USING IOT TO IMPROVE LEARNING

Andreia Magalhães[*]
José Matias Alves[**]
António Andrade[***]

Abstract

Having identified the dynamics of the classroom as an important factor for improving students' learning, we intend to present Internet of Things (IoT), through the learning platform SOLL: Smart Objects Linked to Learning, as a resource capable of generating favorable conditions to an environment of learning.

This because the IoT allows, from sensors, the collection of data in real time in different contexts such as greenhouse, swimming pool or atmosphere, among others. These data generated by the context, for example humidity, temperature or distance, among others, will be analyzed and used by students to carry out theoretical-practical and practical activities, in order to consolidate the Essential Learnings of each discipline involved in the project.This, so that the student finds meaning in what he is learning, without failing to fulfill the essential learnings and the one defined in the student's profile after leaving compulsory education. Therefore, in order to show that the use of IoT can improve learning, an investigation of qualitative methodology was developed, using the SOLL learning platform for interdisciplinary work with 8th graders and their teachers in the disciplines of physics and chemistry, natural sciences, mathematics, geography and information and communication technology, in which the chosen context was the greenhouse, where data on sun moisture, soil and air temperature, soil pH and plant growth were collected to carry out activities. Thus, during the performance of the interdisciplinary activities, data were collected: from the students, a description was chosen, and from the professors, a focused discussion was chosen.

The data obtained show that, in general, activities that use IoT, whether theoretical-practical or practical, create an environment conducive to learning, awaken the senses, increase the motivation for meaningful learning and favor curriculum development from the context as a way to overcome curriculum decentralization, leading students to learn more.s

Keywords: Internet of Things, Education, Learning

[*] Centro de Investigação para o Desenvolvimento Humano (CEDH), andreiamagalhaes78@gmail.com, Universidade Católica Portuguesa – Porto

[**] Centro de Investigação para o Desenvolvimento Humano (CEDH), jalves@porto.ucp.pt, Universidade Católica Portuguesa – Porto

[***] Centro de Estudos em Gestão e Economia (CEGE), andrade@porto.ucp.pt, Universidade Católica Portuguesa – Porto

1. Introduction

"Technologies are in society and bring new challenges, needs and possibilities" (Bruno, Schuchter and Junior, 2019, pp.62), offering "additional tools for the search of information and knowledge" (Morgado, 2015, pp. 167). The European Commission (Comissão Europeia, 2012) note that "digital technologies have an impact on education, training and learning through the development of more flexible learning environments adapted to the needs of a highly mobile society".

According to OECD, "students learn better science if they see the point of what they learn. Relating the scientific concepts learnt in class to the everyday life of children or, more generally, showing the relevance of what is taught to everyday life problems makes science more attractive and its teaching and learning more effective" (Vincent-Lancrin, 2019, pp. 93). It is added that "conducting experiments and investigations gives students an entry point into the work life of scientists, and a better understanding of its empirical dimension" (Vincent-Lancrin, 2019, pp.58). In this sense the "computers and digital devices are well suited to support the acquisition of procedural knowledge through repetition and drilling" (Vincent-Lancrin, 2019, pp. 42).

Hopefully, teachers" will find the right dosage with other, more active learning practices" (Vincent-Lancrin, 2019, pp. 38), because in order to translate it into effective improvement of learning, these must ensure that: the use of technology is appropriate and values the learning in question and that it be framed in the current pedagogical practices of the teacher and the preconceptions of the students; the activity should be structured so that the students have to take some responsibility and have the opportunity to develop active participation; it is essential to promote in students reflection on the underlying concepts and relationships, creating moments of discussion, analysis and reflection; the focus should be on the research activity by developing skills in data collection and analysis; it should clarify the relationship between the use of technologies and the process of teaching and learning; the sharing of findings and ideas within the class group should be encouraged (Osborne and Dillon,

In this sense, the IoT, through the sensors connected to the internet, meets the above, since it makes it possible to obtain information about the environment or activity and these data will be stored for later feedback (O'Brien, 2016). Thus, it becomes possible to work on contents

that meet students and their interests and community contexts in an interdisciplinary way. In this way, it stimulates a dynamic, motivated and participatory pedagogical work, important for the development of skills for the student to articulate and contextualize the acquired knowledge (Morin, 2002) and can be designed to create opportunities for best learning moments (Kukulska-Hulme et al., 2021).

Therefore, their use of IoT in the classroom brings considerable benefits to education (Johnson, et al., 2015), mainly because it motivates students for meaningful learning, as they are actively involved in tasks relevant to the learning process, using their potential skills, which implies that they must make decisions to choose a course of action among others possible and within reach (Bzunec, 2001). In this context, the school will be able to take advantage of the possibilities offered by IoT, since it makes the classroom an "open space" where physical limitations are not relevant for the interpretation of the environment. In this way, it allows an interdisciplinary articulation of concepts, cognitive operations and work processes, providing an improvement in learning and a better understanding of the world and life.

2. Theorical framework

2.1. Internet of things in education

The Internet of Things is a network composed of various objects and devices connected to the Internet, "various technologies that work together" (Sethi and Sarangi, 2017, pp. 1). This introduced "a new paradigm that is rapidly gaining ground in the modern wireless telecommunications landscape" (Atzori, Iera and Morabito, 2010) in which "all available user devices are connected and can be identified, interact and communicate with each other and their surroundings" (Kiryakova et al., 2017, pp. 82), thus creating opportunities to explore places that would be difficult, dangerous or impossible to visit (Kukulska-Hulme et al., 2021, pp. 1). Offering, according to Harpur and De Villiers (2015), conditions for the best learning moments, as it highlights participation, personal contexts and sensory experiences.

According to Aldowah et. al (2017), "new forms of information exchange lay the foundation for more interactive and personalized learning" and real-time data "are useful for analyzing actions, interactions, preference trends and changes in student skill levels" (Aldowah et. al., 2017). This "personalization can be done automatically based on the constructed learner's

profile, his level of knowledge and achievements, the pace of learning and specific needs" (Kiryakova et al., 2017, pp. 82). The teacher remains "essential for guiding students to and through learning objects" and "must also take students away from the variety of disconnected experiences to develop meaning and assimilate their new knowledge, skills and emotions" (Slimp and Bartels, 2019, pp. 35). So, the IoT is applicable to education because, students explore real-world situations in order to "build their own knowledge" (Costa, 2014, pp.116) through the collection of real-time data, issued by these connected environments (Johnson et. al., 2015), and allowing for the exploration of subjects that meet the interests and contexts of students and their community. Acconrding to Kiryakova et al., (2017, p. 80) the IoT

> "may affect teaching and learning processes, including the approaches of creation of knowledge and its dissemination. The learning process may be directed entirely to the participants' needs by physically connected devices. The IoT allows achievement of what is often a matter of controversy – the availability of more technical devices and accompanying technologies helps transform learning in more human-oriented process."

In this way, technology-rich environments changing school grammar, because the "connected devices transforming learning from passive to active" (Kiryakova et al., 2017, p. 82) enrichment experience-based teaching and teaching management aid (Callaghan, 2012) and

> "learning environments with enhanced technology can be designed to create opportunities for the best learning moments - for example, through the use of mobile devices, game-based learning and immersive experiences, and through the use of learning analytics data. New ways of capturing the best learning moments can support reflection on learning and improve the design of learning technology." (Kukulska-Hulme et al., 2021, pp. 1)

As refer Andrade (2012), "a potential for motivation for students by activating multiple senses and (…) allowing them to develop skills beyond technical and scientific knowledge and their academic exploration does not necessarily have to do with "Disneylandization" of knowing! It will be a current response, with new resources for a consolidated pedagogical perspective".

2.2. Learning and curricular articulation

Currently, according to the legislation issued by the Ministry of Education, the intention is to use innovative pedagogical practices with an organization of knowledge that includes significant issues, identified collaboratively by educators and students, beyond the boundaries of the disciplines (Beane, 2002). Thus, according to Cabral and Alves (2018, pp. 21), the

curriculum “starts to be seen as a whole composed of different parts, but that it is urgent to interconnect and articulate, avoiding redundancies, obliterating the connections between different fields of knowledge, scaffolding future learning and resuming past learning, so that learning can make sense to students, becoming more meaningful and solid”. However, in order to comply with the above, it is important to make the curriculum more flexible, “according to the characteristics of the contexts and students and with clear and objective pedagogical criteria” (Cabral and Alves, 2018, pp. 21). As highlighted by Morgado, (2018, pp. 73) “the context has a notable influence, as it depends, to a large extent, on the way the teaching-learning processes are structured and operationalized and the greater or lesser involvement in the educational tasks of the school and social actors”.

Therefore, teachers cannot renounce the “implementation of models of pedagogical innovation that lead to the improvement of students' learning” (Cabral and Alves, 2018, pp. 21). Because these are the best learning moments, recognized as "ideal learning moments", one of the moments of greatest attention and involvement of students when using some technology-enhanced learning apps and these mental states can contribute to more effective learning, one of the best learning moments to be memorable, since strong emotions contribute to the formation of long-term memories (Kukulska-Hulme et al., 2021).

In this sense, the teaching and learning processes must be modified, favoring modes of pedagogical work of initiative and appropriate type (Lesne, 1984) as problem-based learning and the project methodology, which work at the level of the students' dispositions and motivations and try to develop in them a cognitive appropriation of the real, in order to meet the needs of the students (Costa, 2014), who, in the opinion of Hargreaves, Earl and Ryan (1996) need

> “more sophisticated skills, such as complex and critical thinking, problem solving, weighing alternatives, making informed judgments, developing flexible identities, working independently and in groups and discerning appropriate courses of action in ambiguous situations.”

Thus, according to the profile of students leaving compulsory education (Gomes et al., 2017) today, more than ever, the school must prepare students for the unexpected, the new, the complexity and, above all, develop in each one skills and knowledge that will allow them to learn throughout their lives. Through a “coherent articulation of these learnings in relation to the intended purposes” (Roldão, 2018, pp. 11) that must occur at the level of concepts, in a

complementary and convergent way as they are approached from the different fields of knowledge; cognitive operations, what is asked of students in each class and work processes, intentional strategies of understanding and appropriation that will allow the use of the content. With the objective of obtaining a "global, intentional and organized conception of an action or set of actions, with a view to achieving the intended learning purposes" (Roldão, 2010, pp. 68). In this way, it is expected that the teacher breaks with the traditional pedagogy and feels comfortable putting alternative pedagogical models into practice, the teacher will have to work in partnership and cooperation with the educational community. At this point, school leaders become truly important, as Cabral and Alves (2018, pp. 20) state, for

> "Ways of organizing teachers, such as educational teams, tutoring, assistances and others that each school can (re) invent according to the needs evidenced by its students, are certainly much more favorable to a collaborative professional culture and the assumption of a collective commitment by all teachers for the global learning of all students".

Especially because the individualism and isolation with which teachers work are inhibitors of ideas and practices to improve students' learning. Thus, being the professional attitude combined with technological devices that induce a favorable and motivating learning environment, induces the creation of an environment that fosters more creative and innovative approaches, intense organizational relationships are created that provide more effective curricular flexibility and pedagogical differentiation, to provide student with conditions for meaningful learning. Therefore, accompanying students from different contexts in order to respond to the demanding learning and skills necessary for a knowledge society in which we find ourselves.

2.3. Platform SOLL

In order to take advantage of technology to create special learning conditions for students "so that, they are able to critically select and seek the knowledge they wish to acquire, and integrate them into the set of knowledge that they already have and are capable of conducting a practice based on them " (Costa, 2014, pp.69), the SOLL: Smart Objects Linked to Learning (Magalhães, Andrade and Aves, 2019) project was created, which is based on the construction of a greenhouse, monitored by sensors that, through the Internet of Things, transmit real data in real time and is constantly updated by the SOLL platform.

From this platform, students, aged between 12 and 15 years old, worked on Essential Learnings, in the disciplines of physics and chemistry, mathematics, geography, ICT and natural sciences, through a set of activities. To solve these activities, students had to access the platform, using a password. They started by researching the materials to build the greenhouse, the best location and orientation. After its assembly, they built the IoT kit to collect data from the greenhouse, like soil pH, soil and air temperature, soil moisture and plant growth. These data, through a Wi-Fi module, were sent to the platform, which stored them and allowed their observation. From this point on, students analyzed the data and needed them to answer a set of questionnaires. These were also useful in controlling greenhouse conditions for plant development.

During the performance of individual and group activities carried out by the students, the teachers evaluated the students' work in real time. In this way, it was possible to provide feedback at the time of difficulty and manage the autonomy given to each student, making learning more personalized. Figure 1 shows the interaction between the different project targets.

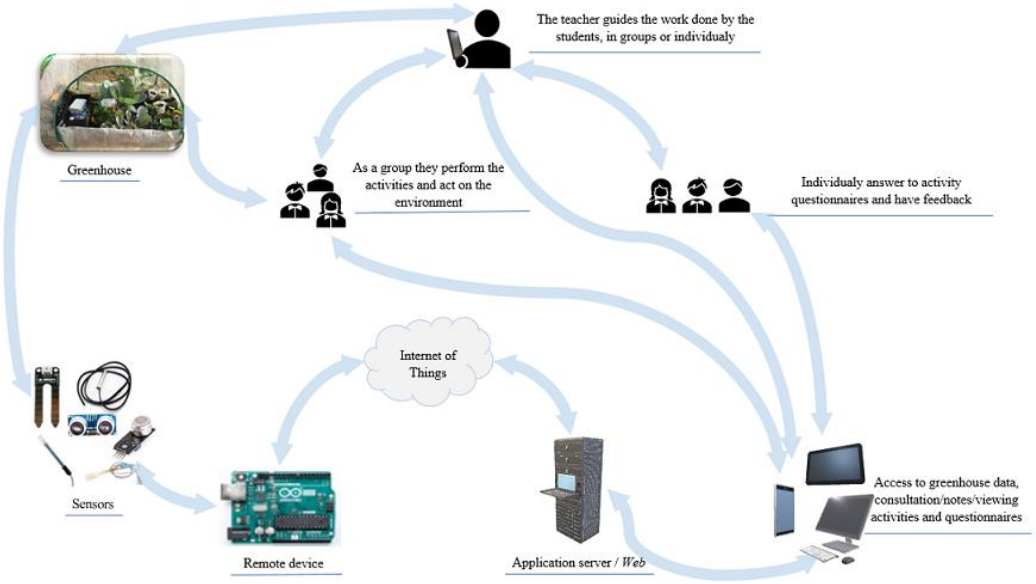

Figure 1: Interaction between the different targets of the SOLL project, prepared by the authors

The online learning platform, www.soll.pt, is supported by a set of technologies that collect and store real data. Figure 2 shows a map of the SOLL learning platform. To access SOLL, both teachers and students need to provide authentication consisting of username and a password, given by the administrator of the learning platform.

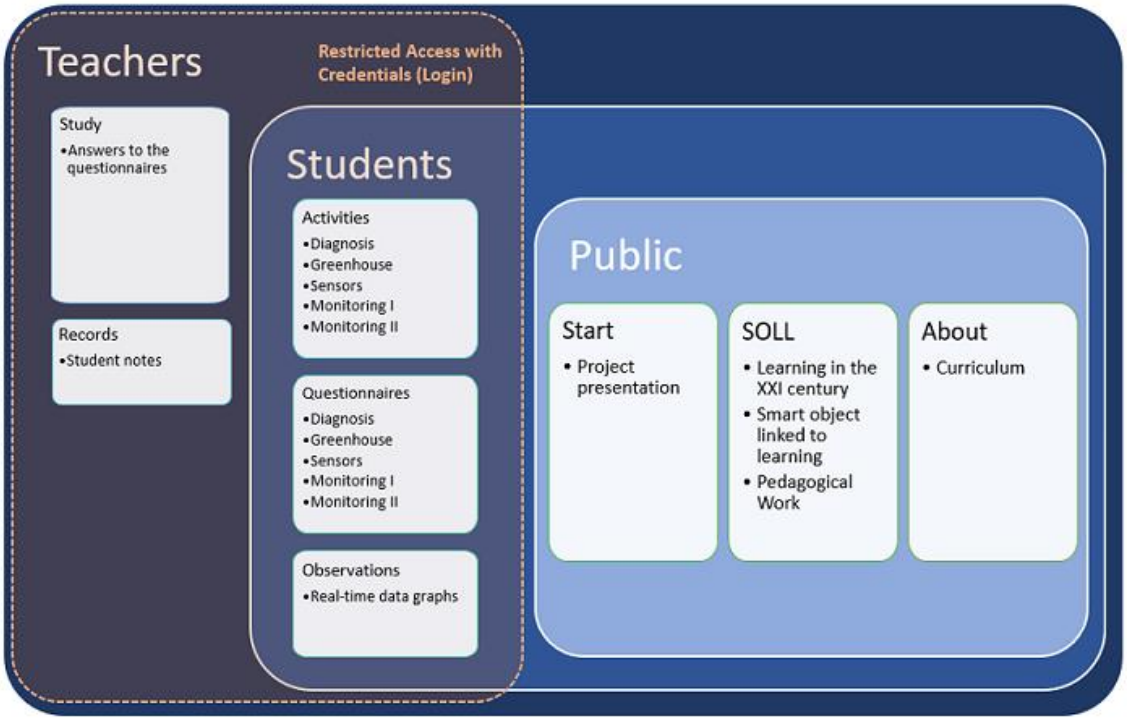

Figure 2: Map of the SOLL learning platform, elaborated by the authors

As can be seen in Figure 3, students have access to activities, questionnaires and observations of actual data from the greenhouse. On this learning platform, students are offered activities, which comply with the Essential Learning of the respective disciplines and which encourage action on the environment.

Each activity has an associated Notepad, useful for noting links for information research, for recording informational documents and present work done.

After the activity was carried out, students were asked to fill in a questionnaire about it and, were then given access to their results for task and an explanation for any wrong answers.

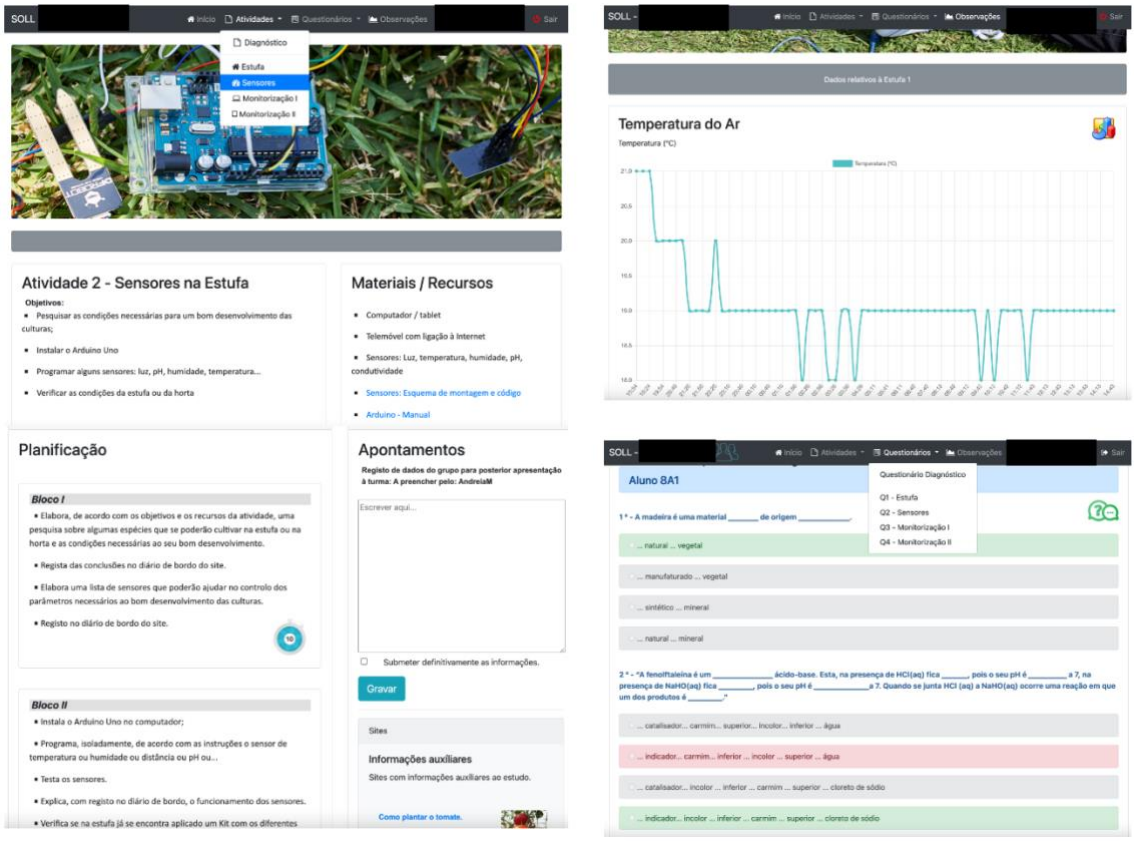

Figure 3 - Soll platform seen by students, with activities, questionnaires and observation of greenhouse data

In this way, "the assessment is continuous and systematic in the service of learning, and provides the teacher, the student, (…) with information on the development of the work, the quality of the learning done and the ways to improve it" (Decreto Lei nº 55, 2018, pp. 3790-(4)) and "the information obtained as a result of the evaluation also allows the revision of the teaching and learning process" (Decreto Lei nº 55, 2018, pp. 3790-(4)).

With this interdisciplinary resource, students achieve what is required in the Student Profile to Exit Compulsory Schooling, in which "Areas of Competence" understood as complex combinations of knowledge, skills and attitudes that allow effective human action in diverse contexts are developed. They are of a diverse nature: cognitive and metacognitive, social and emotional, physical and practical and is important to emphasize that competences involve knowledge (factual, conceptual, procedural and metacognitive), cognitive and psychomotor skills, attitudes associated with social and organizational skills, and ethical values (Martins et. al., 2017, pp.9).

Teachers have access to a student activity management system on the platform, as shown in Figure 4, which allows them to monitor, in real time, the activities performed by the students through the observation of the notebook and their responses to the questionnaires.

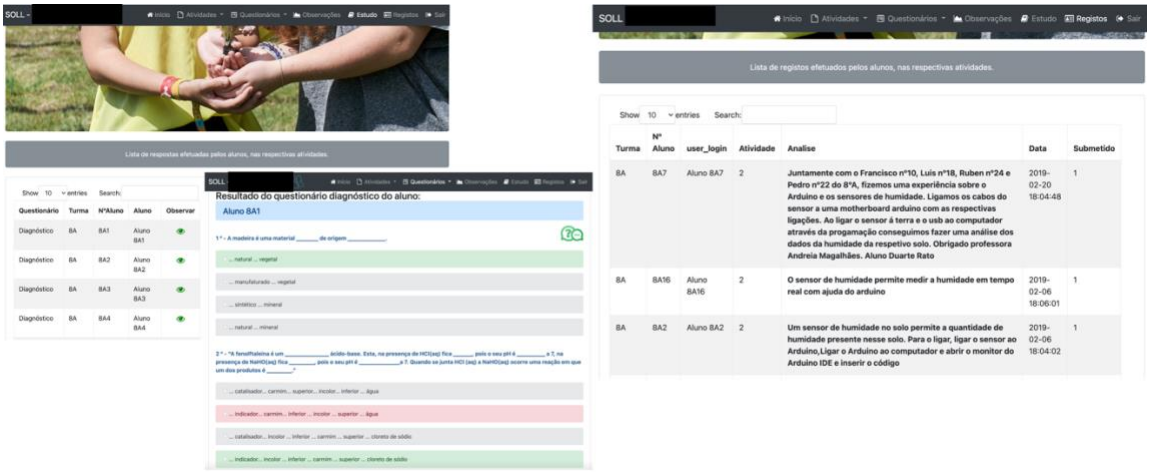

Figure 4 - Soll platform seen by teachers, with everything that the student has plus a part of study and records.

In this way, the teacher has a sense of the students' performance and/or difficulties and can provide more personalized teaching, since it allows for the real-time verification of individual or group work.

3. Methodology

As the study focuses on emancipatory knowledge, which aims to expose the ideologies that condition access to knowledge and actively operate in the transformation of this reality (Coutinho, 2005), we position ourselves in a socio-critical paradigm, a theoretical perspective which, according to Coutinho (2005, pp. 362), is “characterized by greater dynamism in the way of facing reality, greater social interactivity, greater proximity to the real due to the predominance of praxis, participation and critical reflection, and transformative intentionality”. Therefore, aiming for the development of practical and innovative solutions to the serious problems of education (Matta, Silva and Boaventura, 2014), the development of effective learning environments and the use of natural laboratories to investigate teaching and learning (Sandoval, 2004) and because the research does not take place in the context of the researcher's action, it was supported by Design-Based Research. According to Wang and Hannafin (2005), Design-Based Research is a systematic, flexible methodology designed to improve educational practices through interactive analysis, design, development, and real-world implementation. For Barab and Squire (2004) this is not an approach, but several approaches, developed in real

contexts, with the intention of producing new theories, artifacts and pedagogical practices with potential to impact learning. It is assumed to be qualitative nature, since this method allows "to emphasize the specificities of a phenomenon in terms of its origins and the street reason for being" (Haguette, 2005, p.63).

Data collection techniques were chosen from the options proposed by Teddlie and Tashakorri (2009): description and focused discussion. Within this sampling, a random cluster sampling was chosen, which allowed for the equivalence of clusters at the same level. Thus, based on the words of Charles (1998), who states that the sample is directly related to the type of problem to be investigated, the sample had the following characteristics: 154 students, 79 (51%) boys and 75 (49%) girls in 6 classes of 8th grade; 14 teachers (prof.) distributed by the subjects of mathematics (Mat), natural sciences (NS), physics and chemistry (PC), geography (Geo) and information and communication technologies (ICT).

For the students, the description method was chosen because, according to Charles (1998, p.153), this method allows "to transform observations into verbal annotations, but it goes further than notation due to the concern to provide a portrait as faithful as possible of the situation, full of details". This is a method that intends to "investigate natural contexts, processes, events or behaviors in depth" (Coutinho, 2016, p. 106).

Already for the teachers, the focused discussion method was chosen, as the format of “guided discussion”, is intended to verify the “interactions” that are created (Mason and Bramble, 1997), to observe the degree and nature of the agreements and disagreements between participants (Morgan, 1997). In order to meet the objective and collect data on the impact of IoT on student learning processes, these instruments, questionnaires and focus group guides, were constructed based on the work of the following researchers: Welchen and Oliveira (2013); Parellada and Rufini (2013); Souza and Neves (2010); Neves (2007); Neves and Boruchovitch (2007); Knuppe (2006); Siqueira and Wechsle (2006); Alcará and Leite et al (2007); Bzuneck (2001).

For data analysis, MaxQDA software was used for qualitative data analysis of the teachers' focus group interviews and the open response of the questionnaire to students.

4. Results

Although the school is a learning space inserted in a technologically evolved society with population diversity, it was found that there is still a lot of resistance to the use of technology. This is because among teachers it is still thought that it induces distractions and does not help to learn more,

> "If there were no other parallel distractions… I think it would be a huge asset" (Teacher)

despite what the students say,

> "Help me, I don't know how to start! I was not in your last class I was expelled! I don't know my password. Help me get in that I want to do the activity." (8th year student, implementing the SOLL project)

Thus, the use of the SOLL project - Smart Objects Linked to Learning, using IoT, which proves to be an enabler of a motivating learning environment, aroused the senses for meaningful learning and favored curriculum development from the school context as a way to overcome curricular decentralization, leading students to learn more.

Table 1 presents some of the opinions of teachers and students in the development of the curriculum using the SOLL platform, using IoT, in the categories of curricular articulation.

Table 1- Opinion of teachers and students on the categories of curricular articulation

Category	Teachers	Students
Concepts	"We can easily combine 4 areas here ... 5 areas ..."	I stay focused on an activity only when it is related to personal interests
	"There is no better construction of knowledge that is not that way ... it is that they realize that, after all, all areas of knowledge are linked together ... and that complement each other ... in terms of knowledge ..."	Make content more abstract in concrete
	"Science has this advantage a lot ..."	
	"It was even good for flexibility..."	
	"Transversality and interdisciplinarity"	
Cognitive operations	"When we do something like that they always like it because it's the data they collected ..."	"I like this type of activities more because it is more practical!"
	"I had feedback at the moment..."	Allow me to assess whether I know the contents
	"It forces them to interpret, to be critical in the face of the data they are receiving ..., therefore, it ends up building, consolidating and structuring knowledge."	Real situations are addressed
	"In fact, when they didn't know, they went to research."	Promotes research

Work processes	“They can contextualize things and make more sense for them ... they don't ask what this is for ...”	I keep my attention focused on understanding the content of an activity
	“As an application of knowledge ...”	
	"They can always go a little further ..."	
	"The contents that they manage to perceive that are effectively useful, it is not. ... they see that it is useful for something ... they realize that it is used ... it may not be used by them, it is useful ..."	

According to the opinions collected, the Internet of Things presents itself as a tool that easily promotes interdisciplinarity, facilitates the construction of knowledge, because it forces the student to interpret, to be critical in the face of the data he receives and that he ends up building, consolidating and structuring knowledge and appreciate why their data is working. Therefore, this resource, which allows the student to act on knowledge, brings with it multiple learnings and, when doing so with a positive and committed attitude, learns more. Teachers also consider that there is greater control in the verification, identification and correction of students' difficulties in real time, enabling them to monitor their learning. Likewise, at the end of each class, it allows knowing what the student has researched, what he/she has learned and what their interests are, allowing the teacher to reformulate the way in which he guides the learning of the content.

5. Conclusion

From the above, the results obtained are in line with what Ausubel (1969) states when stating that learning only makes sense if integrated with pre-existing mental schemes and with Roldão (2018) when says that learning means mastering increasing levels of complexity and meaningful learning that occur through the permanent establishment of the experience - knowledge - new experience - new knowledge continuum. And so, as Morgado (2018) points out, in addition to essential knowledge, other skills and sensitivities that students need to develop were included.

In this way, we can verify that, as refer Kukulska-Hulme et al. (2021) this technology promotes learning moments that result in learning with high levels of satisfaction and particularly memorable, as they enable multiple learning activities that involve practical activities and participation that are well aligned with student-centered approaches that take into account

individual differences in learning. Thus, it is necessary for the teacher to be attentive to the students' interests, in order to bring teacher and student closer to a more solid and constructive learning (Leite et all, 2005). However, it can be further enhanced if the School asserts itself as a project of society, that is, as a true learning community to enhance the desired changes and generate, from within, an innovative and promotes new ways to capture or record the best learning moments and use them to reflect on learning or to improve the design of learning technology (Kukulska-Hulme et al., 2021).

In short, this resource creates an environment in the classroom that fulfilling the essential learning defined in the student's profile after leaving compulsory education (Gomes et al., 2017), and finds echo in the current guidelines recommended by the OECD (Vincent - Lancrin, 2019), as it responds to the current problems of teaching and learning, brings numerous benefits to the children's development, mainly in the construction of its identity, leading the children towards their autonomy and acquisition of new knowledge, enabling their effective development knowing how to use personal resources in the face of the adversities they will face in their lives (Welchen and Oliveira, 2013).

References

Alcará, A., Guimarães, S. (2007). *A instrumentalidade como uma estratégia motivacional.* Psicologia Escolar e Educacional, II (1).

Aldowah, H., Ghazal, S. Rehman, S. Umar, I. (2017). *Internet of Things in Higher Education: A Study on Future Learning.* Journal of Physics Conference Series.

Andrade, A. (2012). Recurso a simuladores na aprendizagem de fatores de segurança na exploração de tecnologias da informação. In Carvalho, A. *Aprender na era digital - Jogos e Mobile-Learning.* De FACTO Editores.

Atzori, L., Iera, A., Morabito, G. (2010). *The Internet of Things : A survey.* Computer Networks, 54(15), 2787–2805. http://doi.org/10.1016/j.comnet.2010.05.010

Ausubel, D. et al. (1978). *Educational Psychology – a Cognitive View.* Nova Iorque: Holt, Rinehart and Winston.

Ausubel, D., Robinson, F. (1969). *School learning: an introduction to educational psychology*. New York: Holt, Rinchart and Winston.

Barab, S., Squire, B. (2004). *Design-based research: Putting a stake in the ground.* In Journal of the Learning Sciences.

Beane, J. (2002). *Integração Curricular: A Concepção do Núcleo da Educação Democrática*. Lisboa: Plátano Editora.

Bruno, A. Schuchter, L., Junior, S. (2019). *Formação docente e uso dos laboratórios de informática na educação básica: divergências entre os contextos do discurso oficial e da prática.* In Educação e Tecnologias na Sociedade Digital; Whitebooks.

Bzunec, A. (2001). *A motivação do aluno: contribuições da psicologia contemporânea.* Petróp. Vozes.

Cabral, I.; Alves, J. M. (2918). *Inovação Pedagógica e Mudaça Educativa - Da teoria à(s) prática(s).* Porto: Faculdade de Educação e Psicologia da Universidade Católica Portuguesa.

Callaghan V. (2012). *Buzz-Boarding; practical support for teaching computing based on the internet-of-things.* The Higher Education Academy-STEM.

Charles, C. (1998). *Introduction to educational research.* (3.ª Ed.). New York: Longman.

Comissão Europeia. (2012). *Comunicação da Comissão ao Parlamento Europeu, ao Conselho, ao Comité Económico e Social Europeu e ao Comité das Regiões, Repensar a Educação - Investir nas Competências para melhores resultados socioeconómicos.* Estrasburgo, COM (2012) 669 final.

Costa, H. (2014). *Inovação Pedagógica: A tecnologia ao serviço da educação.* Chiado Editora.

Coutinho, C. (2005). *Percursos da investigação em tecnologia educativa em Portugal: uma abordagem temática e metodológica a publicações científicas (1985-2000).* Braga: CIED, Universidade Do Minho.

Coutinho, C. (2016). *Metodologias de investigação em Ciências Sociais e Humanas: Teoria e Prática.* (2ª Ed.) Almedina.

Diário da República S. I. de 2018-08-03 n.o 149/2018, 1o Suplemento, Decreto-Lei n.o 55/2018, de 6 de julho.

Gomes, C., Brocardo, J., Pedroso, J., Carrillo, J.; Ucha, L.; Encarnação, M.; Horta, M.; Calçada, M.; Nery, R. and Rodrigues, S. (2017). *Perfil dos alunos à saída da Escolaridade Obricatória.* Ministério Da Educação.

Haguette, M. (2005). *Metodologias qualitativas na sociologia.* (10ª Ed.) Petrópolis: Vozes.

Hargreaves, A., Earl, L., Ryan, J. (1996). *Educação para a mudança - Reinventar a escola para os jovens adolescentes.* Coleção Ciências Da Educação Século XXI. Porto: Porto Editora.

Harpur, P., De Villiers, M. R. (2015). *MUUX-E, a framework of criteria for evaluating the usability, user experience and educational features of m-learning environments.* South African Computer Journal, 56(1), pp. 1–21. 8.

Johnson, L., Adams Becker, S., Estrada, V., and Freeman, A. (2015). NMC Horizon Report: 2015 Higher Education Edition. Austin, Texas: The New Media Consortium.

Kiryakova, G., Yordanova, L., Angelova, N. (2017). *Can we make schools and universities smarter with the Internet of Things?* TEM Journal, 6(1), 80-84.

Knuppe, L. (2006). *Motivação e desmotivação: desafio para as professoras do Ensino Fundamental.* Revista de Educação, Curitiba, n. 27.

Kukulska-Hulme, A., Bossu, C., Coughlan, T., Ferguson, R., FitzGerald, E., Gaved, M., Herodotou, C., Rienties, B., Sargent, J., Scanlon, E., Tang, J., Wang, Q., Whitelock, D., Zhang, S. (2021). *Pedagogia inovadora 2021: aberto Relatório de inovação da universidade* 9. Milton Keynes: The Open University.

Leite, E., Ruiz, A., Aguiar, T., Oliveira, M. (2005). *Influência da Motivação no Processo Ensino-Aprendizagem.* Akrópolis - Revista de Ciências Humanas Da UNIPAR. Umuarama, v.13, No.1.

Lesne, M. (1984). *Trabalho Pedagógico e Formação de Adultos – Elementos de Análise.* Lisboa: Fundação Calouste Gulbenkian.

Magalhães, A., Andrade, A., Alves, J. M., (2019). SOLL: *Smart Objects Linked to Learning - Educational platform with the Internet of Thingsitle, Em 2019, 14a* Conferência Ibérica Sist. e Tecnol. Informação (CISTI), IEEE.

Martins, G., Gomes, C., Brocardo, J., Pedroso, J., Carrillo, J., Silva, L., Encarnação, M., Horta, M., Calçada, M., Nery, R., Rodrigues, S. (2017). *Perfil dos Alunos à Saída da Escolaridade Obrigatória.* Ministério Da Educação - Direção Geral Da Educação.

Matta, A., Silva, F., Boaventura, E. (2014). *Design-based research ou pesquisa de desenvolvimento: metodologia para pesquisa aplicada de inovação em educação do século XXI.* In Revista Da FAEEBA – Educação e Contemporaneidade, Salvador, v. 23.

Morgado, J. (2018). *Políticas, Contextos e Currículo: desafios para o Século XXI. Centro de Investigação Em Educação (CIEd).* Instituto de Educação, Universidade Do Minho.

Morgado, L. (2015). INGRESS: Potencialidades Pedagógicas de um jogo Georreferenciado de Realidade Alternativa em Rede. *In* Moreira, J., Barros, D., Monteiro, A. I*novação e Formação na Sociedade Digital. Ambientes Virtuais, Tecnologias e Serious Games*. Whitebooks.

Morin, E. (2002). *Educação e complexidade: os sete saberes e outros ensaios,* São Paulo Cortez.

Neves, E, Boruchovitch, E. (2007). *Escala de avaliação da motivação para aprender de alunos do ensino fundamental (EMA).* Psicol. Reflex. Crit. 20(3), Porto Alegre. https://doi.org/10.1590/S0102-79722007000300008

O'Brien, H. M., (2016). *The Internet of Things.* J. Internet Law, 19(12), 1–20.

Osborne, J., Dillon, J. (2008). *Science Education in Europe: Critical Reflexions.* London: Nuffield Foundation.

Parellada, I., Rufini, S. (2013). *O uso do computador como estratégia educacional: relações com a motivação e aprendizado de alunos do ensino fundamental.* Psicol. Reflex. Crit., Porto Alegre , v. 26, n. 4.

Roldão, M. C. (2010). *Estratégias de Ensino: o saber e o agir do professor.* Vila Nova de Gaia: Fundação Manuel Leão.

Roldão, M., (2018). *Pressupostos concetuais da articulação curricular, in Alves, J. e Roldão, A. C., Articulação curricular. O que é? Como se faz? Dos conceitos à prática.* Fundação Manuel Leão: Vila Nova de Gaia.

Sandoval, et. al. (2004). *Design–Based Research Methods for Studdying Learning in Context: Introduction.* Educational Psychologist.

Schutt, R. (1999). *Investigatingg the Social World:the process and pratice of research.* (2.ª Ed.). Thousand Oaks: Pine Forge Press.

Sethi, P., Sarangi, R. (2017). *Internet of Things: Architectures, protocols, and applications.* Journal of Electrical and Computer Engineering. http://dx.doi.org/10.1155/2017/9324035.

Siqueira, L., Wechsler, S. (2006). *Motivação para a aprendizagem escolar: possibilidade de medida.* Avaliação psicológica, 5 (1).

Slimp, R., Bartels, M. (2019). *How the Internet of Things is Changing our Colleges, our Classroom, and our Students.* Foreword by Fred Lokken. Br. Libr. Publ. Inf.

Souza, L. (2010). *Estratégias de aprendizagem e fatores motivacionais relacionados.* Educ. Rev., Curitiba , n. 36.

Teddlie, C., Tashakkori, A. (2009). *Foundations of mixed methods research: integrating quantitative and qualitative approaches in the Social and Behavioral Sciences.* Thousand Oaks, CA: Sage.

Vincent-Lancrin, S., et al. (2019). *Measuring Innovation in Education 2019: What Has Changed in the Classroom?* Educational Research and Innovation, OECD Publishing, Paris.

Wang, F., Hannafin, M. (2005). *Design-based Research and Technology-Enhanced.* Learning Environments.

Welchen, D., Oliveira, M. (2013). *A formação de valores no ambiente escolar*. Revista Inoesc Ciência-ACHS, Joaçaba, v.4.