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SHARED COOPERATIVE ACTIVITIES IN PARENT-CHILD DYADS IN AN EDUCATIONAL ROBOTICS WORKSHOP

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ABSTRACT

Learning robotics can be performed individually or as a collaborative problem-solving activity. Effective pedagogy is based on the latter. In this paper, we offer a work-in-progress report of an observational analysis of parent-child dyads engaged in an educational robotics workshop in a Science Center. We chose this context because learning technological fluency is largely sustained by family-based interactions. We aim to observe what is the relationship between the occurrence of joint engagement in parent-child dyads and their effectiveness in beta-testing of an interactive robot. We use the concept of a shared cooperative activity (Bratman, 1992) as a framework for this analysis and argue for the importance of conducting such analyses in an ecologically valid learning environment.

KEYWORDS

Joint Attention, Shared Cooperative Activity, Collaborative Learning, Joint Engagement, Parent-Child Relationship, Educational Robotics Program

1. INTRODUCTION

The cornerstone of pedagogy is the ability of a teacher and a student to establish common ground in communication to provide personalized leadership for the trainee. This is manifested when learning takes the form of a shared cooperative activity (Bohn & Köymen, 2018) and it is what differentiates pedagogy from mere skill acquisition, as skill acquisition is a broader term, applicable to the learning process of most animals, whereas pedagogy is arguably a human-specific based on shared intentionality (Tomasello & Carpenter, 2007; McClung *et al.*, 2017). We offer a work-in-progress report of a study which aims to show the role of shared cooperative activities in an educational robotics program.

Despite the continually growing offer of educational robotics courses, most of them are addressed only to children and less frequently to parents or families. Parents consider robots as a useful educational instrument, but they rarely see themselves as active participants in robotics-related activities. Instead, they would delegate the teaching role to experts or receive a relatively autonomous self-guiding tool for their children (Feng *et al.*, 2011; Lin *et al.*, 2012). It is hypothesized that it might be challenging for parents with less technological fluency to engage in educational robotics activity with a child when they have to acknowledge their novice status (Bers *et al.*, 2004; Barron *et al.*, 2009). In consequence parental anxiety might limit the frequency of family educational interventions, and not only lessen the exposition to new technology, but also limit the opportunity to embed learning experience within a family system. There is ample body of evidence which shows that parental support during educational activities, and the quality of it, influences children's motivation, behavior and knowledge acquisition (Lee & Nie, 2015; Tenenbaum & Hohenstein, 2016; Sha *et al.*, 2016; Sadka *et al.*, 2018). Hence, it is worthwhile to focus on the methods which could boost parental confidence in using educational technology in a context that often disrupts traditional roles in a family. Shifting parent role from "know-it-all" to "novice" is often unfamiliar situation both for parents and children. The common assumption is that, in task-related context, parent automatically adopts supportive role (Grebelsky-Lichtman, 2014), but it was found that, *e.g.*, the complexity of the task can influence parent behavior. The more complicated the activity, the less cooperation-inducing parental communication becomes (Grebelsky-Lichtman, 2014). On the other hand, there is a modest data on dyadic cooperation in context of family courses in robotics (Bers & Urrea, 2000; Beals & Bers, 2006; Cuellar *et al.*, 2013, 2014; Roque *et al.*,

2016) or other family-focused, non-formal educational interventions (Sadka & Zukerman, 2017; Sadka *et al.*, 2018). Therefore, we decide to investigate dyad dynamics throughout the robotics workshop using bi-directional perspective.

Parent-child interaction is a constantly changing bidirectional dynamic process, in which participants are influencing each other on different levels (behavioral, emotional as well as motivational). Therefore many experts now argue that it might be more beneficial to analyze the dyad as a whole.

The concept of a shared cooperative activity (SCA) was popularized by a philosopher Michael Bratman (1992) and has subsequently been successfully operationalized and applied in various fields of psychology, including neuroscience (Newman-Norlund *et al.*, 2007). SCA happens when people decide to form a pair or a team to achieve some goal, which would be unlikely to be completed individually, and they assist and monitor their performance in the process SCAs are defined by three features: mutual responsiveness, commitment to the joint activity, and commitment to mutual support. Mutual responsiveness is based mainly on joint attention. In the simplest case, it involves a pair of agents, who are engaged in such activity which requires them to pay attention to each other's actions and respond accordingly. Mere joint attention is neutral with regards to the goals of the agents. People can have mutual, neutral (*e.g.*, "I do not care what you do") or opposing goals (*e.g.*, as in combat), but they are interdependent in a situation. Adding joint activity commitment introduces the element of a shared goal. Agents can have different reasons and motivations for this goal, but they communicate about a particular goal and make it theirs. An important quality of such a goal is that it is achieved only when all participants receive their rewards. Only then the collaborative action stops (Hamann *et al.*, 2012). Finally, the commitment to mutual support points to the fact that agents will play different roles in the activity, are prepared to monitor their role performance, as well as offer assistance when needed. As mentioned previously, this is a typical situation in pedagogy the digital age makes the value of SCAs even more apparent. There are similar to SCA concepts, which are wildly used in family studies, *e.g.*, mutuality, which Funamoto and Rinaldi (2014) defined as "concept in the parent-child literature that describes how harmonious, reciprocal, cooperative, and responsive this interaction can be" [pp.4]. Lack of shared goal component, which is an essential factor in family-based educational activities, makes the SCA most suitable for this study.

In this project, we aim to apply the concept of SCA's to the context of an educational robotics program. Our primary research questions are: how do parent-child SCA's change the quality of interaction in the context of robotics? Why do parent-child SCAs break down or are not established at all? Is it mainly due to the problems in mutuality? Inability or unwillingness to agree on the joint goal or perhaps difficulties in coordination of different roles and provision of mutual support? Additionally, we want to create a less domain-dependent measure of SCA's in parent-child collaborative problem solving, which could be used in other educational contexts.

2. EDUCATIONAL ROBOTICS WORKSHOP

2.1 Setting and Participants

Study took place during workshops which were organized in Copernicus Science Center (Warsaw, Poland) during a five-month period from January to May 2018 and additional workshops are planned in August 2018. Final sample of participants should reach at least 60 parent-child dyads. Participants are recruited on a volunteer basis through an internet advertisement. So far 56 children (24 girls), aged 9-14 (girls, M = 10.83, SD = 1.46; boys, M = 10.84, SD = 1.35) participated with their parents (29 mothers; mothers M = 46.34 years; SD = 4.15; fathers M = 44.30 years, SD = 5.37). All families live in the metropolitan area and all parents except one have a university degree. Their self-assessed socioeconomic status was relatively high (M = 6.05 SD = 1.41 using 10-point SSS MacArthur Scale; Adler & Stewart, 2007), but this is typical for individual visitors in the science center. Participants were gifted with free tickets to the science center. Parents gave written informed consent and children gave verbal consent for participation in the study.

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2.2 Robot

Photon (Photon Entertainment LTD, https://photonrobot.pl/en/) is a commercially available educational toy designed with the intent to teach introductory computer programming concepts. Features of the robot include sensors for light, touch, sound, ground contrast and obstacle detection; measurement of traveled distance and angle of rotation; outputs, apart from motor functions, include changing colors of various body elements and playing sounds. Robot can be controlled via a set of applications with different types of interface, suited to changing levels of user's proficiency and age, starting from graphical programming by drawing to creating sequences similar to actual coding. Robot is advertised as a toy for children 5-years and older.

2.3 Workshop Scenario

Scenario design was influenced by social constructivism (Karagiorgi & Symeou, 2005) and Authentic Learning frameworks (Herrington and Parker, 2013) which are regarded as a well-suited methods for educational robotics (Mubin *et al.*, 2013; Chetty, 2017). Workshop design lets the participants gain knowledge in social, collaborative and interactive manner. Steps were taken to provide an authentic context and to make the task meaningful. The goal of the activity was to test various features of the robot and was a real beta-testing experience.

Workshops included a maximum of 16 participants and lasted 45 min. Each workshop was divided into 3 parts: introduction, testing and summary. Each parent-child dyad received the Photon robot along with a Samsung SM-T580 tablet with a control application based on a graphical interface. During the *introductory* part participants were familiarized with work requirements of a typical product beta-tester and given a 10 min instruction on how to use the robot and make a simple code in order to test different robot's features (See: Figure 1).

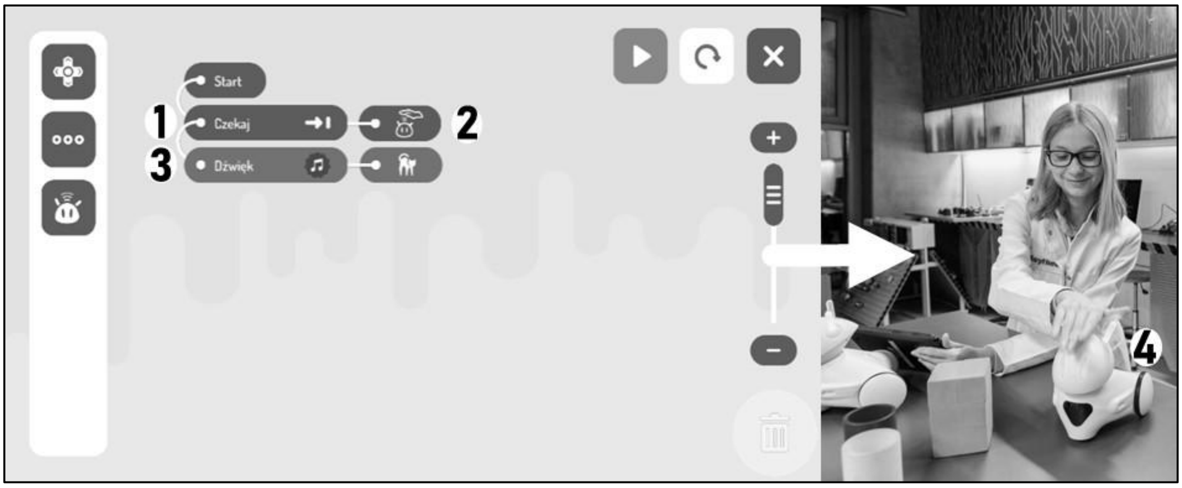

Figure 1. Graphical application interface (left) and Photon robot with the haptic sensor being tested (right). Participants received training in the use of the "wait until" function (1); variety of sensor inputs (2); and a sound output (3)

The *testing* phase was initiated with the statement: "Now test how this robot works. Is it possible to, somehow, make its sensors or motor malfunction? Under which conditions?". Participant dyads were asked to focus on different aspects of the robot and given different additional testing materials (See: Table 1). Testing phase lasted for 20 minutes and was videotaped for further coding. From this point on the workshop animators were passive and engaged only if needed. They only occasionally hinted or asked follow up questions, *i.e.*, "Perhaps check what is the lowest or highest sound which can be registered with the robot's sensor?".

Table 1. Description of the 5 beta-testing conditions and a list of the materials for the workstations

Beta-testing variants (no. of workstations):	***Additional beta-testing materials given to participants***
Touch & Sound detection (2)	Gloves (woolen, hardware and rubber), balloons, foil (copper and aluminum), magnets, radio that generates noise, Vernier sensors, music instruments.
Light detection (2)	Black carton box, flashlight with white, IR and UV light, white LED lamp, blue and red diodes, RGB ball, LED strip, laser, colored filter foils.
Contrast detection (1)	white and black sheet, orange-green mat, chessboard, various tapes - shiny, insulating, silver, whiteboard markers
Distance detection and motor & measurement of rotation angles (2)	Synthetic grass, carpet and blankets, acoustic sponge, foam pads, bubble wrap, twine, ruler, compass, professional protractor.
Obstacle detection (1)	Geometric figures from Plexiglas (various), model of a crystal structure, a sheet of golden, rigid foil, ruler, mirrors, 3D prints (various), bottle, tiles of plywood, Plexiglas, polypropylene and Teflon.

The *summary* part lasted 10 minutes and consisted of participants filling out their tester report and engaging in a group discussion on how the robot could improve. Finally, participants were asked to fill an evaluation questionnaire and a sociodemographic survey.

2.4 Data Coding and Preliminary Data Analysis

Video excerpts from the testing phase (20 min) of the workshop are currently being coded using the BORIS software (Friard & Gamba, 2016) for the occurrence of SCAs in the parent-child dyads and this will be matched with the assessment of beta-testing effectiveness of each dyad. Effectiveness is defined as the quantity and range of beta-testing actions that the parent-child team performed (*e.g.*, the number and variety of additional materials used, testing both high and low sensory/motor thresholds, originality of solutions, number of bug-fixing conclusions). Taking into account the limited time given to each pair for beta-testing and the semi-open-ended nature of the task we expect that their effectiveness will be positively correlated with the stability of their SCAs.

We operationalize the occurrence of SCAs by coding: a) frequency and total time of joint engagement (both agents attentive to each other or to the same object: hardware, software or additional materials); b) frequency and total time of bids for joint engagement on the part of both the parent and the child (due to limits on the quality of recorded audio, this will be mostly based on non-verbal attempts to initiate mutual attention); c) total time of work with division of labor (agents performing on task activity in different roles, *e.g.*, one controlling hardware and the other one software); d) frequency and total time of mutual support (occurrence of a disruption of ongoing activity by one agent in order to assist the other agent in their role).

Analysis of the workshop evaluation questionnaires enables us to offer some preliminary descriptive data on the general agreement between parents and children with regards to their perception of the workshop. We expect that the agreement in perception should reflect better SCAs of the dyad (See: Table 2).

Table 2. Preliminary descriptive data from the workshop evaluation questionnaire: level of agreement in perception of the situation between parents and children

Who spent more time interacting with the robot: parent/child/both?							
Child	Lack of agreement	Agreement	n	Parent	Lack of agreement	Agreement	n
Girls	11 (46%)	13 (54%)	24	Mothers	16 (55%)	13 (45%)	29
Boys	19 (59%)	13 (41%)	32	Fathers	14 (52%)	13 (48%)	27
Both	30 (54%)	26 (46)	56	Both	30 (54%)	26 (46%)	56
How difficult was this task for the child?							
	Lack of agreement	Agreement	n		Lack of agreement	Agreement	n
Girls	8 (33%)	16 (67%)	24	Mothers	18 (62%)	11 (38%)	29
Boys	23 (72%)	9 (28%)	32	Fathers	13 (48%)	14 (52%)	27
Both	31 (55%)	25 (45%)	56	Both	31 (55%)	25 (45%)	56

How did you and the other person enjoy the workshop? Columns describe the level of match in perception									
	None	One	Both	n		None	One	Both	n
Girls	5 (21%)	13 (54%)	6 (25%)	24	Mothers	5 (17%)	9 (31%)	15 (52%)	29
Boys	6 (19%)	7 (22%)	19 (59%)	32	Fathers	6 (22%)	11 (41%)	10 (37%)	27
Both	11 (20%)	20 (36%)	25 (45%)	56	Both	11 (20%)	20 (36%)	25 (45%)	56

Note. % values in a row. Difficulty (1 - definitely too difficult, 5 - definitely too easy). Time with the robot (mostly me, mostly the other person, equal). General enjoyment (5-point visual analogue scale). Agreement means that in particular dyad parent and child marked the same response. In case of "Enjoyment": same response for both child and parent (both); same response for child or parent (one); different ratings for both (none).

3. CONCLUSION

Study offers a framework for the analysis of shared cooperative activities in an educational robotics program which could be applied in a variety of informal and formal educational settings. Among the advantages of current proposal are: a) high ecological validity, as the study involves behavioral observation during an actual learning situation; b) time series data which can show patterns of SCA interactions for those dyads which are most successful at beta-testing; c) promise for development of a less task dependent measure of join engagement in the context of dyads (parent-child; teacher-student; student-student) as well as larger groups. Limitations include: a) exploratory character of the study, which lacks experimental manipulation which would enable us to understand the mechanisms responsible for the willingness or ability of both the parent and the child to create SCAs; b) commitment to a common goal was partially forced as it was presented to the dyads by the explainer; c) participants in the current study were self-selected and their characteristic (*e.g.* high SES) limits generalizability.

We hope that this framework will shed light on the determinants of parent-child mutuality and effectiveness in learning situations. Especially in situations which involve learning of/with new technologies, such as robotics or programming. High level technological fluency is largely sustained by family-based learning and parents do play a significant supporting role in creativity within the realm of new media (Barron *et al.*, 2009).

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