Educational Robotics and Collaboration Skills: Seeking the Relationship between Tasks and Skills

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ABSTRACT

As it is frequently expressed by many scholars and researchers, educational robotics presents a powerful tool in order for a variety of skills to be developed. However, educational robotics by itself is not able to be that groundbreaking if it's not supported by the appropriate pedagogical methodologies and techniques. This research aims to mold pedagogical theories into a framework that supports the development of collaboration skills through the use of educational robotics. This research is on the second year of being implemented in formal school settings and it is important to state that the results are encouraging. During the first year of this research there were observations that were very promising in terms of developing the skills that are directly related to collaboration. However, there were no tangible or quantifiable results to support this. This second year, the observations are paired with tangible and quantifiable results, not only for the need to show evidence that the development is evident, but to try to reveal as well the relationship of the tasks to the development of the skills.

KEYWORDS: *Educational Robotics, Collaboration Skills, Formal Education*

INTRODUCTION

This work presents a genuine attempt to research the effects of educational robotics to the development of collaboration skills. As stated above the pedagogy behind such an attempt is of incremental value since E.R can be easily perceived just as another technological fashion that came along and is destined to perish. The first author of this paper has had a six year experience teaching educational robotics within and outside the school settings and took part in national competitions with successful results. However, there was a constant concern on how to implement E.R. Many times students were left behind during the group work process, some other times the designs and constructions were indeed good, but merely represented the thoughts and efforts of all the group members and sometimes the students had distorted and magnified perceptions of their abilities after their involvement with E.R.

But why is it so important for students to develop collaboration skills? First of all, collaboration skills are one of the core set of skills that "21st century skills" movement is aiming to develop in students. Secondly, collaboration skills, are the backbone of every activity that involves students working in groups. They comprise the collaborative part or collaborative problem solving, which is very important when students are faced with demanding cognitive tasks that E.R constantly presents. Finally, collaboration skills are

reflected within every aspect of social and professional life, therefore it is a valuable asset for the vast majority of students.

Isn't it enough that students come to work together and enhance their teamwork spirit or collaboration skills? Most of relative literature on educational robotics tackles teamwork and collaboration skills as a byproduct of the students' involvement with group work on E.R. It usually presents the observations that students enhance their teamwork spirit without presenting a hard rigorous measurement on either the elements that comprise collaboration or a framework that supports the whole didactical process of developing them. Before even considering introducing E.R into formal school settings it is absolutely necessary to prior investigate and prove its worth under an appropriate pedagogical framework, have distinct aim on to what is expected to be developed through the pedagogical process and finally have a rigorous tool for measuring the effects of the process in order for the didactical process to be reflective to the development of the students' skills.

This research views collaboration skills as both an outcome and a process and its focus is aimed in delivering the appropriate framework in which collaboration skills through E.R. can be honed. In the following pages there is firstly an attempt to briefly present the molded theories that influenced the creation of this framework. Secondly, there is a brief synopsis of what has happened the previous year. Thirdly, it is important to describe what is currently being found in terms of tangible results. The main focus of this paper is to shed some light into the newly found results of this research attempt. In addition there is a discussion of the approach and the contribution that is brought forward for the next step of this research.

MOLDED THEORIES INTO FRAMEWORK

Everything starts from the word "collaboration". What is collaboration? It is enjoyable to search for the definition of the word collaboration. It is like the process of what Ted Panitz (Panitz, T., 1999) characterized as the "search of the Holy Grail" of interactive learning. But is it just a definition that helps us apply all the aspects of collaboration within classrooms?

According to Bruffee (Bruffee K.A., 1993) in order for a classroom to be transformed into a collaborative environment there needs to be a certain phase of "reacculturation". The term "reacculturation" means in simple words that the class has to be transformed into one with a different set of ground rules, structures and authority. Moving towards a collaborative environment, means that students are empowered to form their own ground rules, teachers need to take a step back and become more like facilitators/collaborators and generally there are no structures regarding the authority of knowledge. A collaborative environment must be seen not as a simple set of guidelines though, but a different philosophy approaching education in general.

After establishing the environment in which collaboration can flourish it is important to search for clear cut definitions describing the very nature of the quality of the interactions towards the task. According to Roschelle (Roschelle J., 1992), "…frames collaboration as an exercise in convergence or construction of shared meanings…". This is an important statement and pinpoints the keyword "convergence". So we seek convergence towards the construction of shared meanings. Additionally, Roshelle and Teasley (Roschelle, J. & Teasley, S. D. 1995) define collaboration as "…coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem". Again, after the keyword convergence there are two more keywords that are added into this equation. Coordination and synchronicity were especially supported during this year's research and gave even more depth into the students' interactions.

Settings	
Working space	Two couple per workbench
Group size	Vygotskian pairings (four students)
Time	1h/week/school year
E.R Kit	Lego WeDo 2
Age	11 – 12 years old
E.R Project	Agreed by all – ill-defined with open-ended answers
Teacher stance	Collaborator - Mediator
Prior Knowledge	Scratch Programming
Connections	Booklet with detailed instructions
Curriculum	Part of Computer Science

Seeking even further the qualities of true collaboration Dillenbourg (Dillenbourg, P. 1999) expressed some more elements that comprise it. The first is derived from "symmetry of action" the second from "the symmetry of knowledge" third from the "symmetry of status" and finally from the "symmetry of goals". These statements are in analogy with the collaborative environment that is explained and described by Bruffee, Roschelle and Teasley, but takes things even further in connecting the actual environment to the actions of the students. In simpler words it defines more the settings and the layers of interactions to the activities. Additionally, Dillenbourg states "Another marker of true collaboration is the quality of interactions, especially the degree of interactivity and negotiability" (Dillenbourg, P. 1999).

Furthermore, Vygotsky (Vygotsky, L.S. 1978) is very visible into the teambuilding process of the students in this framework. Even though social engineering is considered a structural approach that is not very compatible to the student centric approach that this framework is built upon, it is considered a necessary and appropriate way of creating work groups given the immaturity of the students (between 11 and 12 years old). Another important issue to the Vygotskian creation of pairings within groups is the necessity of the development of the skills through interactivity. So, the pattern the groups follow is a variation of the one that Vygotsky suggested. A student that is more able in terms of social skills is paired with a student that is less able in terms of social skills. The quantity and eventually the quality of interactions between the students is expected to eventually create the activation and the gradual development of collaboration skills.

This leads to the next line of thought. What are the collaboration skills that need to be developed? Is collaboration a skill or does it comprise of different elements? Before answering these questions it is very crucial to stop and ask. How all of the above can be transformed into measurable, teachable, tangible skills that can follow the implementation of a collaborative framework? One very important tool for assessing collaboration skills is proposed by Hesse (Hesse F., et.al, 2015) and his colleagues. The reason behind selecting this tool is based on the elements that it comprises and the clear distinction of the terms used. So ambiguity between the terms is minimized, while the elements are in parallel with the collaboration theories that support this framework. Another critical factor is that the assessment tool is flexible enough to be used not only in the beginning and the end of exploratory sessions but can be used in and between phases resulting to more information about the gradual development of collaboration skills.

CURRENT OBSERVATIONS AND RESULTS

Having the positive results from last year, the framework shows that has potential, the next step was to start measuring the results. The first thought was to remain on just taking one

measurement at the beginning of the whole procedure and one at the end. However, it was clear that this would not give a great insight on how the collaboration skills develop. On the other hand, this was very challenging since the dual role of being both a teacher and a researcher at the same time made the whole endeavor much more difficult. However, this was solved by taking measurements approximately every two or three sessions in times when tasks seemed to move forward. Again, it was considered to use agents (human or audio/visual) but at this particular time it was perceived as risky because it would undermine the natural behavior of the students, which in our case is of critical importance.

GROUP SESSION 1

During the first session of group work, table 1 was used to capture the state that the collaboration skills were. The figure 2 shows that most of the students gathered values that ranged from 2 to 6. But what these numbers describe? These numbers describe only the level of participative skills that got activated during this first session. None of the students managed to score any points in perspective taking or social regulation skills. The student numbered as 9 was absent during this session so it was decided to insert none participative skill. Similarly, even though student 16 was present during the first two meetings of creating the ground rules and establishing the project's guidelines, his family moved to another city so in order to honor his participation in the very first lessons number 16 was not transferred.

The tasks during this session were mainly of understanding what the parts were and what their use would be for the project. Some students during this session interacted lightly with their groupmates and some did not interact at all. However, most of students presented high levels of action and perseverance.

Figure 1 Results of measured collaboration skills during Construction Phase

GROUP SESSION 4

During this session the students started to have a grasp of what is going on with most of the pieces of the Lego WeDo kit, while they started developing their interactive skills even more in quantity and in quality as well. It is observed that most of the students transformed their high interactions into more meaningful ones in terms of quality. So six students are developing adaptive responsiveness and five students are using adaptive responsiveness in a high level. It is important to mention that the skill of audience awareness is developed by almost fifteen students (6 medium level, 7 high level and 2 between low and medium). The formation of structures and the options that are arising started to engage the students in some form of negotiations as well. So in this stage there is an observable important number of students that start negotiating. The negotiation skill is observed that has a medium level of development and has direct correlation to the negotiation skills the group mates present. So it is observed that within group 1 (s1,s2,s3,s4), there is no development of negotiation skills in comparison to all the other groups that have at least one in the medium level or low level of developing this skill. It is noted as a positive surprise that all students assume responsibility initiative. This is surprising because the rest of the social regulation skills are not developed at all with an exception of the low to medium negotiation

skills.

Figure 2 Results of measured collaboration skills during Construction Phase

GROUP SESSION 5

This session came after 14 days of absence from the laboratory due to the national holiday. There is normally a seven day gap between sessions so it was important to observe and measure if there was any diminishing in the development of the collaboration skills. On the contrary the students came back in the laboratory with high motivation and expressed the feeling of longing to come back and continue their projects.

The students in this session in their vast majority developed their collaboration skills. With a note of being very careful it seems that the socially more able students are pulling up their group mates. This is expressed by the start of a certain pattern of uniformity when measuring the elements that comprise collaboration skills. It is noted as well that the work of the group members becomes more harmonious and the tasks of assembling the parts are done with a sense of agreement. In relation to the skills, it is measured that only three students remain at medium level of perspective taking skills and two of them are in the same group. It is also measured that only one student developed high levels of negotiation skills, while his group mates are between low and medium. There are still no self-evaluation and transactive memory skills on any student. Concluding this phase there is a sense that collaboration skills are both being developed but are also transferable.

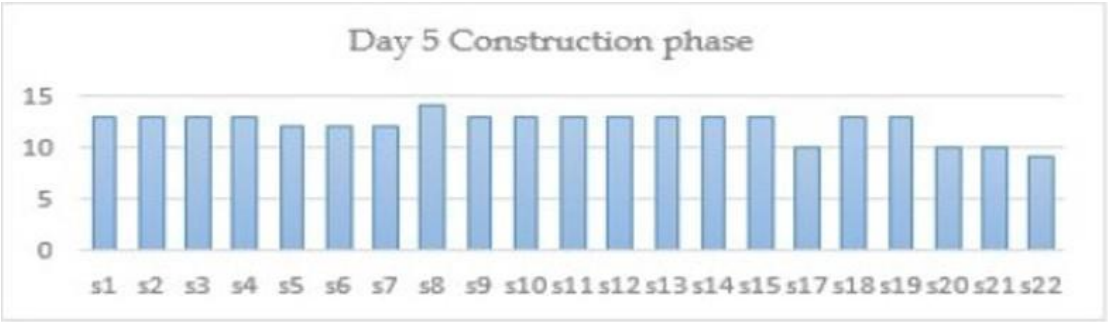

Figure 3 Results of measured collaboration skills during Construction Phase

GROUP SESSION 7

This session was done after an almost 2 month period that the school was closed due to the covid-19 restrictions. Even though this period was quite a long period of absence for the students, this did not by any means diminish their motivation and their skills are still being normally developed. In this stage it is very important to praise the significance of educational robotics as a very successful and attractive tool towards the commitment of the students.

During this session the students in two groups (g2 and g5) are getting ready to jump into the connections phase. The students asked the teacher to help them decide whether they should take the step to move forward. The teacher responded that this decision should be the teams' collective decision and the two groups decided to brush off some small construction and design problems and then move

forward.

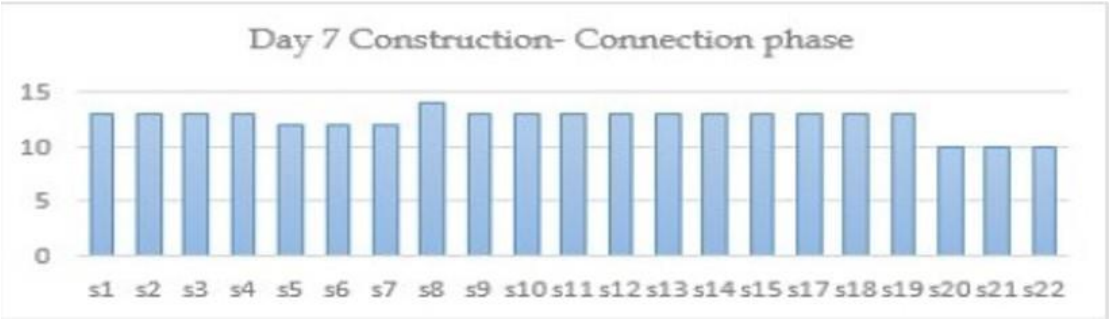

Figure 4 Results of measured collaboration skills during mixed Phase

GROUP SESSION 9

This session was very energetic, because five out of six teams are either going to the connections phase or to the programming phase. G1 decided unanimously to end the project by following a programming method that does not require the use of sensors. This was acceptable because the students had open ended answers for the project. They had a plan A and a plan B if the program did not work.

The teacher approached the happy team and had a conversation with the group mates. During the conversation the students decided that it would be challenging and satisfying if they transformed their artifact into a truly robotic artifact introducing the use of sensors. G2 is currently trying to reconnect the artifact. G3 is currently into the construction phase, patiently trying to perfect their solution. G4 just stepped into the connection phase and are eager to start the programming phase. G5 had some problems with the connections phase because the USB ports do not recognize the Bluetooth device, but they express great stamina and perseverance, both individually and collectively. G6 is currently trying to understand the leaflet instructions for the connections.

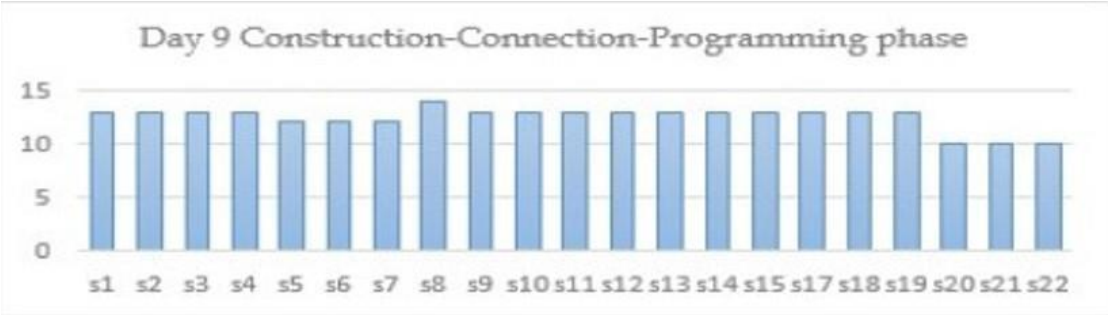

Figure 5 Results of measured collaboration skills during mixed Phase

GROUP SESSION 11

Again, during this session almost all teams had problems in connecting the artifact to the computer. Even though the booklet gave detailed instructions, many times due to simultaneous attempts in connections there were problems. The biggest problem was that the teams became frustrated. The positive element out of this negative experience was that none of the teams gave up the attempts to reconnect and always searched for explanations and solutions. When G1 eventually connected their artifact, they expressed higher level of negotiations on how the programming should be developed including the sensors. This group asked for a pen and a paper in order to write down the possible solutions and discuss them before they apply the solutions into Scratch. G2 found the connection phase very demanding. G3 during this session were calmer and took things in a step like fashion and gave the booklet a lot of attention and showed great quality in their interactions. G4 was initially frustrated and expected more guidance during the procedure, however, they managed to conclude the task.

G5 and G6 concluded the task after numerous attempts and eventually started the programming phase. During this session G1 was the only team that increased their negotiation skills into the highest level. Generally, this session was frustrating because many technical malfunctions happened, even though the guidelines were followed. This shows the level of difficulty sometimes E.R can present to the students. The problems were not expected and the students were unpleasantly surprised. This was last session that took place, before it was announced that the primary schools close again due to Covid-19 restrictions.

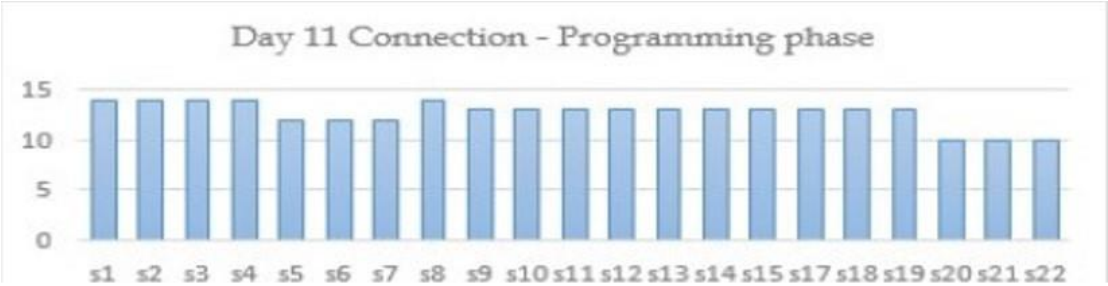

Figure 6 Results of measured collaboration skills during mixed Phase

DISCUSSION AND CONCLUSION

This is the second year of the first research attempt that explores the effects of a pedagogical framework in E.R for the development of collaboration skills, which analyzed the impact of the tasks in parallel to the skills developed.

It is clear that the construction phase of an E.R artifact presents a great opportunity for students to start from the same level of knowledge. It useful to remember the proposal that Dillenbourg has made. The symmetry is very important when it comes to knowledge, and during this first important phase it is vital for students to be at the same starting point. Of course there is an element of concern. Many students now days use the internet and online tutorials in order to sharpen their abilities with an issue that are interested with. This fact can somewhat undermine the notion of "symmetry of knowledge" and bring one student in front of another in generating ideas or having "ready-made" solutions in their minds. It is important at this point to locate this within the groups and with helpful suggestions to bring the students back to more pluralistic and democratic approaches that include all the groups' members. This element brings us to the next important element of synchronicity.

Synchronicity is an element that is mentioned in the statements that Dillenbourg and Roschelle and Teasley expressed for describing the prerequisite elements for collaboration. During the first year of this research synchronicity was tackled vaguely and was not given too much attention during the conversations between the teacher and the students. The major issue in the first year was to seek the elements of convergence. This year the element of synchronicity enhanced and speeded up the process of convergence among the group members and collaborations skills were more visible during earlier phases of the experiment. Even though it was not verbally expressed by the students, high synchronicity among the students was observed to be more tiring mentally.

Another issue that was derived from this year's experiment was that during all the sessions there were no visible (verbal or external expressions) of self-evaluation skills. It is possible that students are afraid to express verbally self-evaluating thoughts because the formal school settings are obligated to follow the grading system. This experiment underwent during a school year within the alumni of computer science module and students expected grades every semester. Even though the teacher/researcher in the beginning of the experiment reassured the students that this will not affect their grades, there is a possibility that the thought of grading could not be forgotten or put aside. For this important issue there will be more discussions next year on this topic so students can express or develop self-evaluation skills.

REFERENCES

Bruffee, K.A. (1993) Collaboration, conversation, and reacculturation in K.A. Bruffee (Ed.) *Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge,* Baltimore, MD: Johns Hopkins University Press.

Dillenbourg, P. (1999). What do you mean by 'collaborative learning?' In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and Computational Approaches* (pp.1–19). Oxford: Elsevier.

Hesse F., Care E., Buder J., Sassenberg K. & Griffin P. (2015) A Framework for Teachable Collaborative Problem Solving Skills. In: Griffin P., Care E. (Eds), *Assessment and Teaching of 21st Century Skills. Educational Assessment in an Information Age* (pp.37-56). New York: Springer, Dordrecht

Panitz, T. (1999) *Collaborative versus cooperative learning: A comparison of the two concepts which will help us understand the underlying nature of interactive learning*. Retrieved from http://home.capecod.net/~tpanitz/tedsarticles/coopdefinition.htm

Roschelle, J. (1992) *Learning by collaborating: Convergent conceptual change*. Journal of the Learning Sciences, 2, 235–276.

Roschelle, J. & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem-solving. In C.E. O'Malley (Ed.), *Computer-supported collaborative learning* (pp. 69–97). Berlin: Springer-Verlag.

Vygotsky, L.S. (1978) *Mind in Society: The Development of Higher Psychological Processes*, Ed. And trans. M. Cole, V. John-Steiner, S. Scribner and E. Souberman, Cambridge, MA: Harvard University Press.