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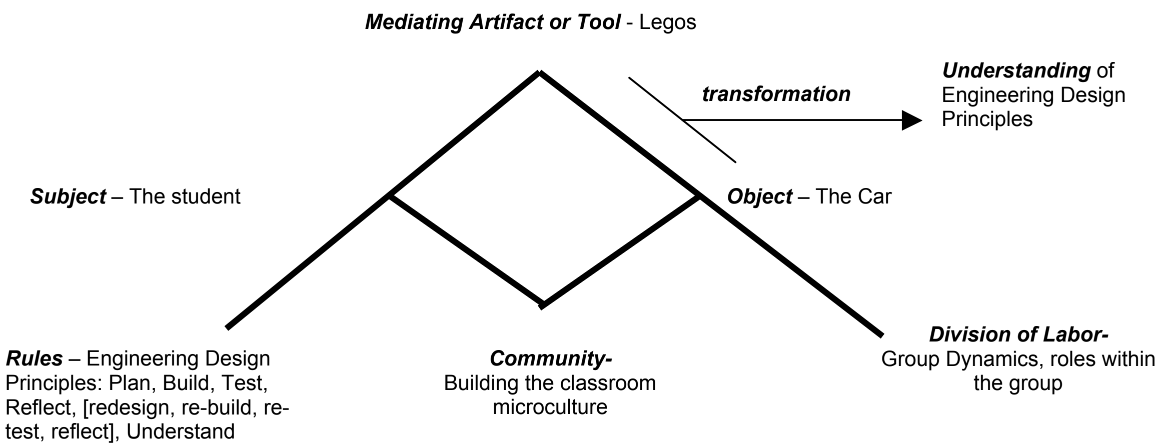
Activity Theory, Special Needs and Engineering Design Understandings

This paper represents a pilot study of a Lego Robotics Curriculum which is currently being used to teach Engineering Design Principles that are presently tested on the Massachusetts Comprehensive Assessment System (MCAS) to a group of special needs students in grades one through five at the Chamberlain Elementary School (pseudonym) in an urban elementary school. The MCAS is the current test used to measure student progress for No Child Left Behind. The current Massachusetts Frameworks for Science and Technology, include Engineering Design principles, thereby creating a need for teaching these concepts in the classroom. The curriculum being used in this project represents the current trend towards moving away from the traditionalist models of learning that are more didactic in their approach. Instead of conceptualizing knowledge and learning as transmitted from the teacher to students, a more social constructivist approach, with students emerging as active participants in their own learning experiences, has emerged.

In this model, teachers move towards the role of guiding the students' learning as they direct their own experiences (Taxen, 2003, Barab et al, 2002). By nature, social constructivism is an active approach towards learning, involving both cognitive and socio-cultural constructs of knowledge (Papert, 1991). These views, while contrasting, can also be seen as being complementary. Two of the more important views of social constructivism are those of collaborative learning and intra-personal reflection that are significant with respect to the ideals of Vygotsky (1978). This paper explores how Vygotsky's principles of socially constructed learning, situated cognition and soviet activity theory can be used to describe and understand students' understanding and learning of Engineering Design Principles. Activity theory was used as both the theoretical lens and tool of analysis in this study.

The relation of the participant and object as it was mediated by the components of the activity system were examined. These components were (a) the tools, which were both human and technology based; (b) the classroom microcultures which demonstrated the emergent norms; (c) the division of labor as indicated by the group dynamics and the student-teacher interactions; and (d) the rules which governed the activity, which, in this case, were the Engineering Design Principles. This diagram demonstrates that activity systems can be seen as complex formations in which equilibrium or balance is the exception; tensions, disturbances and local interventions are the rule that drive the transformation or appropriation (Barab et al, 2002). When this schematic is applied to the Lego activity system the model is transformed to illustrate the activity system shown in the figure below:



Success

In the beginning phases of this project there have been a number of successes noted, most importantly, it appears that the students are engaged and motivated to participate in the curriculum. Survey results indicated that the students were generally interested in topics involving science and engineering, with ninety percent either agreeing or strongly agreeing in their response. Similar responses were indicated about visiting an engineer at work, reading books about engineering, and watching television programs on the topic. However, despite these positive responses indicated on the survey, when the same students completed the Draw An Engineer Test, adapted from the Draw a Scientist Test (Finson, 2003), the students' drawings indicated a lack of understanding about who an engineer is and what an engineer does. This leads to the question of whether the students are actually reading the survey questions or are they simply filling in the "smiley faces" because that is what they think we want them to do.

The students were actively involved in the building of the robotic cars to be both fast and sturdy. However, there were several tensions involved that distracted the students from their specific task. First, The first tension that appeared to emerge was that of aesthetics versus functionality of the car. For example, Students One and Two would focus on a specific part that they wanted to design around because they thought it was "cool" as opposed to finding parts which would meet their design purpose. Additionally, it brings up the idea of being too immersed in the system versus being a deliberate designer. In this instance, the Teacher, as the mediator, helps to re-direct Students 1 and 2 back to the original object outcome, building a fast car.

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Action or Conversation A:

Student 1: So what are we going to do to make the car faster?
Student 2: Put three wheels on the car.... that would look good!
Student 1: Can you make the car bounce with these (picking up purple pieces), you know, like hydraulics?
Teacher: Does that make the car faster?
Student 1: It makes it look good

From this conversation it is easy to see that the students were clearly distracted from the task at hand; by focusing on the aesthetics, the students are forgetting about the challenge of making the car fast.The issue then becomes how do we support the teachers to follow through on the curriculum and activities that go with it? For example, teaching the students to then do their own programming of their robots or building other structures or vehicles such as an underwater ROV.

Vexation

The preliminary data suggests that it is important to begin to look at the complexities of the dynamics of the Lego robotic activity that exist. The dualities or tensions that arise may lead to outcomes that have not been anticipated at the start of this project. For example, tensions which exist between aesthetics and function in the building of the car; between individuals and groups as students move between the various work groups in the classroom; between groups and the classroom as students become distracted by their surroundings and engage in activities that have no relevance to their task; and between students themselves within an activity set or group. These experiences will alter how future studies are situated. Additionally, it is important to determine how to harness these tensions in order to analyze how they affect classroom culture and learning goals of the students and the project.

Several questions have arisen from this preliminary work. First and foremost, how do we get the special needs students engaged and support them in their understanding of the engineering design content that is necessary for the Massachusetts Comprehensive Assessment System (MCAS) testing? Second, how do we support their teachers in the implementation of these activities, particularly through the materials themselves? How many and what types of scaffolds are needed for both students and teachers within the activities? Additionally, in what ways can the motivation and engagement be sustained with these special needs students?

In assessing the outcomes of the Lego Robotics curriculum with special needs students, what is the best method? First, in using activity theory as our framework, is this providing us with the outcomes needed to measure the success or failure of the curriculum? Second, if the activity theory framework is not the best method, then what is the best mechanism for measuring the motivation to participate and engage in the activities of this special group of elementary students?

- ***Student Engagement***: How do we get the special needs students engaged in these activities in a way that provides them a way to understand engineering design principles that are currently tested in the Massachusetts Comprehensive Assessment System (MCAS)?
- ***Support***: What are the best mechanisms for supporting teachers and providing scaffolding (for both students and teachers) within these Lego activities?
- ***Motivation***: How can motivation and engagement be sustained over a period of time with this population of students?
- ***Assessment:*** Is the current framework which we are using providing us with the best mechanism to assess our outcomes? If this is not, what other ways would be appropriate for measuring motivation and engagement for this special population of elementary students?

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