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Demonstrating and explaining math concepts using integrated communication and robot control

Proposal Description:

Learning of math concepts is enhanced when students talk about concepts and their reasoning while performing hands-on activities. Lego robots can be used for manipulation in educational activities and speech generating devices (SGDs) can be used to control them. This paper discusses how three children demonstrated and explained their knowledge of math concepts using their own speech generating device (SGD) to control a Lego robot to do math measurement lessons. The teacher was able to assess participants' procedural knowledge based on how they manipulated items using the robot. She assessed participants' conceptual understanding, use of appropriate language, and explanation of reasoning based on their communication. The participants used SGD output, non-verbal communication and the robot to communicate. The study showed that manipulation and communication can be interrelated and that having access to both enhanced the participants' message.

Learning of math concepts is enhanced when students talk about concepts and their reasoning while performing hands-on activities [1]. Children who have complex communication needs have used speech generating devices (SGD) in math activities, but if they also have physical limitations they find it difficult to manipulate items [2]. Lego robots can be used for manipulation in educational activities [3] and SGDs can be used to control them. This paper discusses how three participants demonstrated and explained their understanding of math measurement concepts using an integrated communication and manipulation system.

METHOD

A 12 year old girl, 10 year old boy and 14 year old girl (M01, 2 and 3) with cerebral palsy participated. All used Vanguard(TM) II SGDs activated using two head-rest mounted Spec(TM) switches, in step scanning. Each child's Education Assistant (EA) was interviewed.

A Lego robot with a gripper, moveable pen, and spindle to hold a spool of string was used for hands-on tasks in math measurement. Items to be manipulated were mounted on either the robot or a block. Items on the robot could be moved in two dimensions. The robot gripper could grasp items on the blocks, and the participant could maneuver them. The infrared (IR) output of the SGD was used to control the robot. The participants designed their SGD control interface [4]. Math vocabulary and the SGD symbol pathway to each word were displayed on large papers for the participants.

The participant's operational, linguistic, social and strategic competencies were measured to establish their existing communication skills [5, 6]. Training on controlling the Lego robot was provided to ensure effective use for the math manipulation [7]. Lessons taught by a Special Education teacher were length measurement from Level 1 and Level 2 of the Math Makes Sense resource guides [8, 9]. Participants had ten 30 to 90 minute sessions over 8 weeks.

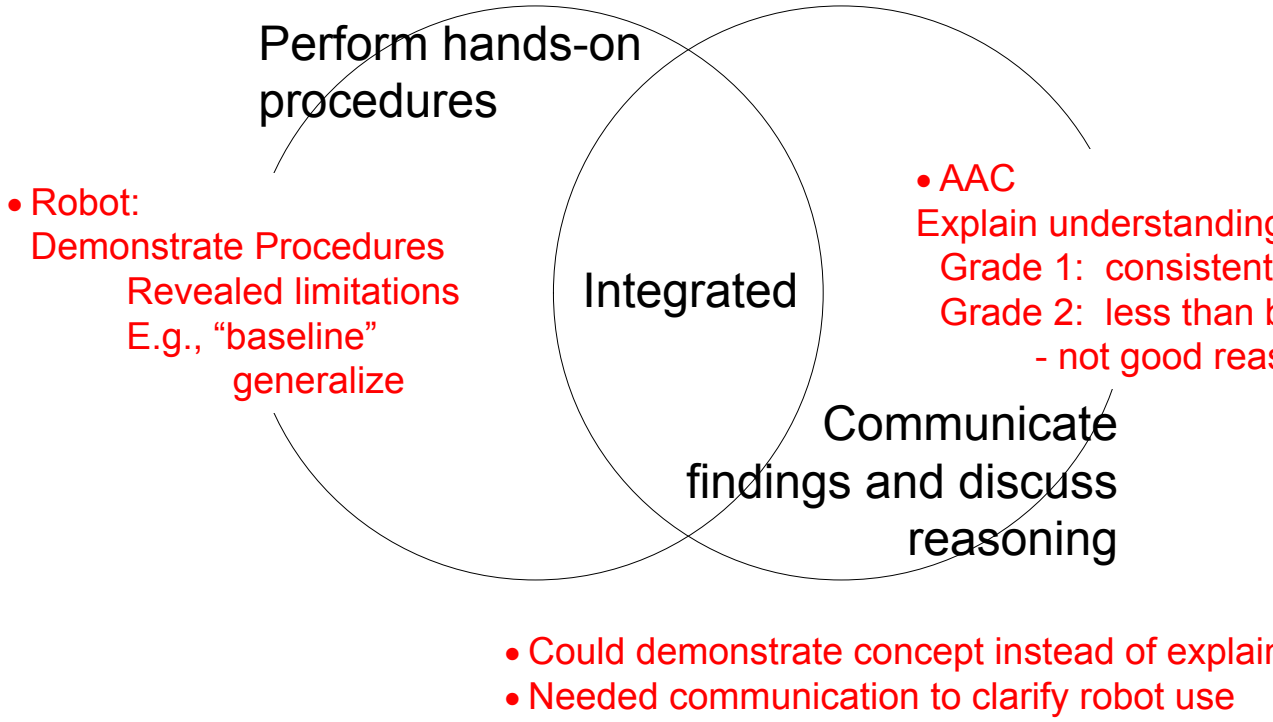
In Level 1, participants compared, sorted, and ordered items. In Level 2, participants measured items with non-standard units (e.g., straws) and then compared and ordered. Performance was assessed from a video of the session using a rubric from the math resources to rate as: Not yet adequate, Adequate, Proficient or Excellent in Conceptual understanding, Procedural knowledge, and Communication.

Observational data regarding manipulation events with the amount of cuing needed and communication events were coded manually. Each communicative event was coded as an initiation or a response, using a mode of SGD, vocalization, or gesture (including eyegaze) [10].

RESULTS AND DISCUSSION

The participants were rated "Excellent" in concepts/procedures they knew already; "Not yet adequate" or "Adequate" at first, but improved in the concepts/procedures in their zone of proximal development (ZPD); and "Not yet adequate" in concepts/procedures beyond their ZPD. The teacher assessed lower procedural knowledge when manipulative events required more cueing and lower conceptual understanding when communicative output was lower.

The manipulation events revealed how the participants understood the math procedures. For example, to compare items in Level 1 participants needed to "Place items parallel" and "Line up ends of items" (also called lining up the "baseline" of the items). All "Placed items parallel" but none demonstrated "Line up ends of items". With practice, all got the concept, but M01 and M03 had problems generalizing it to other baseline formats (e.g., in Level 1 they needed to line up two items and then line up three strings and in Level 2 they needed to line up the end of a non-standard unit with an item and then a string). The EAs attributed the gaps in knowledge to sometimes forgetting to explain what they are doing ("I'm lining up the ends") when they are demonstrating for the students.



Comparing participant's communicative events during the lessons to their pre-existing communication skills revealed how well the participants understood the math concepts. Use of language in Level 1 was consistent with their baseline skills. In Level 2, use of language was lower than expected (they generated fewer and shorter sentences and the teacher ascertained understanding using yes and no questions). Participants use of language was less rich for reasoning than for reporting in both Level 1 and 2.

Integrated robot manipulation and SGD communication led to some interesting events. The participants used SGD output, non-verbal communication and the robot for augmented communication. They used the robot to point and indicate "not there, over here", "let me do it", "I'll show you what I mean", and for teasing (moving the robot away when the teacher reached for it).

The participants also augmented robot use with communication. For example, when M02 lined up the back ends of the items instead of the front ends, the teacher gave him credit for the concept because he communicated what he was doing. As well, when M01 was attempting to place her first straw to measure an item she was not on the baseline. The teacher asked her where she was aiming the robot, and she replied "foot".

CONCLUSION

Participants were able to explain their understanding and demonstrate procedures of math measurement concepts using an integrated communication and robot system. Having "hands-on" experiences enhanced the student learning experiences; doing the procedures themselves revealed gaps in understanding in some areas and by practicing they were able to improve their

performance. Having access to integrated communication and manipulation enhanced the effectiveness of both explaining and demonstrating math concepts and procedures.

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