CHILDREN'S ENGAGEMENT AND LEARNING IN "MOVING TOYS" WORKSHOPS IN THE 1ST CYCLE OF SCHOOLING

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ABSTRACT

The motivation and interest of children and young people in science areas remains a challenge for contemporary education, and there is also evidence of the importance of its promotion since the early years of schooling as well as the use of interdisciplinary approaches.

The Erasmus + AutoSTEM project aims to analyse the potential of constructing automata or "moving toys" as a motivation strategy for learning in the areas of science, technology, engineering and mathematics (STEM), in the early years of schooling. The characteristics of the automata, namely the fact that they have a narrative part and a mechanism, allow, in a playful approach, to implement activities related to the planning and construction of those toys and to enhance skills such as observation, problem solving, creativity and also skills in the referred STEM areas.

In this work, the description of the implementation and evaluation of automata workshops in a school of the 1st year of basic education is made. The data were collected based on direct observation focusing on dimensions of engagement and a questionnaire regarding interest, perception of learning, difficulties experienced, suggestions for improvement. Results evidence that the children showed curiosity for the prototypes presented, having immediately designed their own project, explored materials and completed the construction, in some cases with their own proposals. The perceived difficulties vary according to the age, as well as the type of mechanism chosen.

Keywords: automata; STEM; involvement; learning

RESUMO

A motivação e interesse de crianças e jovens por áreas de ciências continua a ser um desafio da educação contemporânea, existindo também evidências da importância da sua promoção desde os anos inicias de escolaridade e do recurso a abordagens interdisciplinares.

O projeto Erasmus+ AutoSTEM visa analisar o potencial da construção de autómatos ou "brinquedos que mexem" como estratégia de motivação para a aprendizagem em áreas de ciências, tecnologia, engenharia e matemática (CTEM), nos anos iniciais de escolaridade. As caraterísticas dos autómatos, nomeadamente o facto de serem constituídos por uma narrativa, e um mecanismo permitem que, numa abordagem lúdica, atividades relacionadas com a planificação e construção dos referidos brinquedos, potenciem competências como a observação, a resolução de problemas, criatividade e também competências nas referidas áreas CTEM.

Neste trabalho, são descritas a implementação e avaliação de oficinas de construção de brinquedos no 1º ano do ensino básico. A recolha de dados envolveu a observação direta incidindo em dimensões do envolvimento e num questionário, incidindo no interesse, aprendizagens, dificuldades, sugestões de melhoria. Os resultados evidenciam a curiosidade das crianças pelos protótipos apresentados, tendo desde logo elaborado o seu próprio projeto, explorado materiais e concretizado a construção, em alguns casos com propostas próprias. As dificuldades percebidas variam em função da idade, o mesmo se verificando com o tipo de mecanismo escolhido.

Palavras-chave: automata; STEM; envolvimento; aprendizagem

The motivation and engagement of children and young people in science areas continue to be challenges for contemporary education, and there is also evidence of the importance of its promotion since the early years of schooling. The importance of these aspects highlights the need to understand the dimensions that characterize motivation or engagement and strategies that can promote them. Both motivation and engagement are multifaceted and interconnected constructs. In particular, the concept of intrinsic motivation can take on dimensions related to autonomy, interest, sense of competence, stress, perception of value, among others, and complex and subtle dynamics between these various dimensions (Deci and Ryan, 2000). Since "intrinsic motivation results in high-quality learning and creativity, it is especially important to detail the factors and forces that engender versus undermine it" (Deci and Ryan, 2000, p. 55). On the other hand, several dimensions for engagement have been proposed, for example, the affective, behavioral, cognitive levels. Thus, it is possible to say that engagement is a "multidimensional construct that unites affective, behavioral, and cognitive dimensions of student adaptation in

the school and has influence on students' outcomes" (Veiga et al., 2012, p.118). In short, the affective dimension is related to the child's emotional experiences during the learning process; the behavioral dimension is related to the child's effective behavioral participation in their learning process; finally, the cognitive dimension concerns the child's mental orientation during learning (Gonçalves, 2017).

The Erasmus + AutoSTEM project aims to analyze the potential of building automata or "moving toys" as a motivation strategy for learning in the areas of science, technology, engineering and mathematics (STEM), in the early years of schooling. The characteristics of the automata, namely the fact that they consist of two parts, on the one hand, a narrative, on the other hand, a mechanism, allow, in a playful approach, activities related to the planning and construction of the referred toys to enhance the interest and engagement in the aforementioned STEM areas, namely in terms of knowledge and construction of simple mechanisms, understanding of their functioning and / or the narrative they represent, and skills such as observation, problem solving and creativity. In this work, examples of these resources are presented, as well as the description and results of their implementation of workshops in a basic school.

METHOD

Participants

In workshops were present 30 students of the 1st, 2nd, 3 rd and 4th grades of a Basic School of Portugal – centre, with ages between 6 and 9 years. In the Workshop 1 were present twelve students, two from the 1st grade and the remaining ten from the 3 rd grade. In the Workshop 2 were present eighteen students, six from the 2nd grade and twelve from the 4th grade.

Structure of the activity and processes. Automata used

There were two sessions separated in two workshops, Workshop 1 and Workshop 2. These sessions followed the organization usually used in the school. The sessions lasted for four hours each.

The two sessions followed the same structure and processes, involving the observation of automata with different mechanisms and narratives, the planning and construction of their own automata, the presentation of the finished projects and reflection around it.

The activity started with a short presentation about the project and some examples of automata. In the sessions, automata with the rotation mechanism, linkages and lever were presented. After that, it was read a poem about the environment, related to the school network theme and is also very related to the sciences and citizenship curriculums. Children observed the automata presented, explored materials and plan their own automata. It was given to the children total freedom to create their automata based on the mechanisms that were showed.

Learning outcomes

Taking in account the aim of AutoSTEM project to promote motivation of children to STEM, some learning goals were formulated. In this scope, it was expected that children identified and constructed a proposed mechanism with a narrative and that the kids would develop solving problems skills as also their transversal skills and well-being.

The specific theme of this session was the environment, so it was expected that the kids develop some consciousness about it.

Evaluation

The evaluation of the workshops was done through an evaluation questionnaire and participant observation.

The questionnaire includes statements and open questions about motivation, perception of learning, experienced difficulties and suggestions for improvement.

The observation guide includes indicators on engagement: behavioural, affective and cognitive; children's expressions of satisfaction, products developed in order to analyse learning and creativity.

Following the indicators considered in engagement:

- Behavioural engagement was analysed through participation in the activity, to plan a project and to work on it.
- Cognitive engagement was analysed through dimensions as observing with attention, being curious about the movement and mechanisms, exploring materials, making a project and adapting procedures to develop it, asking questions, solving problems. -

Affective engagement was analysed considering expressions of interest, during the session and in the answers to the questionnaire. In the final considerations it is possible to see if the child shows pride in what he/she built.

Learning was considered based on the answers of children to the questionnaire, as well as the analysis of the automata produced. In this scope, the indicators considered were the parts of the automata:

- The automata have mechanical and narrative parts
- The automata are produced with one part, and its functioning.

For creativity, the indicators involved the use of materials or the characteristics of the automata produced: it is a copy of the one presented; have new mechanisms; propose new narratives.

During the workshop, the trainers talked with the children about their ideas, and took some notes. After the workshop children answered the questionnaire.

RESULTS

Next will be presented the data collected through the various instruments and based on the indicators referred to in the previous section. There are three general sections, one for engagement and motivation, other for perception of learning and another for critical incidents. In each section, the results will be presented separately depending on the two sessions, Workshop 1 and Workshop 2.

Engagement and motivation

Initial plans. In Workshop 1, taking in account participant observation, the kids shown very engaged and enthusiastic with the workshop. They immediately started to analyse the automata available, showing curiosity about their functioning. In order to develop their project, children also started to imagine their own and had to make adaptations, experiences, tests. This process can be an evidence of cognitive engagement as children were curious enough to start they own projects as soon as the challenge was launched.

The analysis of the plans evidences that most of the kids drew really similar to the presented automata and in two of the logbooks we couldn't understand the kid's idea.

Regarding the mechanism, seven of the twelve kids drew the mechanism in their initial plans with the decorations they wanted to assemble. In these seven kids that drew the mechanism, two chose the linkages, two chose the lever, one chose the rotation and two children designed different toys with different mechanisms, both chose the lever and the rotation mechanisms. Although not all children had designed the mechanisms they wanted to build, it is possible to see that eight of them intended to build a recycling toy with the lever mechanism.

In Workshop 2, similarly to the described for Workshop 1, the kids shown very engaged and enthusiastic, started to analyse the automata available, the materials and to plan and work on their own project.

In the initial plans, most of the kids drew and planned to build something theme related. Also, most of them in their initial drawings had included the mechanism, some of them didn't drew the mechanism because they planned to build recycling bins with the lever mechanism and in most cases the kids only draw the bins. In the logbooks the kids planned to build three linkages toys, two with linkages and rotation mechanisms, four with only the rotation and six with lever. In this session there was a curious case of a child who drew a new kind of mechanism. In this kid logbook we can see an adaptation of the rotation mechanism by putting a lever inside the box unlike the two rods and the wheels. This last case also shows us how engaging the activity can be, since this kid by exploring the presented prototypes and the available materials was able to create his own innovative project, which can be a cognitive engagement indicator.

In synthesis, in both workshop, children were active engaged into the activity either observing the examples, planning their owns, exploring materials which is a cognitive indicator of engagement. They were inspired by the examples presented but at the same time, more ideas emerged.

Automata produced. The automata produced took in account the prototypes presented, namely the mechanism, but also brought new proposals. In Workshop 1, most of the automata produced were with the lever mechanism, most of the kids built recycling bins and there was only one kid that built a talking animal toy with the box and the lever. Another mechanism also widely used was the linkages, there was six kids that built a linkages toys, some were theme related, with recycling bins, and some others weren't. It was also built one rotation toy with a little doll, this was a singular case since it was one of the youngest kids to build it, after building another toy, with the linkages mechanism (Figure 1). This singular case will be presented later in the critical incidents.

In this session there were two kids that, as planed in their logbooks, built two toys each, one with the lever mechanism applied in recycling bins, and another one with the rotation mechanism. This is an indicator of the engagement

It's also important to refer that in this session there were present kids in different age groups but to all of them were presented all the toys regardless of the degree of difficulty of each one of them. In this way it was possible for us to observe that the younger kids, in the first grade, chose a simpler mechanism, which is the linkages one, and it's what is normally applied to children of this age in sessions in which only one of the mechanisms is presented and built.

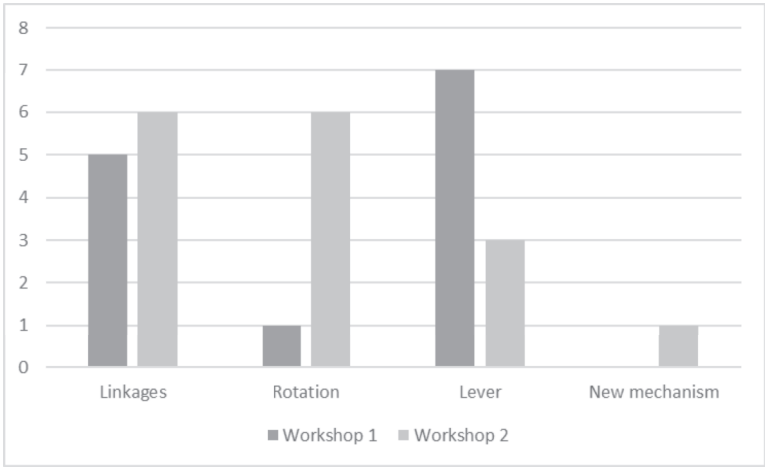
In Workshop 2, the automata produced took in account the prototypes presented, namely the mechanism used, but also brought new ideas and proposals. Most of the automata produced were the linkages followed by the rotation ones. In less quantity were also built three lever toys, two were recycling related and the other one was the new adaptation that a kid made to the rotation mechanism by putting a lever inside a box and not the rods and wheels as usual (Figure 1). This case will also be explained in the critical incidents.

In this session it was visible that the kids respected the theme since almost every toy assembled had something to do with the environment. The kids were very committed in the decorations of their toys and by analysing the final projects it's notorious the effort that each kid put in their toys.

It's important to mention that in this session since the kids were older, they ended up by choosing more difficult mechanism as the rotation one and the percentage of lever mechanism was inferior which is the easier mechanism to build. In the difficulties presented two kids mentioned the assembling of the linkages, due to the fact they didn't had that much instructions to do it.

In synthesis, all children constructed their own automata, correctly as all the products had mechanisms and functioned. Children had original ideas and were very creative in what they were building. Children also invested a lot of effort and imagination in the narrative part of their automata. In Figure 1. the mechanisms constructed in the sessions are presented.

Figure 1. Chosen mechanisms in the two sessions.



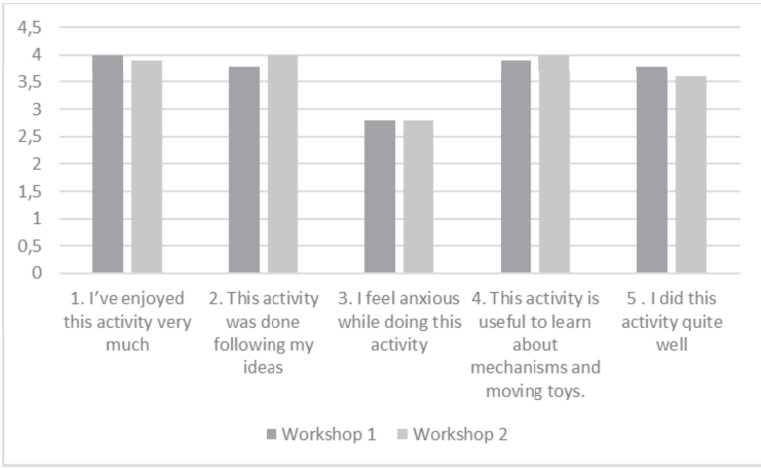
The successful conclusion of the activity, with even some kids that built more than one toy is a behavioural engagement indicator since the children got really into the activity and had an active participation and went through all the planned stages as the curiosity and analysis of the presented prototypes, the planning of their own toys, the assembling and the final reflection.

Participants satisfaction. During the sessions, children also expressed satisfaction of being there, this satisfaction was also expressed in the questionnaires answered at the end of the session. Following these results are presented. Concerning Workshop 1 all the kids answered that they enjoyed the activity very much and that they would like to repeat the activity. Regarding the children expectations most of them concluded they had reached them successfully with only two participants reporting not being completely satisfied. As for the nervousness parameter we can see that most of the participants consider that they didn't felt nervous during the realization of the automata, however, there are three participants who distance themselves from the rest, since they felt very nervous. Most of the children recognized the importance of this kind of activities to learn about moving toys and mechanisms, with only one kid disagreeing with that. Finally, concerning the perception of their aptitudes for the construction of automata all the kids considered they were able to build automata and they were good at it. Respecting the open question about what they most liked, the majority said that the workshop was fun, and they enjoy artistic expression activities. Some kids also answered that enjoyed the activity because they like to build things as toys.

At the end of the Workshop 2, children also answered a questionnaire. In this case, kids also answered that they enjoyed the activity very much and that they would like to repeat it. Most of them considered that the activity is useful to learn about mechanisms and toys that move and that they are good enough building moving toys, which is interesting as allow us to understand their motivation to this kind of activities. Concerning the open question about what they most liked, the majority said that the workshop was fun, and they enjoy handwork activities. Some kids also answered that they enjoyed the activity because they were able to learn about new things as how to build moving toys and with recycled materials. A thing that also pleased the kids was the fact that they were able to use a lot of materials as paints and glue.

In synthesis the results evidenced that in both workshops, there are high levels of satisfaction and interest, pointing to affective engagement. Following, in Figure 2, are presented the results from both sessions.

Figure 2. The results of the answers to the questions related to the intrinsic motivation.



This results can be an indicator of affective engagement since the children's appreciation for this type of activities is notorious as all of them answered they've enjoyed it. During the sessions it was also possible to notice a high level of enthusiasm and the pleasure with which the children completed the tasks. In addition, it was clear the pride with which they presented the pieces they built.

Perception of learning

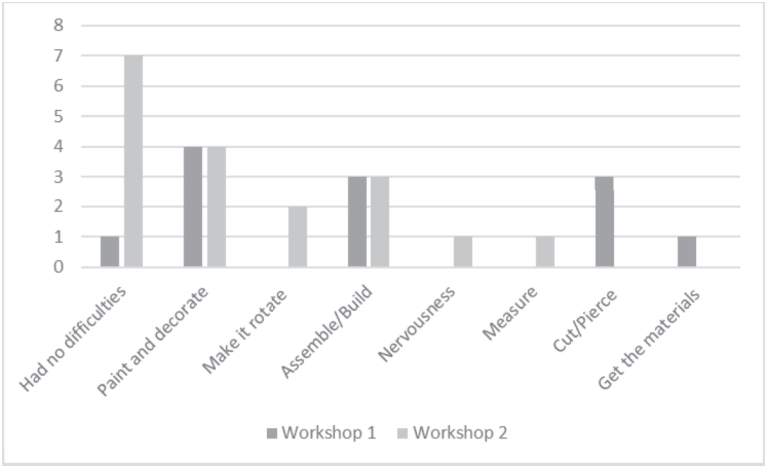
Learning outcomes. In Workshop 1, results from the open question about perception of learning during the activity, evidenced that the kids said that their biggest learning is related to their skills of building toys, and only one kid mentions moving toys. Some kids also answered that they learned about the environment and how to recycle, and two of them answered that had learned about mechanisms and how to paint.

In Workshop 2, results from the open question about perception of learning during the activity, evidenced that the kids said that their biggest learning is related to their skills of building toys that move and with recycling materials. Some kids also answered that they had learned about new things and learned to work with more and different materials.

Perceptions of difficulties and improvements. In Workshop 1, the biggest difficulties presented are related to the assembly of the toy in general and the mechanism. It was also mentioned the paintings as a difficulty and fewer kids also mentioned cutting, decorating and obtaining materials as a perceived difficulty.

In Workshop 2, most of the kids in this session answered that they didn't had any difficulties during the activity, although some others mentioned a few obstacles they felt. Some kids said that they had difficulties on getting the mechanism rotate, to assemble the linkages, in measuring and one kid answered that his difficulty was his nervousness.

Figure 3. Difficulties felt during the sessions.



About the suggestions given by the children in Workshop 1 most of the kids answered that there wasn't nothing to improve. Some of the kids suggested that would be interesting to have more materials in the workshop also to build more and different toys. Some kids also suggested that would be nice to have more people helping.

Concerning the improvements to the project, in Workshop 2, one of the kids suggested think faster which can be a suggestion to himself and not to the project in general. Other than this kid there wasn't any other suggestions of improvement.

Critical Incidents

In Workshop 1, there was one of the youngest kids, from the 1st grade, that in the same time built two toys, one with the linkages mechanism and the other one with the rotation mechanism, which is an harder one and usually applied in activities with older children. By observing during the activity and talking to this kid teachers we were able to perceive that this kid was usually very agitated and easily distracted. In this session there was a behavioural change since he got really committed and engaged in the activity. This kid started by building a simpler toy which is the linkages one, and even got time to decorate it. After that the kid wanted to start a new toy and he was told he could if he wanted to, so he ended up by choosing the rotation one. Even though he had help to build both toys, specially the rotation one, it's impressive the motivation and engagement to the task. This can either be a behavioural indicator as an affective indicator of engagement. In one hand the kid got really into his projects and put a lot of work on it to assemble both toys, in the other hand the kid showed a lot of interest and was proud about his accomplishment in the end. Beyond this even the teachers were surprised by how he was focused on the task and how he completed it so well.

In Workshop 2, one kid, by seeing and analysing the presented prototypes and their mechanisms developed a new idea of mechanism by combining the lever with the structure of a rotation toy. The idea was to switch the rods and wheels that make part of the mechanism by two card strips glued in a perpendicular way. Thus, by pushing the lever the kid was able to make his decorative figure go up and down, in this case it was a rocket.

It was interesting that the kid was really committed to the mechanism and to assembling all the structure but not so much to the decorative part. The kid was enthusiastic bye the assembling and putting together all the parts to prove that his idea would work but when he had put it all together and came the part of decorating, in this case the rocket he got less interested. The part of painting, although in a less enthusiastic way the child still completed but when he had to draw his rocket, he got unmotivated and made a small and simple rocket with no. After a little

motivational talk with the kid in which we explained to him that he had a really good idea by changing the mechanism it was pity to not put a really big and colourful rocket to put in value is amazing toy. The kid eventually agreed and started a new rocket with more motivation and commitment and in the end when it was all assembled, the rocket in the structure, the kid got really proud about his project has every person told him that he was very original and the toy was amazing.

This singular situation can be an affective indicator of engagement, by how proud the kid was in the end, and a cognitive one since the kid was curious enough about the task and about what was presented to him to rethink it and develop a new mechanism.

DISCUSSION AND CONCLUSION

Based on these results, we were able to recognize a convergence in all the parameters analyzed, although small differences emerged according to the ages of the participants in each session.

In both workshops there was a high level of motivation and interest in the task. All the children showed their interest in the activity from the beginning and were quite autonomous in developing their ideas, which proved to be quite creative. Furthermore, it was only in rare exceptions that children were nervous about their ability to complete the task successfully, having most of the time realized their value and their ability to carry out the challenge according to their ideas. All of this was proven by the participant observation made by the educators present during the activity, and by the answers to scales about children's intrinsic motivation.

In addition to this, the engagement in the task was also clear, in one hand during de activity, and in the other hand, in the responses to the questionnaires whose results were previously analyzed. There were several results that show us strong evidence of engagement indicators, both at an affective, cognitive and behavioral level. During both sessions the appreciation of the activity was notable as well as the satisfaction for the work developed by each child.

As a rule, the children said they were happy to participate in the project and also proud of the work developed. At a cognitive level, the curiosity felt by the students about the various prototypes presented and the respective mechanisms was clear from an early stage, which made them involved in the task by asking questions, exploring materials and options and developing new ideas. Finally, the behavioral engagement was equally evident since all children successfully completed the activity, having even exceeded expectations in some cases, as were the cases of the two critical incidents described.

Thus, and based on the idea that motivation and engagement are two great enhancers of learning, we can recognize the importance of activities such as those developed by the AutoSTEM project for the acquisition of learning in the STEM areas. This type of activities allows to develop, in a playful way, the predisposition for learning in STEM areas that previously would be a challenge. In a motivated and engaged way, students ask questions and test hypotheses that they would not have asked in the past, thus developing their learning potential.

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