develop a learning agenda that fosters the evolution of transformative learning to empower individuals and groups to participate in the PowerTech contest through purposeful design.

The activities designed for students in the STC were infused with social learning. Lave and Wenger (1991) argued that from a social perspective learning should be conceived of as a process of social participation rather than a matter of acquisition of knowledge and cognitive skills 'in the head.' Moreover, in 'social learning' the learner acquires a new social 'identity' as a result of a process of social recognition by the community. This may afford new opportunities for action or consumption within the community, and hence motivate learning (Williams et al., 2007). As such, the ultimate goal for students was to win a prize in the PowerTech contest, yet, in order to win, they had to learn some advanced scientific knowledge skills, such as how to work cooperatively, etc. (Williams et al., 2007).

2.2. The denotations of activity theory components in the STC

The basic structure of an activity system can be represented by Vygotsky's basic triangle (Cole, 1996; Cole & Engeström, 1993). Vygotsky (1986) argued that human doing takes place in the form of interactions of the individual among signs, mediating artifacts, or tools. Signs are impressions made on individuals from their interaction with tools, and this impression assists the mediation or the meaning-making process of the individual. The activity theory model is focused on the dynamics of the activity system, where the forces of the development are the "contradictions" between its elements (Engeström, 1999). The upper part of the triangle represents individual and group actions embedded in an activity system. The lower part refers to the division of labor between members of the community, the community that shares the general object of activity, and the rules that regulate action. The focus is on the activity system as a whole and the manner in which the object is collectively formulated through the mediation of cultural tools and artifacts (Engeström, 2001; Yamagata-Lynch & Haudenschild, 2009).

The particular interpretation of activity theory used in this paper to formulate the research questions, cultural historical activity theory, is grounded in the work of Engeström and his Developmental Work Research program at the University of Helsinki. Cultural–historical activity theory addresses human activities as they relate to artifacts, shared practices and institutions. Thus, it goes beyond individual knowledge and decision making to take a developmental view of minds in context. Cultural–historical activity theory, then, as a dynamic model, is particularly appropriate for the study of educational practice (Williams et al., 2007).

To promote technological creativity and collaboration among students, the supervisor of the STC developed a series of robot-design workshops and integrated PowerTech program into an existing club. Major elements of the STC corresponding to the components of activity theory are summarized below.