The Effect of Robotics Activities on Students' Learning and Attitudes

Abstract
This research investigates students' learning of, attitudes toward and motivation for robotics and STEM subjects during their participation in robotics activities. The population consisted of selected groups of middle-school students (ages 13-15 years) who participated in the FIRST® LEGO® League competition. The methodology used was both qualitative and quantitative including questionnaires, observations and interviews during the school year 2012-2013, and mainly group interviews during the school year 2013-2014. A **representational model** was used during the interviews to facilitate externalizing the students' understanding of STEM concepts. The analysis used the revised Bloom Taxonomy to study the students' meaningful learning of STEM during the robotics activities. Four categories (intrinsic and extrinsic motivation, self-determination, and self-efficacy) and environmental factors were used to study the students' attitudes toward and motivation for the activities. The results showed that during their preparation for the competition, almost all the students demonstrated meaningful learning, although some students reached higher levels of the Bloom Taxonomy (BT) than others regarding STEM subjects.
Regarding engineering, most of the students demonstrated the understanding / applying or applying level for each of the design process phases. Some demonstrated the analyzing / evaluating level while a few demonstrated higher cognitive learning to achieve the creating level.
Regarding computer science, most of the groups demonstrated learning up to the level of understanding / applying, except for one group that demonstrated learning at the low level of remembering for the concept of interfacing with sensors. Some of the students achieved higher levels of the BT like analyzing or evaluating.
Regarding physics, the results showed that a few of the students achieved a high level of cognitive learning for each of the physics concepts. Some achieved the understanding / applying level, but most of them demonstrated the remembering level or even less when they had the opportunity to demonstrate learning of a specific concept; instead, they presented irrelevant responses. However, more students demonstrated the understanding / applying level in some concepts, such as speed and balance, than concepts of center of gravity, friction and force.
As for the mathematics concepts, most of the students demonstrated the understanding / applying level. A few students demonstrated higher levels like analyzing or evaluating and a few demonstrated only the remembering level.
Several factors influenced the students‘ learning of STEM subjects: (a) the competitive nature vs. the curricular position of the activities; (b) the teaching pedagogy, the students‘ learning style and the teacher‘s background; (c) the unstable nature of the design of the robot; and (d) the students‘ attitudes and motivation.
Moreover, the research results observed certain learning styles that seemed to play a role in gaining knowledge and achieving a specific learning level: (a) trial and error, (b) learning on demand, and (c) discovery learning.
The results of the students' attitudes and motivation showed no significant difference between the beginning of the activities and after the activities. The students demonstrated high and positive attitudes and motivation when they started their activities and this remained high at the end of the activities. The environmental factors played an important role in positively influencing students' attitudes and motivation.

In particular, females showed more positive attitudes and motivation at the end of the activities. The students' attitudes and motivation toward learning STEM was effective for learning computer science and mathematics related to robotics, while learning physics and engineering was less effective.