Understanding the Correlation between Teacher and Student Behavior in the Classroom and Its Consequent Academic Performance

Adson R. P. Damasceno, Andressa M. de O. Ferreira and Francisco C. M. B Oliveira
Ceara State University, Av. Dr. Silas Munguba, 1700, Fortaleza, Brazil

Keywords: Education, Student Engagement, Dropout, Classroom Management.

Abstract: Education in Brazil has reflected in students' poor academic performance. To reverse this scenario, we propose a technological ecosystem for classroom management which we call Classroom Management (GSA, acronym in Portuguese for Gestão de Sala de Aula). The technology focuses on increasing teenagers' performance and reducing dropout rates. The GSA promotes student engagement in classroom activities; allows the monitoring of students while performing these activities; creates channels of communication between teacher and student; automatically addresses the level of understanding of the class; promotes student participation in class discussions. We tested the GSA and got promising results: 1) For more than seventy percent of the students, the use of technology made them understand the subject better; 2) 85% of them reported that the GSA increased their participation in the classroom activities; 3) For more than 90% of the students, the class has become more interesting, and; 4) 88% of them would like to use the system in all disciplines. For teachers, the GSA: 1) Has not become an object of distraction in the classroom (opinion, 92% of them); 2) It made the students more participative (89%); 3) It made the class more dynamic (82%) and 4) Would like to use the GSA in all their classes (81%).

1 INTRODUCTION

According to OECD (2016), In Brazil, about 36% of 15-year-olds report having repeated their school year at least once, a proportion similar to that of Uruguay. Among Latin American countries that participated in the International Student Assessment Program (PISA) in 2015, only Colombia has a higher school dropout rate, around 43%. Countries with poor performance in PISA and higher levels of social inequality in school are more prone to such rates of school repetition.

Students need to be motivated to learn. OECD (2016) distinguishes two forms of motivation to learn science: students can learn science because they like it (intrinsic motivation) and because they realize that learning science is useful for their plans (extrinsic motivation), or both. In Brazil, between 2012 and 2015, the percentage of students who had skipped a day of school once or twice in the two weeks before the PISA test increased by 21 percentage points, signaling a deterioration in students' engagement with school during the period.

The Vygotsky Activity Theory and Proximal Development Zone (ZPD) grounded the GSA. (Vygotsky, 1980). The first provides a language for understanding complex real-world activities located in cultural and historical contexts, such as a classroom. (Engeström, 1987), (Hasan, 2013), (Leontjev, 1981). As the latter examines the relationship between education and development and is commonly associated with the distance between the actual level of development and the level of potential learning development of individuals. In this context, we present the GSA. The GSA implements Theory of Activity involving people will be in activities and involving technological resources and creates learning opportunities as promotes ZPD between teacher and pupils, since these will count on the intervention of the teacher to the point where they feel the need, obtaining information necessary for the practical completion of the content appropriation process.

This study addresses an initial assessment of GSA acceptance with a group of teachers and students. The GSA consists of a suite of applications (Android and application server), and specialized communication protocols for the classroom. To achieve this goal, the GSA implements some strategies, such as promoting student engagement in classroom activities and allowing teachers and pedagogical coordinators to fol-

Damasceno, A., Ferreira, A. and Oliveira, F.
Understanding the Correlation between Teacher and Student Behavior in the Classroom and Its Consequent Academic Performance.
DOI: 10.5220/0007729103840391
In *Proceedings of the 11th International Conference on Computer Supported Education (CSEDU 2019)*, pages 384-391
ISBN: 978-989-758-367-4

low up on students during these activities. Also, the GSA provides a secondary communication channel between teachers and students in a classroom. The GSA automatically measures the level of comprehension of the class on the content presented. Another strategy is the control of the use of the tablets of students in the classroom by teachers.

The remainder of this article is organized as follows. Section 2 describes the problem with the main elements relating cause and effect in the teaching process in the classroom. Section 3 discusses the main ideas for solving the problem. Section 4 presents GSA (with its characteristics and functionalities). Section 5 outlines the methodology adopted in the evaluation. Section 6 presents and discusses the results. Finally, Section 7 presents the conclusions and identifies possible future work.

2 LOW LEVEL OF ENGAGEMENT OF THE STUDENT IN CLASSROOM

A significant challenge for Brazilian education in high schools is to increase the engagement of students in the classroom, to raise their school performance. This work focused on investigating the possibility of obtaining an increase in the index of learning and a decrease in school dropout using technological resources, through the development of an application to support teachers and students in the high schools in Brazil's Northeast (least developed region in the Country). Figure 1 illustrates the problem and its leading causes.

2.1 Low Student Performance

According to Souza and de Souza (2013) Communication and Information Technologies (ICT) help the studying and simplify the learning by making the knowledge more structured. Technology facilitates engagement in the relationship between teachers and students in class. It is necessary to intervene on the traditional method of teaching to improve the construction of learning, characterized in a direct and passive transmission of content and information from teacher to students. GSA proposes the active participation for students in school activities, through interaction with colleagues and teachers, making use of mediating artifacts, such as tablets and cell phones. Based on this constructivist model (Castorina et al., 2013), active learning is defined as a class style in which students are involved, leading them to take an active role in their learning process. The use of tablets enables collaboration among students, which also promotes learning. Active learning takes the student from the traditional passive position and offers more possibilities for engagement.

Several studies provide evidence of the positive correlation between increased students engagement and their increased school performance and their retention of content in contrast to passive reception (Smith et al., 2005), (Simoni, 2011). The use of tablets in a classroom increases the level of student engagement (Shishah et al., 2013). Student monitoring allows teachers to address individual student deficiencies and act upon them (Beyers et al., 2013). Timid students risk learning less (Frambach et al., 2014). It is necessary to create forms of participation of shy students, without exposing them. The use of devices that allow students' responses to be automatically corrected and the result displayed to the teacher, give them the possibility to reinforce concepts that are not yet wholly assimilated before proceeding (Herrmann et al., 2012).

According to Escolar (2017), soon the final years of elementary school will overcome the last stage of primary education concerning learning gains, due to the current high school situation. The alert comes from the results of the Basic Education Assessment System (SAEB) 2017 and released by the Ministry of Education (MEC) and the National Institute for Educational Studies and Research Anísio Teixeira (INEP). The results show a high school that has been almost stagnant since 2009, and with a weak contribution to the cognitive development of Brazilian students.

2.2 School Dropout

According to Neri et al. (2009), 4 in every ten brazilian students who dropped out of school claimed disinterest as their primary reason for not attending classes. According to the survey, these young people didn't see sense in the subjects taught and affirmed that the contents didn't stimulate them to the point of taking the school seriously. Technologies can help motivate teenagers and consequently reduce their school evasion, as one solution to circumvent evasion is to adapt teaching practices to the current generation of schools by making use of technology as an ally in the classroom. These young people grew with greater ease of access to the Internet, with participation profile and interaction in the more extensive networks. Therefore, classes that are, in fact, great monologues, don't attract them. Proposing new teaching methods and investing in technologies that supports the teaching-

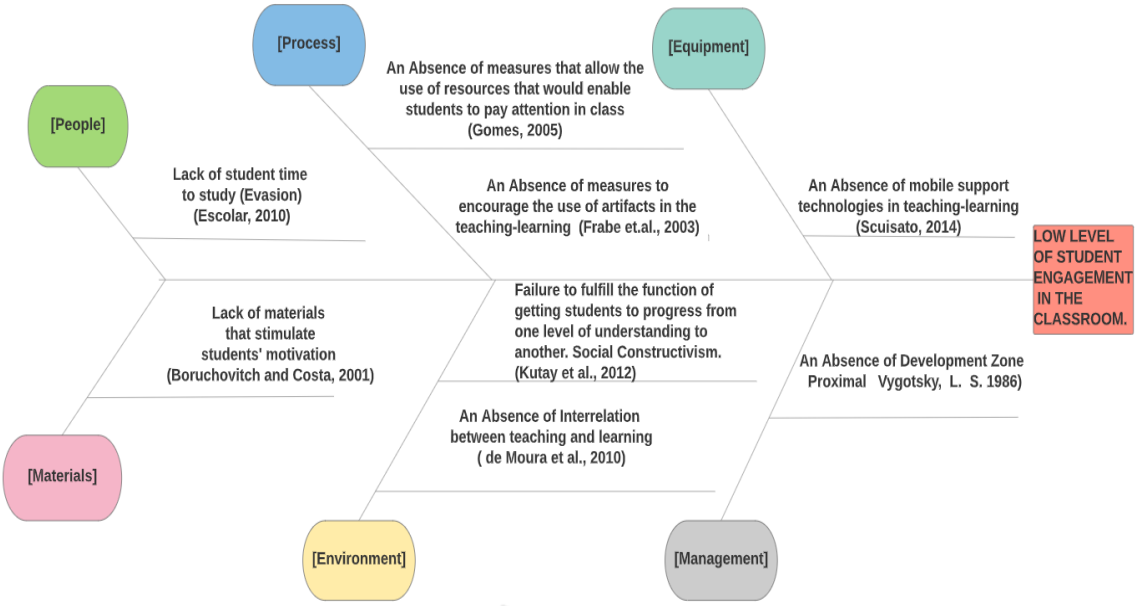

Figure 1: This figure was drawn up by the authors of this paper to illustrate the Diagram of the cause and effect of the low level of student engagement in a classroom.

learning process can help reduce school evasion.

In Brazil, the history of the School Census reveals a progressive decline in school dropout from 2007 to 2013 at all stages of schooling, but this pattern changes in 2014 when rates increase. According to Escolar (2017) between the years of 2014 and 2015 a percentage of 12.9% and 12.7% of the students enrolled in the first and second year of high school, respectively, left school. The 9th year of elementary education has the third highest evasion rate (7.7%), followed by the third year of high school (6.8%). The evasion is about 11.2% of total students considering all high school.

Faced with the harsh reality in Brazilian education and observing the main concepts that involve the teaching-learning process, students and teachers need technical support to overcome the problem concerning the impact of low academic performance and school dropout. Therefore, it opens up space for applications and fosters the production of educational technologies, programs that are useful in the real world.

In an article in his technology column in The New York Times, (Richtel, 2010) argues that mobile technologies "are in the DNA of new generations and that any resistance to its use in the classroom is futile." The author also discusses concerns related to the distraction brought about by the use of these devices in the classroom. However, the adoption of such tools in the classroom may not consider the issue of entertainment an obstacle - the opportunities that arise from its use are innumerable. Strategies and technologies need to be created to provide the necessary security and remove barriers to the entry of devices, such as tablets, into the classroom. Such devices can be great learning tools.

3 CREATING LEARNING OPPORTUNITIES

Encouraging the student to use the recent learnt concepts in a different context creates a vital learning opportunity. It is at this moment that gaps in knowledge arise, the ZPD. The instructor's attention at this particular moment is precious, providing the information needed to validate the concept appropriation process. Innovative ways to monitor how classroom activities in the classroom - held - by teachers and pedagogues to be necessary, the use of tablets facilitates this monitoring.

According to followers of active learning theory (Clancy et al., 2012), the student is the principal agent of his learning. This theory can be easily evidenced by observing the students conducting their research for their school activities. Aware of their deficits, the students seek to solve them, the Internet being the primary means used for this. In this context, the use of tablets simplify such searches and enable collaboration among students, which also contributes to learning. Active learning takes the student from the traditional passive position and offers more possibilities

for engagement. Studies show that the greater the engagement, the higher the learning. With this, Internet research should be stimulated, in the context of the execution of the activities foreseen in the discipline. It's interesting to mention that these ideas are not so recent. In 600 B.C., the Chinese philosopher Lao Tse discussed the active learning theory: "What I hear, I forget. What I see, I remember. What I do, I understand".

New knowledge is, in many cases, acquired constructively. Like bricks on a wall, complex concepts derive from more elemental ones. When a student does not understand a specific idea, its base is compromised, making it difficult to realize a more complex concept derived from this more fundamental first. In traditional classrooms, teachers follow their lessons assuming that all students are assimilating the ideas exposed unless someone manifests and says otherwise. Cases in which students allow the continuity of the class while maintaining a doubt for themselves are frequent. Classrooms where students respond through electronic devices, questions created to investigate the understanding of the content delivered until a given point, provide teachers with instant information about the degree of learning of the class. Teachers can thus adjust the course of their classes to enhance the learning level of all students, thus avoiding the snowball effect of misunderstood contents.

The introduction of tablets in the classroom can also provide the basis for the use of another essential theoretical model, constructivism (Kutay et al., 2012). The main idea of the theory is that we learn through social interactions. At all moment we are learning and teaching each other. When we engage in debates and seek to convince others of our points of view, we use the best of our arguments and all extension of knowledge. Teachers aware of the power of constructivist theory hold classroom discussions and group work. Teachers can even allow students to control digital whiteboards remotely through their tablets, favoring scenarios of discussion and exposure of each student's opinions. The teacher herelf can manage and write on the digital whiteboard from his tablet. Thus, she can walk among the students as she writes on the whiteboard, getting even closer to her class. Focusing on the use of technology to bring together teachers and students, students can ask questions directly and confidentially to the teacher through chats. This new open communication channel is of great value, especially for shy students, who benefit from secrecy to accuse some point not completely understood of the content exposed by the teacher.

One of the factors that hinder the adoption of these techniques in the classroom is the time consumed in their employment. "Administrative" activities such as benchmarking or copying content can be significantly reduced by using technology in the classroom, creating employment opportunity for superior teaching strategies.

The technology builds on the theories and strategies outlined above. The GSA was made available to the national and world market after having passed for an experimental phase in real classrooms in a large local school, presenting promising results.

4 CLASSROOM MANAGEMENT APPLICATION (GSA)

The GSA was designed to mediate the relationships between teachers and students while copresents in the classroom through the use of tablets. The software, of a simple application, can be used in the teaching of any disciplines. The GSA, with the features described below, is already available for commercial use. Its functionalities have been specially developed to improve the dynamics of the class with the use of digital resources (electronic whiteboards, scanned contents and tablets with Android technology).

Figure 2 shows the description of the GSA operational protocol. The first graphic element that stands out in the figure is the quadrilateral that delineates the physical space of the room separating the intra-class components from that extra-class of the solution. The GSA communications protocol, implemented through a series of computational services running on the root server (indicated by the letter A in the figure), manages all communications between the devices. The tough loss of efficacy of high-density wireless networks in educational environments justifies the existence of a protocol so highly specialized, where it was evidenced by (Florwick et al., 2011). In this article, the authors show in detail how the addition of wireless devices (classrooms with more students) exponentially degrades the effectiveness of the network, forming a challenging bottleneck to remove.

Aware of the problem, we have developed a specific communication protocol for the use of the GSA, which proved useful in this type of environment. The protocol, however, will require extensions to contemplate the requirements of this project. It's important to emphasize that the demand for computational resources imposed by the protocol is relatively low and it's therefore feasible that these services reside in the same equipment that controls the digital board (F). Given the GSA protocol, you can use routers (B) without many sophisticated features, which in addition to making the solution expensive can cause un-

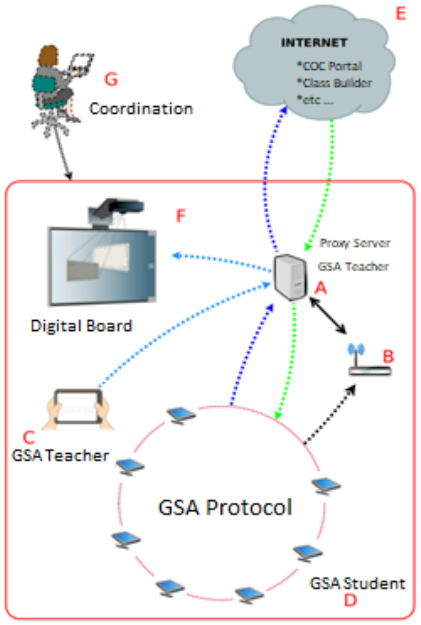

Figure 2: GSA Protocol.

desirable side effects such as shadowing. It is also the protocol that will manage classroom communications with Pearson products and any other remote services (E). The solution is also composed of specific applications for teachers (C), students (D) and pedagogical coordinators (G).

Between GSA resources, we highlight the **Map of the Classroom**. When accessing the application, the student informs in which chair he is sitting, touching the image of a green chair on an electronic classroom map (the red ones represent occupied chairs). The teacher has access to this map from his tablet, which allows him to meet all the students by name on the first day of class. Figure 3 illustrates the room map.

Figure 3: Room map.

Another feature is the **Electronic Call**. At the beginning of the class, the teacher authenticates himself in the GSA, discloses the access key to the students and activates the ”call” option. Automatically, as students log in through their tablets, the GSA will record the presence of all. Figure 4 shows on the map of the electronic classroom an image of what appears on each student's tablet.

As soon as the lesson starts **Monitoring** happens and if a student disables the GSA application on their desk, the teacher will receive a notification informing what happened. The GSA will then indicate which student made the deactivation and where in the room it is positioned.

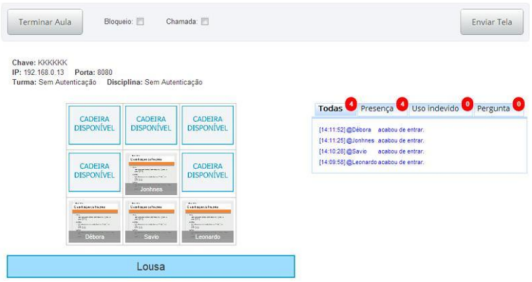

Figure 4: Electronic call and monitoring.

One feature presented by the application is **Content Sequencing**, the teacher starts his presentation on the electronic whiteboard and with the GSA he has complete control over the sequencing of content presentation. It's this functionality that manages the flow of information and thus maintains the focus and attention of students. At the beginning of the class, the teacher projects his or her first slide on the electronic whiteboard or multimedia projector, makes notes as he moves through the class, and when he completes the subject of the slide it passes to the students. Alternatively, he can design/share the slides as he projects them, giving students the opportunity to take notes.

The **Electronic Ink** counts the pen, eraser, color palette, thickness of risks, zooming and panning. It serves as a kind of electronic notebook - the Electronic Ink is used in the resolutions of questions proposed to the students. Figure 5 illustrates the Electronic Ink feature.

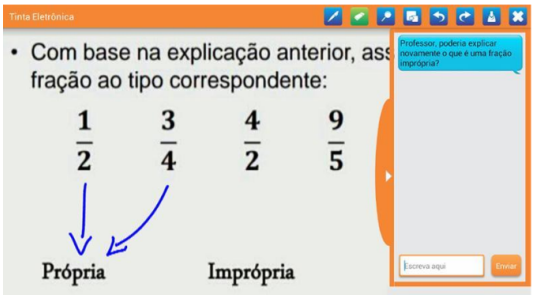

Figure 5: Electronic Ink.

The student can, through the **Chat** feature, discreetly send questions and comments to the teacher's tablet. It's a direct channel of communication be-

tween the shy student and the teacher.

Together with the Electronic Ink feature, the **Autocorrect** will give the teacher the possibility to automatically measure the degree of comprehension of the students in the course of the class, allowing him the adjustment of the exposed and the reinforcement of certain concepts. Figure 6 illustrates the "Autocorrect" functionality.

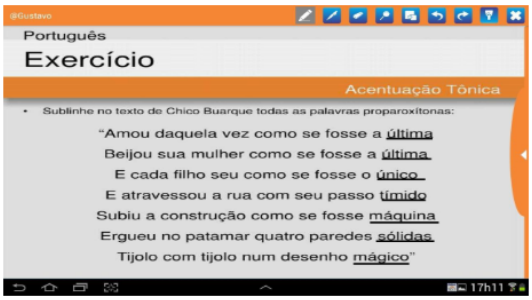

Figure 6: Example of auto-broker. Student emphasizes the word (black griffin) and the GSA automatically answers the answer (green griffin).

With the GSA we seek to solve the problem of the low level of engagement of the students in the classroom, impacting on their improvement of school performance and reduction of evasion from the implementation of strategies listed and discussed below:

1. **Promote Engagement of Students in Classroom Activities.** Several studies provide evidence of the positive correlation between increased student engagement and improvement in content learning and retention, in contrast to passive reception (Smith et al., 2005) (Hrepic, 2009) (Simoni, 2011). The use of tablets in the classroom increases the level of student engagement (Shishah et al., 2013).
2. **Allow the Monitoring of Students, by Teachers and Pedagogical Coordinators, While Carrying out these Activities.** Student monitoring allows teachers to address individual student deficits and act upon them (Beyers et al., 2013).
3. **Create Secondary Communication Channels between Teacher and Students allowing Classroom Use.** Shy students risk learning less (Frambach et al., 2014). It's necessary to create ways to encourage shy students to participate more actively during the classes, but without exposing them.
4. **Automatically Measure the Level of Comprehension of the Class about the Concepts under Discussion.** The use of devices that allow students' responses to be automatically corrected and the result displayed to the teacher, give them the possibility to reinforce concepts that are not yet wholly assimilated before proceeding with the content (Herrmann et al., 2012).
5. **Allow the Control of the use of the Students' Tablets in the Classroom by Teachers.** The GSA experience in the classroom shows that this functionality is never activated because students are engaged in the tasks assigned to them by teachers. However, functionality must be maintained, increasing the level of confidence of teachers as it demonstrates to students their authority and even strengthens in this new scenario.

The technology uses Activity Theory through the tasks generated between teachers and students as co-chairs in the classroom with exposure to the application. According to (Carroll, 2003), the Activity Theory allows us to study several levels of activity combined: from the activity of strict use of a computational artifact to the broader context of use and design. It also allows you to modify the scale and study the connections at multiple levels of activities in which computational artifacts are used and designed, without establishing a permanent hierarchy in the analysis.

5 METHODOLOGY

In this section, we will present the GSA assessment methodology. In this evaluation was applied an experiment to evaluate the impact that the technology that makes use of the theory of active learning causes in the engagement of students in the classroom. Besides, we assess the GSA for validation of its operation.

Application of the Comparative Questionnaire to the End of the Experiment

A post-experiment questionnaire was applied, at the end of the class using the technology. At the time the activity was completed, the participant answered the survey, to guarantee the fidelity of the answers concerning their involvement in the experiment and with the final objective of ascertaining the acceptance of the user when using the tool.

At the end of the experiment, the research subjects answered the questions, with which it was possible to compare the traditional class with the class using the supporting technology and observe how the tool used was analyzed. The issues were elaborated using a five-point Likert scale, responses ranging from "strongly disagree" to "strongly agree."

With the application of this questionnaire we tried to answer the following questions: Are students more

motivated to participate in another lesson with the tool? Teachers and students would like to rely on this technology in future classes? The device does not disturb the communication between teachers and students? We observe the correlation of classroom behaviors between teachers and students as to the activities in which they are involved.

6 DATA ANALYSIS

A large school has closely followed the evolution of the GSA project. Its conservative stance is justified since there is a long history in the city of schools that tried to use tablets in their classrooms and failed. The school has allowed access to its facilities, students and teachers, on an experimental character.

With the GSA we taught classes in Mathematics, Geography, Chemistry, Biology, Portuguese and English. At the end of their first class with the GSA, the students answered electronic questionnaires using the tablets they were using (Likert scale assertions). Figures 7 and 8 illustrates the results for students and teachers.

Figure 7: Students result.

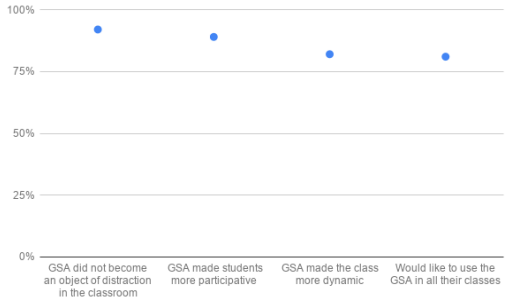

Figure 8: Teachers result.

6.1 Discussion

We tested a trial version of the GSA with 123 high school students and 15 teachers, all members of the institution mentioned above. Teachers and students were introduced to the GSA minutes before classes began. With the training reduced to minutes, the seamless use of the GSA functionality strongly indicates the adoption of large-scale the GSA in Brazilian high schools. However, the logistics of training hundreds of teachers and students add undesirable costs to product adherence and constitutes a barrier to entry of the product into the market.

The GSA worked perfectly. The teacher and student community approved the GSA. Front a positive evaluation, the college itself acquired some licenses from the GSA, instructed its IT staff to pursue further testing and renewed its commitment to continue validating new versions of the GSA on its premises.

7 CONCLUSIONS

This paper deals with the psychological correlatives of school performance related to the attitudes of students and teachers of the high school in the classroom captured automatically through the GSA application.

As a contribution of this study, the GSA implementation allows monitoring frequency, engagement in classroom activities and accuracy percentages among corrected questions by the autocorrect functionality. Besides that, the GSA shows the rate of neighbors' correct answers (given the GSA electronic classroom map functionality), number of notes made in the electronic notebooks and the number of questions asked to the teacher (through the chat function). All these indicators are examples of potential predictors.

As future work, we intend from the tools already available and in a project to address some interesting scenarios. Among them, we highlight the possibility of **predicting** students' school performance. The proposed innovation is the construction of a set of **performance predictors**, from the data collection with the use of the GSA in the classroom. You will not have to wait for the end of semester tests to know that students who do not participate in classroom activities or who do not respond correctly to questions (corrected automatically) will perform poorly. The pedagogical team of the educational institution together with parents may use performance predictors, to rescue early students with difficulty. The frequency, engagement in classroom activities, percentages of correct answers (among the questions corrected by the autocorrect),

the rate of correct answers of neighboring students (given the GSA electronic classroom map functionality), the number of notes made (the role to be developed in the GSA to record these events) are examples of potential predictors. The challenge here is pedagogical. How will students and educators react to the availability of such predictors? What impacts will these numbers have on educational practices? How will the parents and guardians be notified and what will be their reaction? We foresee strong changes in the relationships between the teaching/learning actors. Thus, given the depth of impact, the approach requires some scientific rigor in proposing and evaluating changes in experimental setup.

REFERENCES

Beyers, S. J., Lembke, E. S., and Curs, B. (2013). Social studies progress monitoring and intervention for middle school students. *Assessment for Effective Intervention*, 38(4):224–235.

Boruchovitch, E. and Costa, E. d. (2001). O impacto da ansiedade no rendimento escolar e na motivação de alunos. *A motivação do aluno. Contribuições da psicologia contemporânea*, pages 134–147.

Carroll, J. M. (2003). *HCI models, theories, and frameworks: Toward a multidisciplinary science*. Elsevier.

Castorina, J. A., Ferreiro, E., Lerner, D., and de Oliveira, M. K. (2013). Piaget vygotsky: novas contribuições para debate. *Cadernos de Pesquisa*, (96):83.

Censo, E. (2010). Br. organização associação brasileira de educação a distância. *São Paulo: PearsonEducation do Brasil*.

Clancy, S., Bayer, S., and Kozierok, R. (2012). Active learning with a human in the loop. Technical report, MITRE CORP BEDFORD MA.

de Moura, M. O., Araújo, E. S., Moretti, V. D., Panossian, M. L., and Ribeiro, F. D. (2010). Atividade orientadora de ensino: unidade entre ensino e aprendizagem. *Revista Diálogo Educacional*, 10(29):205–229.

de Souza, I. M. A. and de Souza, L. V. A. (2013). O uso da tecnologia como facilitadora da aprendizagem do aluno na escola. *Revista Fórum Identidades*.

Engeström, Y. (1987). Learning by expanding: An activity-theoretical approach to developmental research.

Escolar, C. (2017). Disponível em:¡ censobasico. inep. gov. br¿. *Acesso em*, 2.

Fabre, M.-C. J., Tamusiunas, F., and Tarouco, L. M. R. (2003). Reusabilidade de objetos educacionais. *RENOTE*, 1(1).

Florwick, J., Whiteaker, J., Cuellar, A., and Woodhams, J. (2011). Wireless lan design guide for high density client environments in higher education-cisco guide, san josé.

for Economic Co-operation, O. and (OECD), D. (2016). Pisa 2015 results in focus.

Frambach, J. M., Driessen, E. W., Beh, P., and van der Vleuten, C. P. (2014). Quiet or questioning? students' discussion behaviors in student-centered education across cultures. *Studies in Higher Education*, 39(6):1001–1021.

Gomes, E. R. (2005). Objetos inteligentes de aprendizagem: uma abordagem baseada em agentes para objetos de aprendizagem.

Hasan, H. (2013). Being practical with theory: a window into business research.

Herrmann, A., Reinicke, B., Vetter, R., Clark, U., and Grove, N. (2012). urespond: A classroom response system on the ipad. *Annals of the Master of Science in Computer Science and Information Systems at UNC Wilmington*, 6(1).

Hrepic, Z. (2009). Impact of tablet pcs and dyknow software on learning gains in inquiry-learning oriented courses.

Kutay, C., Howard-Wagner, D., Riley, L., and Mooney, J. (2012). Teaching culture as social constructivism. In *International Conference on Web-Based Learning*, pages 61–68. Springer.

Leontjev, A. N. (1981). Problems of the development of the mind.

Neri, M. C., Melo, L., Monte, S. d. R. S., Neri, A. L., Pontes, C., Andari, A. B. U., et al. (2009). Tempo de permanência na escola. *Rio de Janeiro: FGV/IBRE/CPS*.

Richtel, M. (2010). Growing up digital, wired for distraction. *The New York Times*, 21:1–11.

Shishah, W., Hopkins, G., FitzGerald, E., and Higgins, C. (2013). Supporting interaction in learning activities using mobile devices in higher education. *QScience Proceedings*, (12th World Conference on Mobile and Contextual Learning [mLearn 2013):35.

Simoni, M. (2011). Using tablet pcs and interactive software in ic design courses to improve learning. *IEEE transactions on Education*, 54(2):216–221.

Smith, K. A., Sheppard, S. D., Johnson, D. W., and Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of engineering education*, 94(1):87–101.

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Harvard university press.

Vygotsky, L. S. (1986). Thought and language (rev. ed.).