Insights from Empirical Results on Robotics in Early Childhood Education: Lithuanian Case

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Abstract **– The paper aims to research the benefits of robotics to early childhood education, specifically prosocial values. The study examined a sample (n = 130) of children from fourteen kindergartens in one Lithuanian region aged 3-4 and 5-6 years old. The results demonstrated statistically significant differences in both groups learning with and without robots regarding collaboration, interest, and joy measures. However, there was no statistically significant difference in group 3-4 children regarding the difficulties measure. Also, the results revealed that children aged 5-6 had fewer difficulties in learning using the robot than without robots. This study provides insights that activities with robots foster positive emotions and prosocial values and decreases negative emotions while learning with robots.**

Keywords **– robotics, early education, prosocial values, learning activity, experiment.**

1. Introduction

Robotics-based education can be used as a meaningful way to involve children in their learning process. The innovative teaching strategies introducing code learning or simple robots improve students' interest because the topics are taught with the active participation of the learners [1], [2].

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Research shows how young children in the developmental process of learning work with others, the design features of certain types of technology can promote social and prosocial development [1].

Prosocial values are defined by personal responsibilities, concern for others' welfare, and preference to cooperate and maximize joint outcomes or equality [3]. Prosocial values are highly related to social and emotional learning [4]. "Social and emotional learning (SEL) has become more central to education because of demand from educators, parents, students, and business leaders alongside rigorous research showing broad, positive impacts for students and adults" [5]. [6] states that "the application of social robots in education opens avenues for using these tools to support early childhood education and learning" and can "support educational activities and have the potential to provide opportunities for learning across a student's social-emotional, cognitive, and physical domains of development". However empirical results on the larger scale on robotics in early childhood education are still limited.

Many scholars have discovered factors influencing learning in early childhood, and the psychological state of humans during learning plays a significant role. [7] states that if the activities are emotionally significant, attention, memorization and other cognitive processes will improve. Therefore, it is necessary to create environments where children's emotions create associations and build learning. As child development theories (e. g., Piaget's cognitive developmental theory) focus on explaining how children change and grow throughout childhood and centre on various aspects of development, including social, emotional, and cognitive growth [8], based on them empowering learning environment can be created. The highly experimental PEARL project [9] aimed to create such an environment. A new inclusive educational model based on concrete and solid neuropsychic-pedagogical theoretical foundations, combining academic research (Vygotsky, Piaget, Montessori, metacognitive pedagogy, proximal learning, co-structural, environmental, and relational constructivism) with

modern educational strategies such as peer education, cooperative learning, constructivism, and the utilization of information and robotic technologies were developed. As [10] points out, working with educational robotics in groups allows the children to practice relational skills because they have to cooperate to solve problems or find a common solution. Educational robotics is an adaptable methodology to teach prosocial values working on different topics. In the project's scope, specific activities for early childhood education were created, implemented, and experimented with. The paper aims to present the experiment results on how educational robotics influence collaboration, interest, joy, and rising difficulties, such as anger and anxiety during group learning with and without educational robotics. The results of the piloting experiment at the national level with the sample of 130 children from fourteen kindergartens in one Lithuanian region aged 3-4 and 5-6 years old are systemized and analyzed.

The paper seeks to provide evidence-based data about the positive impact of the robotics-based approach on early childhood learning experiences. Children were given learning activities to work in a group with/without a robot, and emotional expressions regarding collaboration, interest, joy, and other difficulties like anger and anxiety have been observed. The literature review results are presented in the first section of the paper. The second section describes the research methodology, following with the results presented. The paper ends with conclusions, research limitations and future research prospects.

2. Methodology

The participants in the experiment were sampled with the help of kindergartens' teachers. Therefore, the sample is convenient and included 130 children attending kindergartens in a sub-urban setting in Panevezys, Lithuania. In total, 65 were 3-4 years old and 65 were 5-6 years old. All the children were Lithuanian. The first and second data collection procedures took place in April 2021.

With the children aged 3 to 4 years old and 5 to 6 years old, the experimental phase aimed to observe the development of educational emotions and an empathetic proximal learning environment supported using a robot as an engaging tool that accelerates the educational processes that influence communication and inclusion. From the didactical point of view, the activity will also permit to introduction of essential competencies on robotic. Detailed procedure of the creation process of activities is provided as follows: there are two separate versions of the 3-4 age and 5-6 age group events with the robot and without robot activities. The theme of the event does not differ according to these two versions. In the activity where the robot is not used, the activity process continues routinely and ends. At the activities where the robot is used, the robot is included in the activity process in the last part of the activity; at the beginning of the activity, children are expected to perform the tasks they perform themselves through the robot. For example, in the 3–4-year-old robot new activity, children try to create sentences of three words with picture sentence cards. In the 3–4-year-old activity with the robot, after studying with sentence cards, a robot platform consisting of picture sentence cards is revealed, and children are asked to code the robot and collect the picture cards related to the specified sentence on the platform via the robot. In the 5-6 age group activity with the robot, children collect cards with numbers and a Dino image representing that numbers. For example, by showing the card with 8 Dino pictures, the answer to the question "Which Dino cards we bring together will we reach 8 Dino?" is by finding the relevant Dino cards. In the robot version of the activity, after collecting exercises with Dino cards -a robot platform with the robot and Dino cards with some numbers on it, for example, by coding the robot to create the 8 Dino cards- the children are expected to collect them on the platform via the robot.

The experimental activity was challenging for the pupil, so it was possible to observe the reactions (positive and negative) to frustration, the rising of educational emotions and how they influence communication and inclusion. The study's general objective is to verify whether robotics-based learning through specially designed learning activities is helpful for early age children in respect to emotional development. Likewise, the study raises the following specific objectives to analyze the use of robotics for learning of prosocial values for children of 3-4 years old and 5-6 years old:

1. To analyze if the robot used in a small group with certain activities fosters positive emotions and collaboration.
2. To analyze if the robot used in a small group with certain activities influence the negative emotions.

There were two experimental groups per age group: 5 children working without a robot (control group) and five children working with a robot (experimental group). Both groups' activities had a role assignment. The sessions took place in a different environment to avoid the interference of other classmates or the noise in the standard room. The sessions were video-recorded for later analysis by experts in the psycho-pedagogical field to observe and analyze the recorded videos of the experimental activities. The names of the participating children

were pseudonymized. The experts completed a report about the models of interaction and communication and the educational emotions risen during the experimental activity.

Based on the research objectives, statistical hypotheses are stated:

Collaboration score:

H0:There is no difference in collaboration score between learning without and with the robot.

H1: There is a higher collaboration score for learning with the robot than learning without the robot.

Interest score:

H0: There is no difference in interest score between learning without and with the robot.

H1: There is a higher interest score for learning with the robot than learning without the robot.

Joy score:

H0: There is no difference in joy score between learning without and with the robot.

H1: There is a higher joy score for learning with the robot than without the robot.

Difficulties score:

H0: There is no difference in difficulties score between learning without and with the robot.

H1: There is lower difficulties score for learning with the robot compared to learning without the robot.

The present study uses a quasi-experimental design, which helps to answer whether there are differences in the children's emotional development level by learning with and without educational robots. Children working in a group with/without a robot were under analysis, intending to observe children's emotional expressions towards collaboration, interest, joy and other difficulties like anger and anxiety. To do this, four questionnaires about the performance of the activity without and with the robot were created. Each questionnaire was made of items to be scaled using the 10-points Likert scale ranging from 0 representing "absolutely no/not present at all" to 10 representing "absolutely yes/always present".

JASP v. 0.14.11 was used to perform all analyses. As reliability refers to the repeatability or consistency of the measurement for both the questionnaires, Cronbach's α were examined. The dependent variables were measured on a 10-Likert scale and treated as an interval scale. The average for each characteristic was taken, and based on those statistics, the analysis was performed.

The primary analyses were performed in two steps. First, the descriptive statistical analysis and Shapiro-Wilk test for normality was performed to know each measure's distribution. Following this analysis, both parametric Student test and non-parametric hypothesis analysis – non-parametric Wilcoxon test for dependent samples was conducted to assess changes in collaboration, interest, joy and difficulties in each group.

Descriptive statistics for both groups show a positive effect of learning with robots compared to learning without robots regarding collaboration, interest, and joy. For the group age of 3-4 more, there is a minimal difference in score.

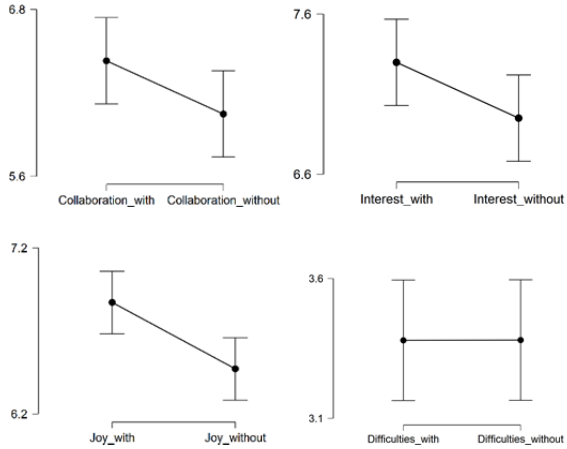

Figure 1. The plot of means for 3-4 y. o. group

However, it is noticeable that differences arose in the group age of 5-6. A different situation is noticed concerning the construct of difficulties. Visual representation among 5-6 years old participants give some insights into the positive effect of learning with robots compared to learning without robots.

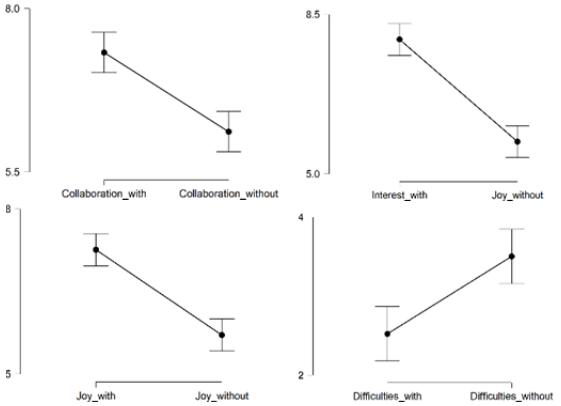

Figure 2. The plot of means for 5-6 y. o. group

To check if there are statistically significant differences between the pre-test (learning without the robot) and post-test (learning with the robot) for data distributed normally paired samples t-test (student test) has been applied. Respectively for non-normally distributed data, non-parametric hypothesis analysis – non-parametric Wilcoxon test for dependent samples has been chosen and the effect size calculated in each case. The outputs of statistical analysis are provided in the following tables. A

[1] JASP - A Fresh Way to Do Statistics (jasp-stats.org)

pared-samples t-test (Students' and Wilcoxon signed-rank test Wilcoxon) was used to determine whether there was a statistically significant mean difference between the scores when the children were learning without a robot compared to learning with the robot. No outliers were detected. The normality assumption was not violated for the measures of collaboration without and collaboration with for the 3-4 group, as assessed by Shapiro-Wilk's test, respectively, $p = 0.324$ and $p = 0.121$. The same normal distribution has the measure joy without and joy with for the 3-4 group, as assessed by Shapiro-Wilk's test, respectively, $p = 0.669$ and $p = 0.325$.

Participants of age 3-4 showed more collaboration when learning with robot ($M = 6.43$, $SD = 1.82$) as opposed to the learning without robot ($M = 6.05$, $SD = 1.89$), a statistically significant mean increase of 0.383 95% CI [0.017, ∞], $t(64) = 1.744$, $p < 0.043$, $d = 0.216$. Participants of age 5-6 showed even more collaboration when learning with robot ($M = 7.33$, $SD = 1.60$) as opposed to the learning without robot ($M = 6.11$, $SD = 1.87$), a statistically significant mean increase of 1,213 95% CI [0.848, ∞], $W = 1808.500$, $p < 0.01$. The effect size, using the rank-biserial correlation was 0.686.

Participants of age 3-4 showed more joy when learning with robot ($M = 7.30$, $SD = 1.663$) as opposed to the learning without robot ($M = 6.95$, $SD = 2.032$), a statistically significant mean increase of 0.400 95% CI [0.177, ∞], $t(64) = 3.00$, $p < 0.002$, $d = 0.372$. Participants of age 5-6 showed even more joy when learning with robot ($M = 7.26$, $SD = 1.527$) as opposed to the learning without robot ($M = 5.71$, $SD = 1.973$), a statistically significant mean increase of 1.390 95% CI [1.095, ∞], $W = 2013.00$, $p < 0.01$. The effect size, using the rank-biserial correlation was 0.877.

Participants of age 3-4 showed more interest when learning with robot ($M = 6.87$, $SD = 0.956$) as opposed to the learning without robot ($M = 6.47$, $SD = 1.189$), a statistically significant mean increase of 0.235 95% CI [0.01, ∞], $W = 1251.500$, $p < 0.048$, The effect size, using the rank-biserial correlation was 0.242. Participants of age 5-6 showed even more joy when learning with robot ($M = 7.95$, $SD = 1.453$) as opposed to the learning without robot ($M = 7.96$, $SD = 1.671$), a statistically significant mean increase of 0.340 95% CI [0.340, ∞], $W = 1515.00$, $p < 0.01$. The effect size, using the rank-biserial correlation was 0.503.

Participants of age 3-4 showed the same difficulties when learning with robot ($M = 3.38$, $SD = 2.454$) as opposed to the learning without robot ($M = 3.38$, $SD = 2.430$). There is no statistically significant difference found with 95% CI [-0.254, ∞] ($0.498 = p > 0.05$) Participants of age 5-6 showed less difficulties when learning with robot ($M = 2.52$, $SD = 2.407$) as opposed to the learning without robot ($M = 3.50$, $SD = 2.332$), a statistically significant mean decreases of -1.075 95% CI [- ∞, -0.700], $t(64) = 1.564$, $p < 0.01$. The effect size, using the rank-biserial correlation was 0.552.

The study measured emotional wellbeing using four measures: collaboration, interest, joy, and difficulties during learning like anxiety and anger. The experiment results show that the change of learning environment by enhancing it with educational robots can improve children's learning regarding the emotional wellbeing during learning. It should be highlighted that two groups (3-4 y. o. and 5-6 y. o.) playing with robots showed higher scores in collaboration, interest, and joy. One plausible explanation for these findings is that children were enthusiastic about trying a new approach to learning. Indeed, after such an unusual experience, it is reasonable to think that they were more favourable to the value of learning with educational robotics in comparison to learning than they would have been under ordinary circumstances.

The results also showed that children of the group 3-4 years old expressed difficulties to the same extent. It can be worth noticing that because of the age, it could be a bit more difficult for children to concentrate on new learning tools compared to the kids of age 5-6. Because, for the latter group, the number of difficulties was less while playing with educational robots. Still, further research is needed to find out the reasons behind it. It can be assumed that age influences different behaviour. Concentration on programming skills and computation thinking while working in a group minimizes expressing negative emotions or experiences mater.

3. Conclusion

The paper aimed to research the hypotheses about the benefits of robotics to early childhood education, specifically the development of prosocial values via learning in groups. Although the study examined a sample ($n = 130$) of children from fourteen kindergartens aged 3-4 and 5-6 years old playing the activities based on collaborative group learning, the study still has several limitations. First, the use of a small convenient sample reduces the generalizability of the findings. Second, gender and age-level differences were not examined because of the small sample size. Third, the results are correlational and should not be interpreted as cause to affect relations. Further investigations are needed to understand the meaning of the results better. Despite these limitations, this study assessed children's emotional wellbeing changes while learning in different learning environments: with and without educational robotics.

The results demonstrated statistically significant differences in both groups learning with and without robots regarding collaboration, interest, and joy measures. However, there was no statistically significant difference in group 3-4 children regarding the difficulties measure. The results revealed that children aged 5-6 had fewer difficulties learning using the robot than without robots. This study provided insights that activities with robots foster positive emotions and prosocial values while learning with robots decreases negative emotions. The study demonstrated the successful incorporation of robotics in early childhood education and identified the importance of motivating educators in embracing robotics as an enhancement learning tool with high potential to develop prosocial values in children.

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