5. Children's engagement and learning in a Moving toys workshops in a primary school[1]

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Introduction

This case study analyses children's engagement and motivation in **AutoSTEM** project workshops. The **AutoSTEM** project aims to analyze the potential for building automata or "Moving toys" as a motivational strategy for learning in the subject areas of science, technology, engineering and mathematics (STEM), it is important to to understand how this is done and whether it is having the desired results.

The motivation and engagement of children and young people in science subjects continues to be a challenge for contemporary education, and there is evidence of the importance of its promotion in the earliest years of schooling (e.g. Campbell, Punello, Miller-Johnson, Burchinal & Ramey, 2001). The importance of this highlights the need to understand the dimensions that characterize motivation or engagement,

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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 & 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 & Ryan, 2000, p. 55).

Several dimensions for engagement have been proposed, for example, at 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).

In the **AutoSTEM** project the automata used consist of two parts, , a narrative part and a mechanism, These allow, a playful approach, with activities related to the planning and construction of the automata toys to enhance the interest and engagement in the STEM subjects listed above. Particularly in the 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.

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Context, approach, and implementation

In this case study 30 children in the1st, 2nd, 3 rd and 4th grades of a primary school in Portugal between 6 and 9 years old, participated in two workshops. In Workshop 1 were twelve students, two from the 1st grade and the remaining ten from the 3rd grade. In Workshop 2 were eighteen children, six from the 2nd grade and twelve from the 4th grade.

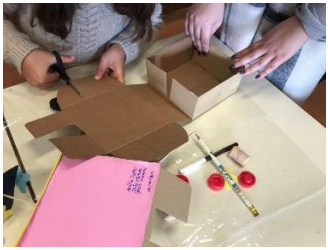
These two workshops kept the classroom arrangement in the school and were three hours each. The two sessions followed the same structure and processes for the children, involving:

- The observation of automata with different mechanisms and narratives,
- The planning and construction of their own automata,
- The presentation of their finished automata and reflecting on what they have done

The activity began with a short presentation about the project and some examples of automata with a rotation mechanism, linkages, and a lever. Next a poem was read about the environment, related to the school network theme and closely related to the science and citizenship curriculums. Children looked at the automata, explored the available materials that had been made available, and planned their own automata (Figures 1, 2 & 3).

The children had total freedom to create their own automata based on the mechanisms that they were shown (Figures 4, 5 & 6).





Figures 1, 2 & 3. Children working on their automata.



Figures 4, 5 & 6. Children building automata.

After the time allocated for construction time was complete, children showed their automata to the class and then answered a questionnaire (Figure 7).

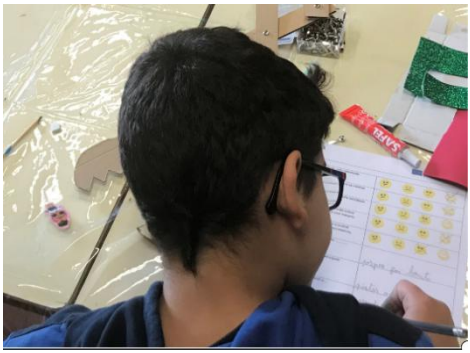


Figure 7. Child answering the questionnaire

To evaluate these two workshops both a questionnaire and participant observation were referenced. The questionnaire

included statements and open questions about motivation, perception of learning, experienced difficulties, and suggestions for improvement. The observation guide included indicators on engagement: behaviour - affective, and cognitive; children's expressions of satisfaction and products developed in order to analyse learning and creativity.

The indicators considered in the engagement analysis were:

- Behavioural engagement analysed through participation in the activity, to plan a project and to work on it.
- Cognitive engagement, analysed through the areas of 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 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 analysed based on the answers of children to the questionnaire, as well as the analysis of the automata produced. The indicators considered were the parts of the automata:

- That the automata have mechanical and narrative parts
- That the automata has been produced with at least one part that is functioning.

For creativity, the indicators involved the use of materials or the characteristics of the automata produced:

- That it is a copy of the one presented;
- That is has new mechanisms;
- That it has new narratives.

Challenges

A challenge was that a variety of automata with different mechanisms, were presented simultaneously to the children, that required the children to make decisions about what they wanted to make, as well as requiring the preparation of a plan. This needed the children to feel sufficiently involved, with the motivation necessary, for its implementation.

Results

The various data collected has been analyzed into three general sections:

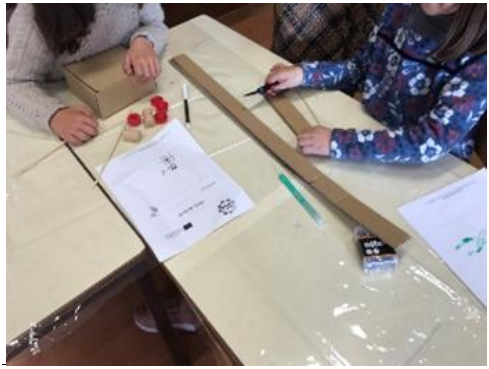
- For engagement and motivation,
- For perception of learning
- For critical incidents.

In each section below, the results will be presented separately and interpreted as two sessions, Workshop 1 and Workshop 2.

Engagement and motivation

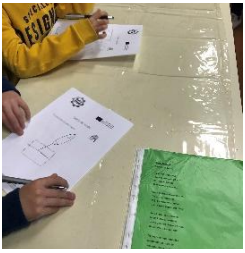
Initial plans In Workshop 1, taking in to account participant observation, the children were very engaged and enthusiastic during the workshop. They immediately started to analyse the automata available, showing curiosity about their functioning.

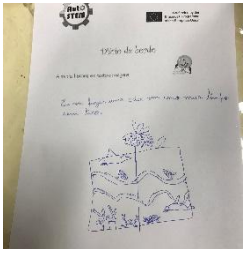
To develop their own project, the children started to imagine their own automata and how they would make adaptations and test it. This process can be seen as evidence of cognitive engagement as the children were curious enough to want to start their own projects, as soon as the challenge was launched. An analysis of the plans showed that most of the children drew something that was similar to the automata that they had been shown, but in two of the children's logbooks, we couldn't understand the child's idea (Figures 8 & 9).



Figures 8 & 9. Children working with their initial plans

Workshop 2, was similar to what has been described for Workshop 1, the children showed strong engagement and enthusiasm. They wanted to start to analyse the automata available, the materials, and to plan and work on their own project (see Figures 10, 11 & 12).





Figures 10, 11 & 12. Children working on their initial plans.

In this session, there was a interesting case of a child who drew a new kind of mechanism. In this child's logbook, we can see an adaptation of the rotation mechanism by putting a lever inside the box unlike the two rods and the wheels in the displayed example. This case shows us how engaging the activity can be, since this child by exploring the presented prototypes and the

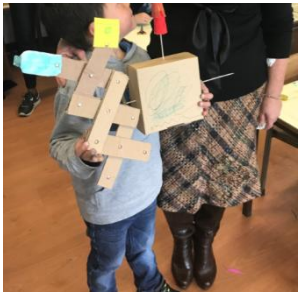
available materials, was able to create his own innovative project, which can be a cognitive engagement indicator.

In conclusion, in both workshops, children were actively engaged in the activity either observing the examples, planning their own, exploring the materials that are cognitive indicators of engagement. They were inspired by the examples presented but at the same time, more ideas emerged.

Automata produced.

The automata produced took in to account the automata and mechanisms presented to the children, but also inspired new ideas. In Workshop 1, most of the automata produced were with the lever mechanism, most of the children built recycling bins, similar to one shown them at the beginning, where each box has a lever with similar colour to the box. There was one child that built a talking animal toy with the box and the lever (Figures 13 & 14). Another mechanism used widely was the linkages, there were six children that built toys with linkages, some were theme related, with recycling bins, and others were not. One rotation toy with a small doll was built; by the youngest child after it had built a linkage toy, (Figure 1). This single case will be presented later in the critical incidents.

In this session, two children planned to build two toys each and described them in their logbooks, one with the lever mechanism applied in recycling bins, and another one with the rotation mechanism. This can be seen as an indicator of engagement.



Figures 13 &14. Children presenting their automata.

It is also important to know that in this session there were children from different age groups. All of them were shown all the toys regardless of the individual difficulty for each child. In this way, it was possible for us to see that the younger children, in the first grade, chose the simpler linkage mechanism. This is the one normally given to children of this age in sessions in which only one of the mechanisms is presented and built (Figures 15, 16 & 17).

Figures 15, 16 & 17. Children presenting their automata from Workshop 1.

In Workshop 2, the automata produced used the mechanisms of the automata presented, but also brought in new ideas and proposals. Most of the automata produced used the linkages next in popularity were the rotation ones. Three lever toys were also built, two were related to recycling and the final one was a new adaptation that a child made of the rotation mechanism

by putting a lever inside a box and not the usual rods and wheels (Figure 1). This case will also be described in the critical incidents below.

In this session, it was clear that the children respected the theme since almost every toy made had something to do with the environment. The children were very committed to decorating their toys and by analysing the final projects it is very clear how much effort each child put in to their toys.

It is important to mention that in this session as the children were older, they chose more difficult mechanisms to build, such as the rotation one. In dealing with the difficulties encountered, two children mentioned the assembling of the linkages, they said that they didn't have detailed instructions how to do it (Figures 18, 19, 20, 21 22 & 23).

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Figures 18, 19, 20, 21, 22 & 23. Some automata produced in Workshop 2.

In conclusion, all the 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 built. Children also invested a lot of effort and imagination in the narrative part of their automata. In Figure 24 the mechanisms constructed in the sessions are shown.

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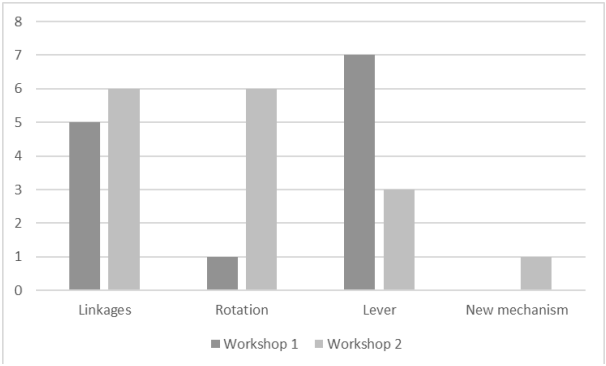

Figure 24. Chosen mechanisms in the two workshops.

The successful conclusion of the activity, with some children even building more than one toy is a behavioural engagement indicator since the children fully engaged with the activity and exhibited active participation. They progressed through all the planned stages from curiosity, to analysis of the presented prototypes, planning of their own toys, assembling and a final reflection.

Participants' satisfaction

During the sessions and when completing the questionnaires, children expressed satisfaction with the activity. In Workshop 1 all the children responded that they enjoyed the activity very much and that they would like to repeat it. Regarding the children expectations, most of them concluded they had reached them successfully with only two participants reporting not being completely satisfied. As for feeling nervous, it can be seen that most of the participants did not feel nervous during the making of the automata; however, there were three participants who distanced themselves from the rest, saying that they felt very nervous. Most of the children recognized the importance of these kinds of activities to learn about moving toys and

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mechanisms, with only one child disagreeing. Finally, all the children thought they were able to build automata and they were good at it. In response to the open question about what they most liked, the majority said that the workshop was fun, and they enjoy activities where they can use artistic expression. Some children also answered that they enjoyed the activity because they like to build toys.

At the end of the Workshop 2, children also answered a questionnaire and the results also showed that they enjoyed the activity very much and that they would like to repeat it. Most of them thought that the activity is useful to learn about mechanisms and toys that move and they are good enough at building moving toys. This is interesting, as it allows us to understand their motivation for these kinds of activities. Concerning the open question about what they most liked, the majority said that the workshop was fun, and they enjoy activities were they work with their hands. Some children also said that they enjoyed the activity because they were able to learn about new things like how to build a moving toy, and working with recycled materials. Something that also pleased the children was that they were able to use many materials as paints and glue.

In conclusion, the results showed that in both workshops, there were high levels of satisfaction and interest, pointing to affective engagement. In Figure 25, are the results from both sessions.

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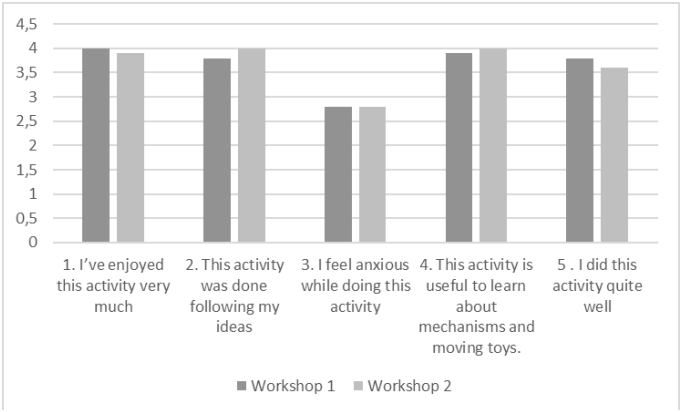

Figure 25. The results of questions related to the intrinsic motivation.

These results can be an indicator of affective engagement since the children's appreciation for this type of activities is clear because all of them answered that they have 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 had built.

Perception of learning

Learning outcomes. In Workshop 1, the children answered the open question on the perception of learning that the primary learning is related to their skill in building toys, only one child mentioned moving toys. Some children 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, the results from the same open question about perception of learning showed that the children thought that their primary learning is related to their skill in building moving toys and using recycled materials. Some children also answered

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that they had learned about new things and learned to work with more different materials.

Perceptions of difficulties and improvements

In Workshop 1, the biggest difficulties were the assembly of the toys in general, and the mechanism. It was also mentioned that the painting was difficult and a few children also mentioned cutting, decorating and obtaining materials as a difficulty.

In Workshop 2, most of the children in this session answered that they did not have any difficulties during the activity, although some mentioned a few obstacles. Some children said that they had difficulties in getting the mechanism to rotate, or to assemble the linkages, in measuring and one child answered that his difficulty was his nervousness (Figure 26).

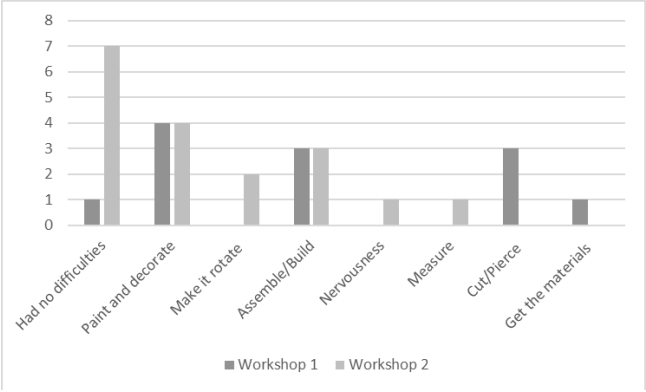

Figure 26. Difficulties felt during the sessions.

When asked to for suggestions, the children in Workshop 1 answered that there was nothing to improve. Some of the children suggested that it would be interesting to have more materials and to build more and different toys. Some children also suggested that would be nice to have more people helping.

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Concerning improvements to the project, in Workshop 2, one of the children suggested to think faster, which could be a suggestion for himself and not to the project in general. Other than this child, there were no other suggestions for improvement.

Critical Incidents

In Workshop 1, one of the youngest children, from the 1st grade, that built two toys, one with the linkages mechanism and the harder one with the rotation mechanism, which is usually used in activities with older children. Observation during the activity and talking to this child's teacher, we understand that this child is usually easily distracted. In this session, there was a behavioural change since he was really committed and engaged in the activity. The child started by building a simpler toy, the linkages one, and even found time to decorate it. After that, the child wanted to start a new toy and he was told he could if he wanted to, so he chose the rotation one. Even though he had help to build both toys, especially the rotation one, The motivation and engagement for the task was impressive. This can be a behavioural indicator as an affective measure of engagement. Firstly, the child really got into his projects and put in a lot of work to assemble both toys, secondly, the child showed a lot of interest and was proud about his accomplishments. Even the teachers were surprised by how he was focused on the task and how he completed it so well.

In Workshop 2, one child, seeing and analysing the presented prototypes and their mechanisms developed a new idea for a mechanism by combining a 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 child was able to make his

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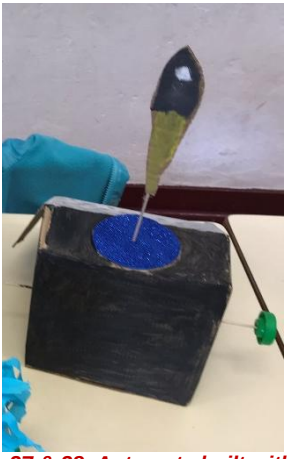
decorative figure go up and down, in this case it was a rocket (Figures 27 & 28).



Figures 27 & 28. Automata built with an innovative mechanism.

It was interesting that the child was committed to the mechanism and to assembling the structure but not as much in decorating it. The child was enthused by the assembling and putting together all the parts to prove that his idea would work but when he had put it all together and was meant to decorate it, he was less interested. The child still completed the painting, in a less enthusiastic way but when he had to draw his rocket, he was not motivated and made a small and simple rocket. After a motivational talk with the child in which we explained to him that he had a good idea by changing the mechanism it was a pity not to put a really big and colourful rocket to add value to his amazing toy. The child eventually agreed and started a new rocket with more motivation and commitment and in the end when it was all assembled, the child was proud of his project because everyone told him that he was very original, and the toy was amazing.

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

Evaluation

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 observations made by the educators present during the activity, and by the answers to scales about the children's intrinsic motivation.

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

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Generally, the children said they were happy to participate in the project and proud of the work developed. At a cognitive level, the curiosity felt by the children about the various prototypes presented and the respective mechanisms was clear from an early stage, which made them involved in the task. This was evidenced by them 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.

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 STEM subjects. These types of activities allow the development, in a playful way, of the interest in learning of STEM subjects that previously could be a challenge. In a motivated and engaged way, children ask questions and test hypotheses that they would not have asked in the past, thus developing their learning potential.

References

Campbell, F. A., Pungello, E. P., Miller-Johnson, S., Burchinal, M. & Ramey, C. T. (2001). The development of cognitive and academic abilities: Growth curves from an early childhood educational experiment. *Developmental Psychology, 37*(2), 231-242. DOI:10.1037//012-1649.37.2.231.

Gonçalves, S. S. B. (2018). *Envolvimento do aluno na escola, perceção de apoio familiar e desempenho escolar*. Mestrado em Psicologia da Educação. Universidade da Madeira.

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Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology*, 25(1), 54-67.

Veiga, F. H., Carvalho, C., Almeida, A., Taveira, C., Janeiro, I., Baía, S., Festas, I., Nogueira, J., Melo, M., & Caldeira, S. (2012). Students' engagement in schools: differentiation and promotion In M. F. Patrício, L. Sebastião, J. M. Justo, & J. Bonito (Eds.). *Da Exclusão à Excelência: Caminhos Organizacionais para a Qualidade da Educação* (pp. 117-123). Montargil: Associação da Educação Pluridimensional e Escola Cultural.

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