

Impact of the Internet of Things on 3rd cycle students motivation in an interdisciplinary approach to science

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Abstract - Recognizing in IoT an advantage to make teaching evolve to a model based on the development of competences, which requires students to play a more active role, it is intended, using a mixed methodology, to study its impact on 3rd cycle student motivation, in an interdisciplinary approach to science. Thus, through surveys, student questionnaires and focus group interviews with teachers, the obtained data show that students, in general, remain motivated. This brings numerous benefits to its development, leading to greater autonomy in the acquisition of knowledge.

Keywords: Internet of things, Education, Motivation

I. INTRODUCTION:

IoT presents itself as an unprecedented technology [1] and [2] creating an impact on society equivalent to that of an Industrial Revolution [3]. This, through sensors, allows objects to be connected to the internet to obtain information about the environment or activity that will be stored and to provide feedback and control [3], characteristics that, for Yang & Chu [4] have significant advantages in education. Callaghan [5], shows in his work on IoT in education that it can enrich experience-based teaching, help with teaching management and expand education. Thus, its application in education may change the school grammar as it will allow to monitor the surrounding environment, collecting real time data for future study, with the data emitted by these connected environments [6], allowing, in an interdisciplinary way, the exploration of subjects that meet the interests and context of the students and their community, stimulating a dynamic, motivated, participative and interdisciplinary pedagogical work, important for students to develop skills to articulate, contextualize, globalize and gather acquired knowledge” [7].

In the classroom, the immediate effects of using IoT for meaningful student learning are their motivation, that is how they are actively involved in the relevant tasks to the learning process, initiating, sticking to and maintaining them, using their skills potential, which implies that they have chosen this course of action among others possible and

within their reach [8]. The same author adds that a demotivated student is characterized by not investing in his natural resources, not applying his efforts, doing only the minimum required or giving up easily when the task seems a little more demanding [8]. The motivated student still asks many questions, participates in discussions on study subjects, demonstrates curiosity, devotes much of his time to the activities, deliberately seeks extracurricular activities, seeks to explore new spaces to create [9]. For Alcará and Guimarães [10], the student's motivation to fulfill a school activity occurs when: he focuses his attention on understanding the content of an activity, the meaning of a given content is related to personal interests and the proposed activity is defined with specific and short-term goals, stimulating the perception that with a certain level of effort its conclusion is possible. For Leite et al [11] motivation is and will always be a great ally in learning, but for it to be satisfactory and not just a complement of information, the act of learning must be based on meaning and utility. Which leads to the conclusion that this is not only intrinsic, that is, not only depends on the student, it also depends on the context in which it is inserted. Thus, it is not enough to provide different teaching materials, it is necessary for the student to feel motivated to use them and, from there, the student will have to build knowledge. Corroborating Knuppe's [12] opinion, it must come from the student, but the teacher and the school need to provide an approximation of the school contents with the students' reality.

Parellada and Rufini [13] consider that nurturing the basic psychological needs of students, providing them with the appropriate means for expressing meaningful personal choices, personalizing activities and cooperation, and appropriate challenges, avoiding a climate of competition, has an influence on student motivation and may affect the quality of learning, involvement and persistence of students in school tasks. Thus, students becomes more motivated and, paraphrasing Welchen and Oliveira [14], brings numerous benefits to the child's development, especially in the construction of their identity, leading the child 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 life. According to Aldowah et. al [15] “new forms of information exchange lay the foundations for more interactive and personalized learning” and real-time data “are useful for analyzing actions, interactions, preference trends and changes in student skill levels”.

II. METHODOLOGY

Being the study focus on emancipatory knowledge, which aims to expose the ideologies that condition access to knowledge and actively operate in the transformation of this reality [16], we position ourselves in a socio-critical paradigm, theoretical perspective that, according to Coutinho ([17], p. 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 at the development of practical and innovative solutions to the serious problems of education [18], the development of effective learning environments and the use of natural laboratories to investigate teaching and learning [19] and the fact that research does not take place in the context of the researcher's action, in this research work will be used the method called Design-Based Research. According to Wang and Hannafin [20], 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 [21] 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 mixed in nature, since the combination of the quantitative method and the qualitative method makes it possible to cover a larger field of research possibilities by raising the public's ideas while quantifies opinions. Occurring, according to Teddlie and Tashakorri [22], in a parallel mixed design, in which the use of qualitative and quantitative methods occur simultaneously. Data collection techniques were chosen from the options proposed by Teddlie and Tashakorri [22]: observation techniques, focus group, and questionnaire surveys. In this research work, a probabilistic approach was used, since the selection of subjects is intended to be random in order to exclude the systematic error that affects non-probabilistic samples [23]. Within this sampling, a random cluster sampling was chosen, which allows the equivalence of clusters at the same level. Thus, based on the words of Charles [24], who say that the sample is directly related to the type of problem to be investigated, the sample will have 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).

Thus, a questionnaire survey was designed for students to answer at the following times: before the

activities, pre-test; at the end of each proposed activity and after the completion of the activities, post-test, with closed questions, whose answer allowed graduation on the Likert scale. This questionnaire survey was validated by conducting it on a sample of teachers and students from another context to allow, if necessary, to make adjustments before applying it. For the teachers, was chosen the focus group method, because with the format of “guided discussion”, it is intended to verify the “interactions” that are created [25], to observe the degree and nature of the agreements and disagreements between participants [26] and from which we will obtain poorly structured qualitative information [23]. Therefore, to achieve the objective and collect data on the impact on students' motivation, provided by a set of interdisciplinary pedagogical activities, which the IoT came to offer in creating a new teaching and learning context, it was used as instruments, questionnaire survey and focus group guide, were constructed based on the work of the following researchers: Welchen and Oliveira [14]; Parellada and Rufini [13]; Souza and Neves [27]; Neves [28]; Guimarães [10]; Neves, E; Boruchovitch [9]; Knappe [12]; Siqueira, Wechsle[29]; Alcará and Leite et al [10]; Bzuneck [8].

For data analysis, the MaxQDA software was used for qualitative data analysis: the teachers' focus group interview, the open survey response of the students and the researcher's diary; SPSS software was used for quantitative data analysis: student survey.

III. RESULTS

• *Students questionnaire survey*

Regarding the students' data that compare the impact on motivation, between the diagnostic survey before the activity (pre-test) and the final survey after the activity (post-test), we choose the Sign Test. This test is a nonparametric alternative to the t-test for paired samples, which “allows to analyze differences between two pre-test and posttest conditions in the same group of subjects” ([46], p. 478), which should be as similar as possible in aspects that may affect their responses in ordinal or higher level variables. This test was chosen because it does not have requirements for the form of data distribution, it is only necessary that the data is selected independently and that they can be sorted from smallest to largest, as it does not use the numerical value of the answers neither of their difference but only their sign. Within each pair (X_i, Y_i) , $i = 1, 2, 3, \dots, n$, mutually independent, the two are compared and the pair is classified as: “+”if $Y_i > X_i$, there is an increase; “-”if $Y_i < X_i$, there is a decrease e “0” if $Y_i = X_i$, there is a tie. The fact that relationships can be given meaning is one of the biggest advantages of this test. For $\alpha = 0.05$, the hypotheses for the nonparametric statistical test, sign test, are: H_0 : There are no differences regarding the topic between pre-test and post-test, $(X_i = Y_i; p=0,50)$ e H_1 : There was an improvement in the topic at the end of the activity, $(Y_i > X_i, p>0,50, unilateral test)$. Thus, for each motivation statement, which is found in the pre-test and post-test questionnaire survey, Table 1 was constructed.

TABLE 1: STUDENT RESULTS REGARDING THE IMPACT ON MOTIVATION BETWEEN THE DIAGNOSTIC SURVEY BEFORE THE ACTIVITY (PRE-TEST) AND THE FINAL SURVEY AFTER THE ACTIVITY (POST-TEST)

	Pre-test		Post-test		Sign test
	Mean	SD*	Mean	SD*	Asymp. Sig. (2-tailed)
During class I learn to avoid punishment.	3,17	0,746	3,28	0,673	0,302
During classes I choose activities that offer me constant challenges.	3,15	0,668	3,26	0,629	0,166
During class I only do the minimum required	2,39	1,016	2,42	1,025	0,180
During the classes I participate in discussions about study subjects.	2,87	0,735	2,98	0,726	0,566
During class I stay focused on an activity only when it is related to personal interests.	2,57	0,948	3,12	0,895	0,000
During the classes real situations are addressed.	3,17	0,721	3,31	0,692	0,101
During class I show curiosity.	3,35	0,637	3,32	0,613	0,625
During class I keep my attention focused on understanding the content of an activity.	3,17	0,652	3,37	0,545	0,017
During class I feel motivated when we use real data.	3,31	0,639	3,39	0,616	0,550
During classes I look for extracurricular activity.	2,96	0,820	3,16	0,713	0,201
During class I easily gave up when the task seemed a little more demanding.	2,27	1,080	2,42	1,033	0,251
During class I get involved in the tasks even though I am not doing it myself.	2,94	0,794	3,23	0,629	0,005
During class I learn for the purpose of acquiring good grades.	3,39	0,618	3,43	0,583	0,734
The activities with technological support arouse curiosity.	3,35	0,694	3,48	0,613	0,248
Teachers encourage a competition environment.	2,69	0,947	2,85	0,973	0,124

Regarding student data on the impact on motivation across the four activities, we chose the Friedman Test. This “applies when there are three or more pairing conditions where each variable is rated on at least an ordinal level scale” (Pestana; Gageiro, 2008, p.478) thus comparing the mean scores of each variable. For $\alpha = 0.05$, the Friedman Test hypotheses refer to the existence or not of preferences between activities. Thus: H_0 : There is no difference throughout the activities e H_1 : There are differences throughout the activities. For each motivation statement, which is in the questionnaire survey of each of the four activities performed, table 2 was prepared.

TABLE 2: STUDENT OUTCOMES REGARDING IMPACT ON MOTIVATION ACROSS THE FOUR ACTIVITIES

Hypotheses:	Activ 1	Activ 2	Activ 3	Activ 4	Friedman test
For each statement the following hypotheses were posed: H_0 : There are no differences throughout the activities. H_1 : There are differences throughout the activities	Mean Standard deviation				Asymp. Sig.
During this activity I performed the task in order to avoid punishment.	3,16 0,874	3,21 0,776	3,24 0,815	3,15 0,877	0,939
During this activity I did only the minimum required.	2,33 1,078	2,43 1,048	2,20 1,132	2,35 1,081	0,208
During this activity I gave up when the task seemed more demanding.	1,93 1,083	2,13 1,021	2,17 1,103	2,15 1,076	0,155
I give up easily when the task seems a little more demanding.	1,92 1,037	2,17 1,041	2,17 1,103	2,14 1,023	0,124
During this activity I participated in discussions on topics of study.	3,13 0,731	3,02 0,815	3,24 0,707	3,19 0,693	0,252
During this activity I felt motivated when using actual data.	3,24 0,969	3,11 0,643	3,27 0,717	3,31 0,629	0,038
During this activity I kept my attention focused on understanding the content of an activity.	3,33 0,689	3,23 0,634	3,36 0,653	3,33 0,611	0,158
During this activity I got involved in the tasks even though I didn't do it myself.	3,08 0,783	3,02 0,787	3,24 0,707	3,12 0,744	0,205
During this activity I learned for the purpose of getting good grades.	3,24 0,652	3,21 0,662	3,33 0,711	3,30 0,683	0,373
During this activity I asked many questions.	2,36 0,868	2,51 0,969	2,55 0,944	2,57 0,966	0,169

- *Teacher focus group*

Regarding the impact of technology on student motivation, teachers' statements are presented in table 4.

TABLE 4: TEACHER RESULTS ON THE IMPACT OF TECHNOLOGY ON STUDENT MOTIVATION

Teachers' Statements	
Geo1	• the motivation yes ...
Mat1	• yes, increase motivation ... Noted that when it is such a class they end up being more interested and end up ... positive ... I think so ...
PC1	• yes, it increases the motivation ...
PC2	• it increases motivation ... for them it increases motivation to use new technologies, but it is for what they want and for the tastes they have ... games and ... it's games and social networks ... if you pick them up with your mobile phone in class, you'll see they're on Facebook or Instagram

	... or sending a message ...
PC3	<ul style="list-style-type: none"> if it is more playful ... they really like it, but kids are very much into games... but when you pass by and get caught ... you see on the screen where they are ... they are always on social networks ... it is an impressive thing ... they do not disconnect from the social network ...
NS2	<ul style="list-style-type: none"> yes ... for the feedback they are giving and the reaction we see in class ...

Comparatively, table 5 recorded the teachers' opinion on the impact of using IoT on student motivation.

TABLE 5: TEACHER RESULTS REGARDING THE IMPACT OF IOT ON STUDENT MOTIVATION

Teachers' Statements	
Geo1	<ul style="list-style-type: none"> In this case we only have this example ... your example is not ... but I think they were motivated, yes ... they liked it ... but 8thE is from all the classes I have, I have A, B, E and D, and the others I think are even worse, it's not ... so 8th E is ... it's the one that there are the most curious students ... 8thE students are more autonomous ... and tougher in terms of ... they like ... to know, to learn ...
Geo2	<ul style="list-style-type: none"> they liked ... is, motivated ... Yes, I agree
Mat1	<ul style="list-style-type: none"> Yes... it is . another impact ... here it is not quite that but when it is applied... Reality makes more sense, isn't it ...
PC1	<ul style="list-style-type: none"> yes, they liked ... were always asking when the next activity was ... In the 8thE I found it very organized and when they didn't know, they even liked it ... your questionnaires went a little beyond the curriculum ... they even wanted to know more ...
PC 2	<ul style="list-style-type: none"> Yeh ... that I didn't think it was like this anymore ... did not notice ... only the latest activities showed ... did not see much difference in their attitude in the first and last ... did not see big difference ... did not see big difference ... now, in fact it was also a construction... but I didn't find the enthusiasm ... but it has nothing to do with the project ... it has to do with the characteristics of the students ...
PC 3	<ul style="list-style-type: none"> I noticed that they were trying to answer, but it was ... the perception I have is that ... they were trying to see if they competed with each other, to see if they got any better than each other ... student characteristics ...
NS1	<ul style="list-style-type: none"> there was a class that sometimes complained ... complained about it ... I think they sometimes, for example ... have to do with the class profile ... but the 8thD sometimes said "again!" Means, ok ... not even that, let's say different class, because there it is ... often what I think is that those students who have a lack of interest in studying ... not even that ... because they like computers and mobile phones a lot but it's for ...
NS2	<ul style="list-style-type: none"> yes, motivated ... of course ... yes, yes, yes ... further away from their reality ... it's completely different ... I think it is ... and in that respect you notice the difference ... another impact ...

In order to know the motivation of the teachers, the word that each teacher associates with the teacher's work and the degree of agreement with the statement "I am motivated to teach" was recorded in table 6.

TABLE 6: TEACHERS' RESULTS REGARDING THEIR MOTIVATION

Teachers' Statements	
Geo1	<ul style="list-style-type: none"> knowledge...
Geo2	<ul style="list-style-type: none"> I don't know... guiding...
Mat1	<ul style="list-style-type: none"> I've had nicer adjectives ... more frustrating... in some classes ... one gives pleasure ... I like to be there ... I feel that they are learning ... that I am contributing to ... and another that I am talking to the walls ... I still think it gives me satisfaction ...
PC2	<ul style="list-style-type: none"> educate ... fully educate ... scientifically, personally ... which is what I think I have a hard time doing today ... personally they are people with very few values, completely inarticulate ... especially the kids ... that's a mess in those heads ... and scientifically they don't care ... it's a drought, it's a lot of work to study ... but I think we make the whole citizen ... integrally, it's not ... and that's what is very difficult ...
PC3	<ul style="list-style-type: none"> is a constant challenge ... the challenge is in this sense ... a

Word associated with teacher work

	<p>challenge that we are constantly being asked to overcome these difficulties in terms of personalities ... some ones want to know and are very interested and others don't care and we have to turn around, not it is ... it is in this sense ... the word challenge is what comes up ... it is what I feel challenged every day ... doing a job that sometimes doesn't seem to pay ... but it pays ...</p>
NS2	<ul style="list-style-type: none"> challenging ... but I'm not talking about how I feel with students. I'm thinking about myself, what I feel for myself ... later when I get to the ground ... would have other adjectives ... when I think of profession itself, the mission ... is my mission... for me it's a challenge every day...
Geo1	<ul style="list-style-type: none"> Well ... well ... I mean ... this is very complicated ... I like to teach, I love to teach ... when I leave a class and feel that I taught something I feel accomplished ... but when I leave school empty ... I don't feel like coming to school ... I like to be a teacher, I like to teach, I only know how to do it ... But not put up with ... I'm not a babysitter, I'm not a psychologist ...
Geo2	<ul style="list-style-type: none"> we have to ... we have to prepare because we are training students who don't even know what professions they are going to have ... they will need some skills ... yes ... that's for sure, so the more skills we can give them the better ... motivated, I feel it because I like what I do... although this would involve a lot and if we were to talk about motivation we would have to ...
PC1	<ul style="list-style-type: none"> I feel motivated because there are always students who ... there are students that we are going to the classroom and it is a disgrace ... we are not going motivated at all ... but there are others who really arrive ... we have to be motivated because we have to think that there are always, for example in a class of 30, if there are two or three who are motivated to learn and willing to learn ... this is good ... we know that we are not going to teach everyone or everyone will like it ...
PC2	<ul style="list-style-type: none"> although I have many moments already ... I came to the profession because I really liked it ... and I always liked it a lot ... in recent years I have felt some breaks ... I hope I don't always feel break ... break, break ... because I still lack a lot for the retirement ... but ... I like to be a teacher ... I like ... still ... despite everything the balance is still positive ...
PC3	<ul style="list-style-type: none"> I already felt more ... the balance is still positive.
NS1	<ul style="list-style-type: none"> I agree... I feel motivated to teach... But then the daily life ... the daily life ... is completely destructive and we ended up doing a little bit like we always did ... so settling in a little bit ... so sometimes I would like to have more time to invest in class preparation ... and I think this class preparation work has been very undervalued ... by the structure, isn't it ...
NS2	<ul style="list-style-type: none"> I keep motivated ... we have to motivate ...

Degree of agreement with "I feel motivated to teach"

IV. DISCUSSION

From the analysis of the students' results obtained before, during and after the activities it is verified that the students do not agree, with the statements: I only do the minimum required, I participate in the discussions about study subjects, I easily give up when the task seemed a little more demanding. We can conclude that students are not unmotivated, because according to Bzunc [8] an unmotivated student is characterized by not investing in his resources, not applying his efforts, doing only the minimum required or giving up easily when the task seems to him a bit more demanding. The motivation of the students is confirmed by the fact that, although they express that they do not ask many questions, they are curious, participate in discussions of the themes, keep their attention focused on understanding the content of an activity. Regarding the statements: during classes I look for extracurricular activities and activities with technological support arouse curiosity, students agree, but at the post-test the degree of agreement was higher. Characteristics supporting the

opinion of Neves, E; Boruchovitch [31] who states that a motivated student still asks many questions, participates in discussions on study subjects, shows curiosity, devotes much of his time to activities, deliberately seeks extracurricular activities, seeks to explore new spaces to create. Teachers have the same opinion that technology has a positive impact on student motivation, which is in line with what Lei & Zhao [32] that says that technology has provided students with new avenues for exploring interests and enrich learning experiences.

The students who did not agree in the pre-test with the statements: during classes I keep focused on an activity only when it is related to personal interests and during classes I get involved in the tasks even though I didn't do it myself, came to agree on the post-test, with statistic evidence. The teachers also consider that, during the activities performed using the IoT, the students were motivated because they were curious, exploitative and competitive. The 8thE, considered by NS1, as the least motivated class in performing the activity, even because it is class with poor results and that, according to Geo1, "does not correspond well to the project work, they work best in lectures, to pull on them", they came to the activity room before the teacher, asking what we were going to do and everyone wanted to have a role. Situations that corroborate the opinion of Knuppe [12], who says that motivation must come from the student, but the teacher and the school need to provide an approximation of the school contents with the students' reality. As stated by Leite et al [11], they need to be aware of the students' interests so that their classes are more lively, motivating and dynamic and thus bring teacher and student closer, in order to make a more rewarding class for the teacher, which It serves as a stimulus and a more solid and constructive learning for the student.

Students agree with statements such as: during class I learn to avoid punishment, during class I learn for the purpose of acquiring good grades, teachers encourage a competition environment, and teachers influence student motivation. However, according to Parellada and Rufini [13] teachers should nurture the basic psychological needs of students, putting at their disposal the appropriate means for the expression of meaningful personal choices, personalization of activities and cooperation, and appropriate challenges, avoiding a competition environment which influences students' motivation and may affect the quality of learning, involvement and persistence of students in school tasks. Throughout the activities it is emphasized that the students agree that they asked more questions and participated more in the discussions about study subjects, although there was no statistically evidence about that differences. Also noteworthy is the fact that the students agree, with significant statistical evidence, that throughout the activities, they were motivated by the use of real data. Therefore, it appears that students are motivated and that it is enhanced by the use of technology and application to real cases, which meets Benson [33] when considering that the IoT has the potential to produce significant capital gains in educational institutions, among many things, in terms of academic learning systems. However, it is not confirmed

that over the course of the activities, with the disappearance of the novelty, the student involvement has decreased and the inappropriate use of the computer has increased, as stated by Downes, J., Bishop [34].

Regarding teachers, although they show motivation when they define their work, with reference to words such as: knowledge, guidance, satisfaction, pleasure, training, challenge, learning, challenging, it is dissipated, according to teachers, by the type of students, extensive curricula, lack of time to plan and bureaucracy. Challenges that corroborate Alves [35] when he says that "bureaucratic and professional logics structure the school system and the schools. They profoundly influence the organization of work and create a vicious circle that is difficult to break by reinforcing stability." This is because, according to the same author, "change is in fact opposed to a rigid organization centered on a single order."

V. CONCLUSION

The results analysis shows us that the students, in general, are motivated, which, according to Welchen and Oliveira [14]. However, it is noted that it is enhanced by the use of IoT, because it allows the exploration and enrichment of learning through the realization of dynamic, contextualized and real activities that provide the development of various skills, "useful for analyzing actions, interactions, preference trends, and changes in student skill levels," as refereed by Aldowah et. al [15]. However, students only do in the classroom what teachers provide them, and although they also consider that, in general, IoT driven activities motivate students, they use external factors such as bureaucracy, the fact that they do not master advanced technologies in the classroom, the belief that some methodologies do not allow the use of advanced technology and the lack of time to comply with the program for not using this resource, which is in line with Chumbo, Silva & Goncalves [36]. Paraphrasing Goulão & Henriques ([51], p.28), the teacher should take advantage of the IoT 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". Because the IoT in the classroom cannot be, says Goulão & Henriques ([51], p. 28 and 29), just for the "acquisition of content is, above all, a change of mindset and posture in the teaching and learning process. The teacher must accompany, motivate, dialogue, be a leader and mediator, fostering and mediating a positive human interaction".

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