SOLL Platform and the adoption of innovation by teachers

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Abstract. The Internet of Things (IoT) appears with great educational potential, as it is a network composed of various objects and devices connected to the Internet, allowing the performance of interdisciplinary activities. Thus, we present the SOLL platform: Intelligent Objects Linked to Learning, which, supported by a set of technologies that collect and store data from a greenhouse, allows dynamic, interactive and interdisciplinary learning and a synchronous or asynchronous evaluation.

In this article, the platform architecture is exposed and, using a focus groups of teachers, the data obtained show that teachers recognize that they would adopt this innovation, at least that it responds to the structure of the learning community, adopting a different learning model, with exploration and enrichment of educational information.

Keywords: Education, Technology, Internet of things, Innovation adoption.

1   Introduction

In the perspective of Díaz and Hernández de Frutos [1] that, in a way, inspired the perspective of this study, knowledge also results from a set of network connections in which learning results from the ability to create and cross those connections that emerge in the network from the interaction within a group. However, although these interactions can arise spontaneously, it is something that should be encouraged [2].

Therefore, the technologies "allow the distance learning paradigm to be created" ([3], p. 120) and provide some of the informal social interactions students have at school, based on connectivity, introduced by Siemens in 2004, which is characterized by a network of knowledge and learning, with an emphasis on the use of digital technology to improve and extend online interaction and finding an echo in the words of the European Commission [4], which considers 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". This will have to evolve into a model based on the "cultivation of skills," ([5], p.98) in which the student needs a more active role. Given the high speed of information and knowledge spread in today's society, students will have to maintain lifelong learning,

and it is necessary that they be equipped with tools that allows them to evaluate and assimilate new knowledge.

However, new media do not necessarily lead to new pedagogies or new learning [6], as the expository model of content transmission is often maintained, with the novelty of "we can see the teacher from a distance, or watch recordings of your classes, follow your expositions without the special restriction of the classroom and without the temporal restriction of the fixed schedule" ([3], p.120). What is intended is that the teaching-learning process is understood as a construction that involves an active role on the part of the students. It is imperative that they develop the capacity to establish their own goals, to plan and monitor their efforts towards a better academic performance, directing, to a certain extent, their learning in the school context [7]. According to Adrião ([5], p.134), the interactivity provided by the digital educational resources can help both in the task of teaching and in the task of learning and encourage and support constructivist pedagogy [8]. In this way, is more likely to reach all students who wish to participate in the process of knowledge construction and teachers who implement it have further improved technology environments [9]. The result could be a democratization of education never seen before [8] and an aid in the fight against school failure.

In this context, "the fundamental paradigm that emerges is teaching in a project environment" ([3], p.122), which due to its dynamics and interdisciplinary characteristics "captures more attention and involvement from students" ([3], p. 122), in relation to the expository classes. For this reason, the Internet of Things introduced "a novel paradigm that is rapidly gaining ground in the modern wireless telecommunications scenario" [10]. Some authors argue that it is an unprecedented technology [11]. Is such an innovative technology that its impact on society will be equivalent to that of an Industrial Revolution [12]. In this way, Internet of Things "is not a single technology; rather it is an agglomeration of various technologies that work together" ([13], p. 1) in an interconnection of everyday objects, which are often equipped with ubiquitous intelligence [14] and which exchange ample information between them [15]. This technology will increase the ubiquity of the Internet because it will integrate all objects into an embedded system, which will give rise to a strongly present network of objects communicating with humans or other objects. For Gubbi et al. [16], IoT is considered as something more user-centred and not restricted to communication protocols, that is, it is the "Interconnection of detection and actuation devices, providing the ability to share information across platforms through a unified framework, developing a common operational framework to enable innovative applications. This is achieved by ubiquitous detection, data analysis, and information representation with cloud computing as a unifying structure" ([16], p.1647).

In other words, it is a technology that allows, through sensors, to connect objects with the Internet so that information about the environment or activity can be obtained and that will provide feedback and control [12]. According to Aldowah et. al [17] "new forms of information exchange lay the foundation for more interactive and personalized learning" and real-time data "are useful for analysing actions, interactions, preference trends and changes in student skill levels" [17]. The teacher remains "essential for guiding students to and through learning objects" and "must also take stu-

dents away from the variety of disconnected experiences to develop meaning and assimilate their new knowledge, skills and emotions" ([18], p.35). This technology, according to Area [19], should mobilize and integrate pedagogical dimensions, such as: informational, resources and materials, texts, videos; practice, experience and learning activities, individual and group; communicative, social interaction between students and teacher and dimension tutorial and assessment, monitoring and assessment of learning by the teacher. As for the pedagogy to be used, according to Mortimer [20], it is any conscious activity of a person designed to improve the learning of another. Thus, the teacher should use several pedagogical models to focus the discussion on the essential topics, acting as a guide and a facilitator of learning [21]. The teacher must help to contextualize, to expand the universe reached by the students and to help the discovery of new meanings [22]. In a social dimension, the teacher should act as a discussion advisor [23] motivating participation [24] and facilitating interactivity in the learning community [25]. For the teacher to guide students towards meaningful learning and in a dynamic learning environment Garrison & Aderson [26] establishes a set of indicators of the presence of teaching, which includes the cognitive and social presence, which is shown in Table 1, cited by Monteiro & Moreira ([27], p.41) withdrawn and adapted from Garrison & Aderson [28].

Thus, an opportunity arises for the development of new learning skills, recognized in the Profile of Students Leaving Mandatory Schooling, to help students develop skills in order to become successful students, confident and creative individuals, as well as active and informed citizens [29] e [30].

In this sense, the use of technology-rich environments that replicate the interdisciplinarity of the real world is a determining factor and the Internet of Things is an excellent ally to motivate and involve students in learning, particularly the young ones, due to the lower capacity for self-regulation.

Table 1 - Indicators of the presence of teaching cited by Monteiro & Moreira (2013) withdraw and adapted by Garrison & Anderson (2003)

Presence of teaching	Design and organization	Cognitive presence	Organize and limit the curriculum, select activities
			Set times
			Design assessment tools
		Social presence	Establish an environment of trust, hospitality, warmth, control, accomplishment, sharing and dialogue
	Speech facilitation	Cognitive presence	Focus and moderate discussions
			Asking stimulating questions
			Questioner, promote reflection
		Social presence	Motivate students to participate
	Direct instruction	Cognitive presence	Offer different ideas and perspectives for analysis and discussion
			Respond directly to questions and make comments more developed
			Recognize the uncertainty where it existed
			Make connections between ideas
			Build structures
			Summarize discussions and conduct learning
			Provide for closure and foreshadow further study
		Social Presence	Shaping the discussion, but not dominating it
			Give feedback with respect
			Be constructive with correction comments
			Be open to negotiation and justifications
			Deal with conflict quickly and privately

In order to operationalize the above, the SOLL platform: Smart Objects Linked to Learning emerged, supported by a set of technologies that collect and store real data for later interdisciplinary analysis.

1.1 Online Platform - SOLL

In order to take advantage of technology to create for students special learning conditions "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 " ([13], p.69), the SOLL: Smart Objects Linked to Learning [14] 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 constantly updated for the SOLL platform. From this, the students perform a set of activities, which fulfil the Essential Learning of the subjects of the 3rd Cycle of Basic Education, and intervene in the environment, acquiring new values. From the interaction between the different project targets, as shown in figure 1, all the work is developed by students in an integrated and interdisciplinary way.
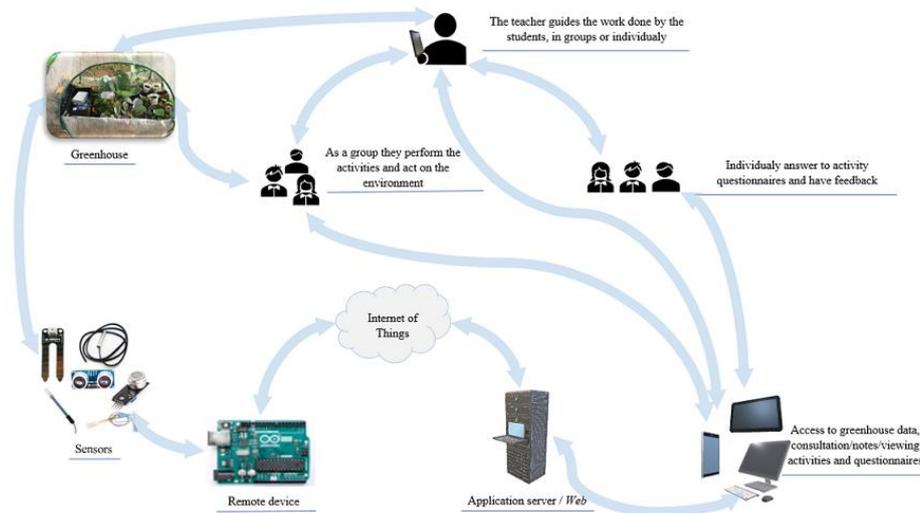
Figure 1: Interaction between the different targets of the SOLL project, prepared by the authors

The online learning platform, www.soll.pt, is supported by a set of technologies that collect and store real data. Figure 2 shows a logical architecture of the system as opposed to a physical architecture in which the equipment emerges and not the service of the SOLL learning platform. To access this learning platform - SOLL, both teachers and students need to do an authentication. For this, they require a user and a password that will be sent by the administrator of the learning platform.
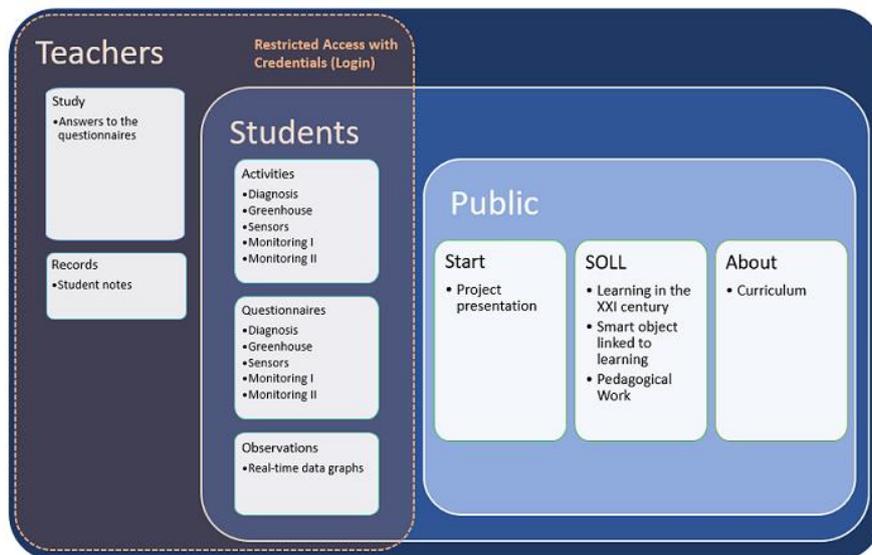
Figure 2: Logical architecture of the system as opposed to a physical architecture in which the equipment emerges and not the service of the SOLL learning platform, elaborated by the authors

As can be seen from the diagram, students have access only to activities, questionnaires and observations of actual data from the greenhouse. From this platform of learning, students are offered some activities, which comply with the Essential Learning of the respective disciplines and encourages action on the environment. Each activity has associated a notepad, useful links for information research, access to tools that work synchronously and asynchronously, for the presentation of the work done and informational documents.

After the activity is carried out, students will be asked to carry out a questionnaire about it and, in the end, a feedback on the evaluation and correction of the incorrect answers will be provided. In this way, as you wish, "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" ([33] p. 3790-(4)) and "the information obtained as a result of the evaluation also allows the revision of the teaching and learning process" ([33] p. 3790-(4).

With this interdisciplinary resource, students achieve what is required in the Student Profile when Exit Compulsory Schooling, in which "Areas of Competence add competencies understood as complex combinations of knowledge, skills and attitudes that allow effective human action in diverse contexts. They are of diverse nature: cognitive and metacognitive, social and emotional, physical and practical. It is important to emphasize that competencies involve knowledge (factual, conceptual, procedural and metacognitive), cognitive and psychomotor skills, attitudes associated with social and organizational skills, and ethical values ([34], p. 9).

The teachers have access to a management system of student activity on the platform and, the same learning platform, allows teachers to monitor, in real time, the activities carried out by the students through the observation of the notepad and the answers to the questionnaires.

At any time during the learning process, so that there is contact between teacher and students or between students, an email and hangouts connection is contemplated. The teacher has a sense of student performance and / or difficulties and can provide more personalized teaching, as it allows real-time verification of individual or group work.

This sample has the following characteristics: 154 students, 79 (51%) boys and 75 (49%) girls in 6 classes of the 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).

2   Results

From the focus group of teachers, some opinions were collected about innovation adoption category that are presented in the table 2.

Table 2 - Teachers' opinions on innovation adoption

Now that you know what the IoT offers, would you redesign the activities?	"yes, it could be applied in other situations..."
	"exactly ... in fact I even think it should be applied in other situations..."
	"Oh, without a doubt ... I think that in order to have continuity for a moment ... I would have the advantage of redesigning myself to be able to use it concretely in certain subjects ... if I am going to do an interdisciplinary or flexible job..."
Are you motivated to take more advantage of the resource?	"I think so..."
	"of course ... of course ... we are always open to innovation ... always..."
	"yes, yes ... of course ... anyone who doesn't will be left behind..."
	"but it is true ... it is not to be left behind but it is ... we have reached a point where ... is my point of view, I know that not everyone thinks like that, but ... there are teachers who are very resistant ... yes, it is not ... in these things..."

Regarding the Internet of Things, it appears that teachers consider that it would be applicable to other contexts, so they would redesigned the activity to apply to other situations. In this sense, they are motivated to take advantage of the resource, as they are open to innovation and do not want stay out of date. However, they recognize that not all teachers think the same way, there is a lot of resistance.

3   Discussion

When analyzing the data obtained, it appears that teachers, with regard to the adoption of innovation, consider technology to be a useful tool to make classes more dynamic and demonstrate motivation to apply the Internet of Things to other content in order to take more advantage of this resource. In other words, teachers consider that it would be applicable to other contexts, so they would redesign the activity to apply to other situations. Corroborating with Meirinhos & Osório ([36], p. 93) when they mention the "appearance of new forms of learning and training, more in line with the new current social environment". As weaknesses, teachers identify: for some students, even technology does not matter, because excess leads to saturation; lack of resources, difficulty in controlling the class.

The difficulty encountered in adopting innovation is the lack of resources, since free versions are often limited. Now, it is necessary that teachers start to "plan and structure the educational process in an open and flexible way, which allows diversified approaches, where motivating, dynamic, current resources and teaching materials are inserted, using an interactive and cooperative methodology for this, placing several communication channels at the service of teaching" ([37], p. 28).

From the foregoing, we can see that teachers believe that the use of this technology will improve school performance, corroborating with Meirinhos & Osório ([36], p.93). So they are motivated to take advantage of the resource, as they are always open to innovation and don't want to stay out of date, although they recognize that not all teachers think the same. There is still some resistance to the use of technology, as a result of a predominance of a pedagogy exhibition centered on the teacher, in the pressure to teach the subjects and fulfill the program, in the ignorance about technology and its pedagogical use and weak leaderships. The use of IoT needs some necessary conditions for a pedagogy of student involvement and autonomy, training in the context of action, involvement of intermediate leaders in this pedagogical metamorphosis.

4   Conclusion

This platform appears as an asset for learning, as teachers recognize that they would adopt this innovation. Therefore, its exploration becomes useful for the enrichment of interdisciplinary learning through the realization of dynamic, contextualized and real activities that provide the development of various skills, "Useful to analyse actions, interactions, trends of preferences and changes in levels of student skills", as referenced by Aldowah et. al [17]. So the teacher can take advantage to "plan and structure the educational process in an open and flexible way, allowing diversified approaches, where resources and dynamic, current and motivating teaching materials are inserted, using for this an interactive and cooperative methodology, placing at the service of its teaching several communication channels" (Goulão & Henriques, [37], p.28) and enjoy this technology to accompany, motivate, dialogue, be a leader and mediator, fostering and mediating a positive human interaction

This platform, find echo in the current directives recommended by the OECD [39], when responding to current learning, since it brings numerous benefits to the development of children, especially in the construction of their identity, leading them to their autonomy and acquisition of new knowledge, enabling their effective development knowing how to use personal resources in the face of the adversities that will face in their lives [40]. In this way, the teacher can accompany, motivate, dialogue, be a leader and mediator, fostering and mediating a positive human interaction" ([37], p. 28 e 29).

In short, the SOLL platform demonstrates robustness, as it is recognized by teachers the intention to adopt this innovation, applying it to other contexts and redesigning activities, since it induces a central shift from a pedagogy of explanation to a pedagogy of implication, participation and autonomy. This translates into an asset for the interdisciplinary development of the cognitive process of students in the 3rd cycle and an excellent ally to motivate and involve students in learning, especially the youngest, due to the lesser capacity for self-regulation.

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