Exploring the learning object weight fair: an experience in elementary school

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ABSTRACT

The research we present in this article aimed to investigate whether the use of a particular learning object through the digital board would be able to provide interactivity and interaction between technological resources, students and the teacher. The article presents the description of an educational product and the procedures established for its exploration with a group of ten students from a 6th grade class of an Elementary School in the Paraná state school network that had this specific technological equipment - the digital board - since 2013. The activities that make up the learning object – Weight Fair - were explored by students through a digital board. Our option was for a qualitative research approach, since the data collection occurred during Mathematics classes in Elementary School, through field notes and video recordings made by the researchers. For the interpretation of the information collected we are guided by the procedures of Content Analysis using the procedures of organization, interpretation and analysis, according to the methodological and analytical concepts of the authors Moraes (1999) and Moraes and Galiazzi (2011). Such an analytical process allowed evidence of interactivity (with the digital board, the learning object, the *ultrabook*, the mobile phone and the blackboard) and interaction (with other students, teachers and members of the pedagogical team) that arose naturally as a result of the activity tasks explored on the digital board and the *ultrabook*.

KEYWORDS: Digital board. Learning object. Interactivity and interaction. Educational product.

INTRODUCTION

Digital technologies in school settings are necessary. This situation motivates the development of innumerable studies and discussions on the use of these technologies in the classroom, which are guided by diverse issues that pertain to the way of teaching, the inherent contributions to learning, the availability of such technologies in the school environment, the training of teachers in relation to pedagogical, didactic and technological aspects of this endeavor.

From this range of stimuli, needs and appropriations relevant to the field of Technologies integrated in the educational context, we list the digital board (DB) for the development of our research, as the main research object.

According to research in literature, the DB incorporates an amalgamation of the potentialities of a conventional board with the resources of a computer, providing interaction and interactivity between subjects and technological objects aiming at a collective construction of knowledge. This makes the presence of the DB in the classroom a potential and instigating element for the development of investigations (CARVALHO, 2014).

However, despite its potential as a pedagogical resource, the presence of the DB in the school is not enough to alter the teacher's pedagogical practice, as will be discussed in this article, the teacher can, through using digital technologies, develop proposals very similar to those that happen in environments without these resources. In other words, it is possible that digital technologies are only inserted in the school environment, but not integrated with pedagogical and didactic practices and the school curriculum.

In this perspective, "what will bring improvements to teaching is the way in which technology will be used, that is, the availability and skill of the educator is what counts for making significant changes" (NAVARRO; KALINKE, 2018 apud AIHARA et al., 2019, p. 6, our translation).

In view of this scenario, we proposed to remove the DB that was found since 2013 in a cardboard box kept in a school cupboard where we work as teacher-researchers, placing it as the protagonist of an investigative movement that integrates a research program that has studied student action as the activity that students develop in the classroom, while considering the learning of school knowledge.

In this investigation, we opted for a qualitative research approach adopting the procedures of Content Analysis, with the expectation of categorizing students' actions during classes planned with technological resources: learning objects (LO) and the DB.

Next, we present: considerations regarding the DB and its resources; clarifications on what we assume by interaction and interactivity for the development of this investigation; some information and comments about the investigated LO repositories; presentation of the LO (object of analysis of this research) explored by the students and the teacher, as well as the objectives of the proposed activity through the resource and the repositories in which it can be found.

After this presentation, we describe: the methods used to collect and analyze the data; what happened in the classroom; the data obtained through the filming

of the classes and the field notes; the interpretations, analyzes and reflections that this investigative practice has arisen as a result of the use of the DB as an interaction tool in the construction of mathematical knowledge (in this case, ordering numbers and comparison of masses); our conclusions and intentions for future research.

THE DIGITAL BOARD: A TOOL FOR INTERACTION

Regarding the concept of the DB, which in this research will also be called interactive digital board, we highlight the definition by Gomes (2010, p. 61, our translation):

> The interactive digital board is a technological resource that enables the development of pedagogical activities, making use of images, texts, sounds, videos, internet pages, among other tools [...]. [...] It provides teachers and students interaction with the content and activities displayed on the board and with the tools presented by it, using only the touch of a finger on the board.

With regard to the conceptualization of the interactive digital board, García, Fernandez and Souza (2011, p. 94, our translation) affirm that "[...] it is an increasingly well-known technological equipment, and educational institutions invest in the acquisition of this equipment". However, they clarified that in addition to knowing and valuing the potential of the resources that this technological equipment provides, it is essential to research whether these resources are capable of helping the teacher to teach.

Still, in relation to the concept of the DB, Nakashima (2008, p. 111, our translation) considers it to be "a modern and innovative technology, with resources that can assist in the creation of new teaching methodologies", perceiving this technology as a tool that "brings the interactive digital language of school practices". Like Nakashima (2008, p. 109, our translation), we share the idea that "the digital board enhances the performance of more interactive activities".

For Kalinke and Balbino (2016, p. 15, our translation), "the digital whiteboard can contribute to educational processes, enabling a more interactive pedagogical practice through direct manipulation", providing a collaborative learning environment. Consequently, it promotes the social construction of knowledge, since the use of this technological resource enables the participation of many people in the communicative process.

We emphasize that the differential of the DB is in its use as an instrument of interaction, that with the touch of the digital pen on the board there is an interactivity between people and machine; not using it just as a common projector, whose functionalities are the reproduction of images, videos, spreadsheets, presentations and the use of the internet in a didactic way. In this sense, this technological equipment - the digital board - can provide the insertion of interactivity and interaction in the classroom.

However, for the interactivity and interaction features of the DB to be highlighted, it is necessary to use specific applications. We are in agreement with Kalinke (2013) when mentioning that LO can be these resources, as they enable greater interactivity between the user and the subject to be investigated.

Derossi (2015 apud KALINKE; BALBINO, 2016) argues that it is possible to enhance the work on the digital board with the use of LO. The author states that LO are innovative resources that work with simulations and animations and when used in DB can be considered as differentiated resources in the production of knowledge. The simultaneous use of DB with LO provides interactive learning, creating an innovative environment for educational processes.

According to the understanding of Gallo and Pinto (2010, p. 4, our translation), a LO can permit the student "to test different paths, monitor the temporal evolution of relationships, check cause and effect, create and prove hypotheses, relate concepts, awaken curiosity and solve problems, in an attractive and fun way [...]". This type of object offers possibilities for exploration, navigation, discoveries, capable of stimulating autonomy in students' actions and choices (GALLO; PINTO, 2010).

Still, with regard to the concept of learning objects, it is understood by Kalinke and Mocrosky (2016, p. 25, our translation) as: "[...] any virtual resource, of multimedia support, that can be used and reused in order to support and favor the learning of a specific content, through interactive activity, in the form of animation or simulation."

Due to the existence of divergences between the different groups of authors regarding the terms interactivity and interaction, we chose to take as a basis a single author. Our choice was Belloni (1999), who makes a distinction between interaction and interactivity. For this author, interactivity is understood as a "technical characteristic that means the possibility for the user to interact with the machine" (BELLONI, 1999, p. 58, our translation). In this sense, interactivity is an action established between people and machines. Interaction is understood as a "reciprocal action between two or more actors where intersubjectivity occurs" (BELLONI, 1999, p. 58, our translation), that is, it is the relationship that is established between individuals, such as the relationships between: student-student or teacher-student.

REPOSITORIES AND LEARNING OBJECTS: SOME CLARIFICATIONS

Among the various repositories of learning objects (RLO) accessed, we focus our attention on those which: had objects related to content in the area of Mathematics; were in Portuguese language; that allowed both viewing and using LO online and downloading them to be used at another time, without the need to establish a connection to an internet network; that were in accordance with the classification proposed by Battistella et al. (2009, p. 3, our translation), when they state that interactive learning objects "need user input to be used" and are exploratory because "they allow changing the state of the object to obtain new outputs and information. Examples: games, simulations, concept maps" (BATTISTELLA et al., 2009, p. 3, our translation).

In view of these criteria, we chose four repositories, from which we selected and studied, during the investigative process, six learning objects (Table 1). However, in this article, we highlight the repository of the Research and Production Group of Interactive Environments and Learning Objects (PROATIVA) and as results of applying only one object from this repository, we present the LO Weight Fair. Regarding the information contained in Table 1, we clarify that the

same LO can be located in more than one RLO, therefore, our option was to indicate only one of them and as a criterion we consider the repository responsible for its creation.

Table 1 – Information about the selected LO

Learning objects	RLO where they are found and the respective electronic address	Possible mathematical content to be studied
Build a Fraction	PhET Interactive Simulations Available at https://phet.colorado.edu/pt_BR/simulations/category/math	Fractions, equivalent fractions and mixed numbers.
Associate Fractions	PhET Interactive Simulations Available at https://phet.colorado.edu/pt_BR/simulations/category/math	Fractions, equivalent fractions and mixed numbers.
Weight Fair	PROATIVA Available at http://www.proativa.virtual.ufc.br/objetos_aprendizagem/feiradosPesos/feiradosPesos.html	ordering of unknown weights (ascending and descending orders).
Swinging	PhET Interactive Simulations Available at https://phet.colorado.edu/pt_BR/simulations/category/math	Fractions, equivalent fractions, mixed numbers and decimal numbers.
Fractions	RIVED/UNIFRA Available at http://sites.unifra.br/rived/RivedUnifra/tabid/410/language/pt-BR/Default.aspx	Fractions.
Silly Mathematics	NOAS Available at http://www.noas.com.br/	Successors, and predecessors of natural numbers.

Source: The authors (2018).

PRESENTATION OF THE EDUCATIONAL PRODUCT

The LO **Weight Fair** - Figure 1 - was the object explored by the students and the teacher. The creators of this LO list some objectives of this resource: to introduce algebraic concepts; to put unknown weights in order, making comparisons between them; to awaken students' hypotheses; and to make students interact with the computer, being able to test their own hypotheses about the relationships of the masses on a two-plate scale. The creators state that students need to have as prerequisite some notions of comparison, such as: greater than, less than and equal (PROATIVA, 2015).

Figure 1 – LO **Weight Fair**: home screen

Source: PROATIVA (2015).

This LO is composed of a single activity called **Weight Fair**[1] and makes it possible to choose the level of difficulty - levels 1 to 5, with level 1 being the least difficult and level 5 being the most difficult. It also allows students to select the way in which the weights are to be ordered - in ascending or descending order in relation to the masses of objects - which must be chosen by the students before the beginning of the attempts.

During the activity, the resource records the number of times - number of movements - that a weight was placed on one of the scales. Also, it contains the History topic that lists the attempts made during the organization of the weights on the scale, indicated by expressions such as: A<B, C<B, etc.

The use of this simulation requires: *Windows* or *Linux* operating systems; *Flash Player software*; a *browser* that supports *Flash Player*, such as *Adobe*. To make use of the activity without having to be connected to an internet network, it is necessary to perform the following procedures: 1. Locate the LO on the repository website; 2. Click on *download*, waiting a few seconds; 3. Click on "extract everything" and "extract" to unzip the file; 4. In the "*downloads*" folder, locate the folder titled "downloadFeiraDosPesos", click on it and with the right mouse button click on "copy"; 5. Open the "documents" folder on the computer and, using the right mouse button, click on paste, thus keeping the folder with the LO files saved in the "documents" folder; 6. With the left mouse button, click on the folder "downloadFeiraDosPesos"; 7. Click on the HTML document with the left mouse button, opening the Weight Fair activity.

DATA COLLECTION AND SOME METHODOLOGICAL PROCEDURES

Our search for RLO took place through access to the GPTEM website in the LINKS section. The electronic address[2] is maintained by the Research Group on Technologies in Mathematics Education (GPTEM), linked to the Graduate Program in Science and Mathematics Education of the Federal University of Paraná and to the Academic Department of Mathematics at the Federal Technological University of Paraná. Its members aim to develop studies and academic research related to the use of technologies in Mathematics Education

We emphasize that the Research and Production Group of Interactive Environments and Learning Objects (PROATIVA), from which we selected the LO Weight Fair, aims to: create learning objects, train teachers to use LO in teaching,

conduct research on the use of LO by students and teachers. The PROATIVA team consists of students from different fields. The members of this RLO are also dedicated to LO research and production, digital resources (animation, simulation, video, among others), resources that enable teachers and students to explore specific concepts in several areas of knowledge, with greater emphasis on Science teaching and Mathematics Education, directed to Elementary and High School students (PROATIVA, 2015).

The classes were planned in 2015 and 2016 by the researchers (who also acted as teachers). The classes were conducted with a group of ten students from the 6th year of Elementary School at a public school in the state of Paraná, during extra-curricular hours. The implementation of the classes took place between September and December of 2016, totaling four months.

The classes were filmed and followed up by elaborating a collective field notebook maintained by the researchers, which resulted in an expressive amount of data. Therefore, we chose to bring the analysis of the application of one of the LO (conducted in September 2016)[3]. During the research process, the analysis of the filming (transcriptions) and the field notes were conducted, and the students' actions in relation to the DB and the LO were observed.

With the intention of maintaining discretion in relation to the researched subjects, the names of the students and the school were omitted, however the students were aware of their participation in the research, as well as their parents/guardians. The school was properly registered at Plataforma Brasil in the research project entitled "Teaching and learning science and mathematics in the classroom and in informal settings", coordinated by researcher Sergio de Mello Arruda, having been approved by the Ethics Committee (Number CAAE: 57663716.9.0000.5231. Report Number: 1.666.360).

Moraes (1999) explains that Content Analysis is a research methodology used to describe and interpret the content of all types of documents and texts. For Olabuenaga and Ispizúa (1989 apud MORAES, 1999, p. 7, our translation), Content Analysis "is a technique to read and interpret the content of all types of documents, which, when properly analyzed, open the door to knowledge of aspects and phenomena of social life otherwise inaccessible". With regard to the methodology that underlies Content Analysis, Moraes (1999) conceives it as consisting of five stages: 1. Preparation of information; 2. Unitarization; 3. Categorization or classification of units into categories; 4. Description; 5. Interpretation.

For Olabuenaga and Ispizúa (1989 apud MORAES; GALIAZZI, 2011, p. 148, our translation), in Content Analysis the researcher can assume several roles in their analysis, such as: "reader, analyst, judge and critic, when reading intends to be explicit or manifest; interpreter, explorer, spy or counter-spy, when reading intends to reach the hidden or implicit". Content Analysis can assume all these roles, sometimes focusing on the manifest, sometimes on the hidden (MORAES; GALIAZZI, 2011).

Prior to the methodological procedures described, in possession of the data and in a first moment of contact, it was necessary to carry out a reading called "floating" which, according to Bardin (2011, p. 126, our translation), "consists of establishing contact with the documents to be to analyzed and to know the text allowing itself and to be invaded by impressions and orientations". In this

process, reading gradually becomes more accurate, due to emerging hypotheses. This is the moment when the researcher allows himself to be immersed by the data, without having in mind the concern of carrying out any analysis or inference about it.

In continuity, we bring clarifications in relation to the procedures adopted in the analysis of the collected and interpreted data:

I. We watched the videos of the two classes in which the learning object chosen by the teacher was explored by the students and we recorded their actions during the performance of tasks related to the activity called Weight Fair provided by the use of the object, actions which evidenced the occurrence of interactivity (with the digital board, the learning object, the ultrabook, the mobile phone and the blackboard) and interaction (with other students, teachers and members of the pedagogical team) that arose spontaneously as a result of carrying out the tasks of that activity;

II. We accommodated the actions perceived in groups that indicated the similarity of meanings, listing them in two categories: interactivity and interaction, established a priori according to the investigative objectives;

III. We re-analyzed the data accommodated in each of the categories, a process in which resulted in five subcategories for the interactivity category: Interactivity with the digital board; Interactivity with the learning object; Interactivity with the ultrabook; Interactivity with the mobile phone; Interactivity with the blackboard; and, in four subcategories for the interaction category: Interaction with a partner and other students; Interaction with the teacher; Interaction with other teachers; Interaction with the pedagogical team;

IV. We organized these subcategories in two tables and resumed the analysis process, which led us to design interpretative units for each of the listed subcategories that are directly related to the students' actions through the DB and LO;

V. At the end, we wrote comments regarding our perceptions about the actions of the students subject to the research, supporting the hypothesis that interactivity and interaction occurred during the exploration of the selected LO.

It is also worth noting at this point that these categories and subcategories were considered during the analysis of the investigative results of the application of the LO Build a Fraction (VICENTIN; PASSOS, 2017). Despite the similarity between the categories and subcategories, we have - as will be discussed in the continuity - divergences as to the frequency with which they manifest and as to the specific actions of the students.

PRESENTATION AND APPLICATION ANALYSIS

Next, to elucidate details of the research, we bring several fragments of the intervention data that we carried out - extracted from two classes that took place in September 2016 - in which we used the LO **Weight Fair**. We justify this choice because it was the resource that provided a greater number of actions registered in the data analysis process, being one of the most representative applications.

To carry out the specific activity of this LO, students were organized in pairs by the teacher - five in total -, with the purpose of encouraging interaction between them during the execution of the tasks proposed by the activity. We believe that this form of student organization allows them to learn from each other and practice the exercise of discussing the activity of the LO.

The first pair (A) performed the level 1 task of the LO **Weight Fair** (using the ascending order to order the masses); the second pair (B), the level 2 task; and so on, until the end of the level 5 tasks. The same order was used during the exploration of the tasks of each of the five levels of this activity, but arranging the weights in decreasing order of mass.

During the execution of the tasks - following the order previously described that was proposed by the teacher as a way of organizing the activity - some pairs decided to choose another level of difficulty, not following the recommended order. The reasons for the changes in the pairs were different, for example: they chose the most difficult level of the LO activity because they considered it an easy task to perform; they opted for a lower activity level because they considered it a difficult task.

Later in this article, we will present and describe three tasks - of the 20, in total - carried out by the pairs of students when exploring the activity related to the LO **Weight Fair**, explaining the objectives provided by it.

Figure 2 illustrates a task of the activity, referring to level 1 (ordering in ascending order) and, at this moment, being performed by pair A. This task allowed students to compare and order - in increasing and decreasing orders of mass - unknown weights, testing and proving their hypotheses about the relationship between weights on a two-dish scale and developing logical reasoning.
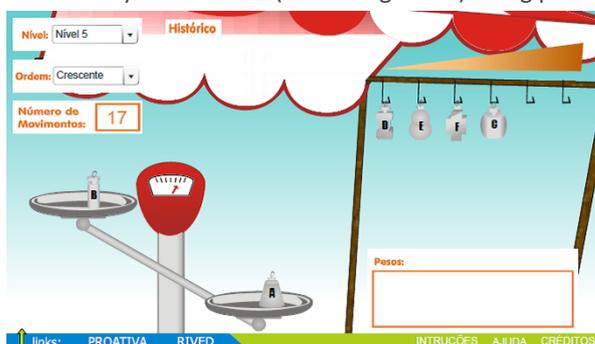
Figure 2 – **Weight Fair** Activity: level 1 task (ascending order) being performed by pair A
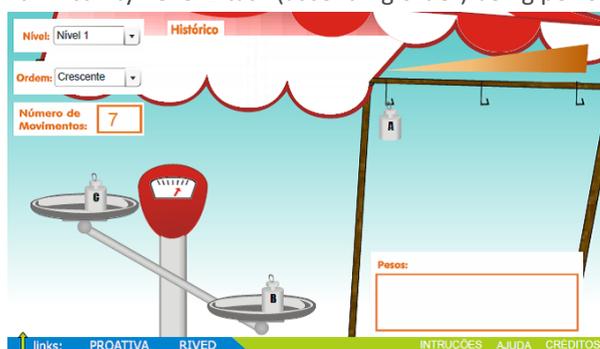
Source: PROATIVA (2015).

The level 5 task (ascending order) of the **Weight Fair** activity - illustrated by Figure 3, contemplates the objectives already explained above. The task also makes it possible for students to realize that the object with the largest shape is not always the one with the greatest mass.

Figure 3 – **Weight Fair** Activity: level 5 task (ascending order) being performed by pair E

Source: PROATIVA (2015).

Figure 4 shows the image of the level 3 task (descending order) being done by pair C. In addition to contemplating all the objectives achieved by the accomplishment of the level 1 task (Figure 2) by pair A, it led the students to verify that when performing the task again choosing the same level and order previously selected, the learning object changed the values of the masses of each object.

Figure 4 – **Weight Fair** Activity: level 3 task (descending order) being performed by pair C

Source: PROATIVA (2015).

After these examples, we present the data obtained through the procedure of analyzing the field notes recorded by the teachers of the video transcriptions; the interpretations, analyzes and reflections that this investigative experience provided during the use of the DB as an interactive tool in the construction of mathematical knowledge.

This last procedure culminates, after repeated readings, in the allocation of data in the two categories assumed *a priori*: interactivity and interaction. In the continuation of the investigation, resuming this first organization in categories and restarting a new process of interpretation and analysis, we highlight a set of subcategories and their respective interpretative units. Such accommodations will be presented below, in a succinct manner, in two tables - Table 2 and Table 3.

Table 2 – Subcategories of the **interactivity** category and its interpretative units

Subcategories	Interpretative units
Interactivity with the digital board	They perform the activity proposed by the LO using the DB. They use the digital pen in the interactive mode. They touch the DB receptor. They touch the unused digital pen that was on the table or the blackboard eraser holder. They move objects (weights) with the digital pen. They select the order (ascending or descending) with the digital pen. They select the level of difficulty with the digital pen.
Interactivity with the learning object	They risk an answer to the proposed activity. They seek a solution strategy for the proposed activity. They move objects (weights). They perceive that with each new task the LO changes the mass of each object (weight). They pay attention to the LO activity. They select the order (ascending or descending) of the LO activity performed. They select the level of difficulty of the LO activity to be performed. They select the most difficult level of the LO activity performed.
Interactivity with the *ultrabook*	They sit in front of the equipment and pay attention to the activity of the LO. They use the equipment to do the activity using the mouse. They select the order (ascending or descending) with the mouse. They select the level difficulty with the mouse.
Interactivity with the mobile phone	They touch the equipment. They hear and record voice messages. They take pictures of the LO projected on the screen.
Interactivity with the blackboard	They erase what they recorded on the blackboard. They draw on the blackboard. They write on the blackboard.

Source: The authors (2018).

In Table 2, for the interactivity category, we inserted the subcategories and the respective interpretive units, which highlight the students' actions in view of the situation they were in, that is, the exploration of the LO Weight Fair in the DB. We emphasize that the five subcategories of the interactivity category are located in column 1 and are named as follows: Interactivity with the digital board; Interactivity with the learning object; Interactivity with the *ultrabook*; Interactivity with the mobile phone; Interactivity with the blackboard. In column 2, we have the interpretive units that represent the students' actions regarding the exploration of the selected learning object, for each of the subcategories presented.

The first seven interpretive units listed in Table 2 (allocated in the subcategory Interactivity with the digital board) show students' actions with technological resources, revealing, according to what we assumed by definition, the occurrence of interactivity. The first five actions show that this LO allowed students to: perform the activity proposed by the resource using the DB, use the digital pen to select the level of difficulty and/or the order (ascending or descending orders of mass) and moving objects (weights) during the performance of the activity proposed by the LO. The last two interpretative units shown are

actions that occurred sporadically and probably occurred due to the students' curiosity regarding the components (receiver and digital pen) that make up the digital board.

The units displayed in the sequence show evidence of interactivity between the learning object and the students, so they were allocated to the subcategory Interactivity with the learning object. The explored learning object led to actions that can be seen in Table 1. We emphasize that the last action perceived in students that "They select the most difficult level of the LO activity performed" came about as a result of the explored learning object presenting a challenging activity for students.

After these eight interpretative units that reveal actions with the learning objects, we have four of them that demonstrate the "Interactivity with the *ultrabook*", the third subcategory. The first action "They sit in front of the equipment and pay attention to the activity of the LO" arose from the fact that some students chose to observe the performance of the activity by other students through the referred equipment, becoming a common practice, instead of simply waiting for the moment to carry out the activity or carry out the observation directly from the screen on which the LO image was projected. The next three arose due to the occurrence of technical problems: the digital pen did not work when exploring the LO, making it impossible to move objects (weights), as well as the selection of the order and level of difficulty of the activity. It should be noted that, for this problem, we have not identified solutions.

The next three actions described in column 2 of Table 2 reveal evidence of interactivity between the mobile phone and the students, a fact that led us to elaborate the subcategory "Interactivity with the mobile phone" and to accommodate these interpretative units. We emphasize that these actions, during this analytical process exposed here, did not seem to have a direct relationship with the activity of the learning objects, however they were provided by the learning environment in which they made use of a technological resource - the digital board - during the exploration of the LO. We also report that the action "They hear and record voice messages" was casual, as it had a single occurrence during the use of the referred learning object. The action "They take pictures of the LO projected on the screen" arose perhaps because the students found the activity proposed by this object interesting, "cool", "interesting", (manifestations that are part of the recordings). We also clarified that it was not possible to have full control over the use of mobile phones of students to know what they were doing. However, these actions did not appear to have been necessary to perform the tasks, but it was decided to maintain them as interpretive units because they caused changes in the events of the classroom.

Still, we have the last subcategory of Table 2 "Interactivity with the blackboard", whose interpretative units can be seen in Table 1 (row 5, column 2). We justify the occurrence of interactivity, because, sometimes, the last two actions - which refer to writing and drawing on the blackboard - helped students in solving the activity proposed by the LO.

In a final analysis with regard to the actions registered in Table 2, we could observe that the first two subcategories related to the **interactivity** category have the largest number of interpretive units (seven for "Interactivity with the digital board" and eight for "Interactivity with the learning object") and is dedicated to

highlighting the students' interactivity with these resources. Therefore, we emphasize that the use of this learning object as a resource of the digital board allowed the insertion of interactivity in the classroom, since it enabled interactivity between students and machine.

In this sense, the DB made approximation of the "interactive digital language of school practices" possible, as recommended by Nakashima (2008, p. 103, our translation). Still, the concomitant use of the DB with the LO enabled learning in an interactive way, as advocated by Derossi (2015 apud KALINKE; BALBINO, 2016).

The same form of organization and detail was used in Table 3, shown below, for the **interaction** category. The four subcategories of the interaction category can be seen in column 1 and are named as follows: Interaction with their partner and other students; Interaction with the teacher; Interaction with other teachers; Interaction with the pedagogical team. In column 2, are the interpretative units that represent the students' actions regarding the use of the selected learning object, for each of the subcategories presented.

Table 3 – Subcategories of the **interaction** category and its interpretative units

Subcategories	Interpretative units
Interaction with their partner and other students	They accept or not the strategy suggestions suggested by classmates. They assist classmates in the LO content. They assist the partner in moving the objects (weights). They assist the partner in solving the activity. They discuss possible solutions. They tell the answer to their classmate. They indicate the error to the classmate. They watch the other students do the activity. They receive help from students about the LO activity. They receive help from students on the content of the LO. They receive help from students on how the digital pen works. They receive help from students regarding the LO activity. They receive help from classmates on possible solution strategies. They respond to questions from classmates. They reject help from classmates during the performance of the LO activity. They ask students for help with the operation of the digital pen. They suggest solution strategies to classmates.
Interaction with the teacher	They discuss possible solutions. They ask to do the activity proposed by the LO again. They ask if there is a need to be connected to the internet to operate the LO. They pay attention to the teacher's explanation of the LO content. They pay attention to the teacher's explanation of the LO activities. They pay attention to the teacher's explanation of the strategies used by other pairs during the performance of the LO activity. They pay attention when the teacher calls the students' attention to help the pair that are doing the LO activity. They receive help from the teacher about the LO activity. They receive help from the teacher on the content of the LO. They receive help from the teacher on the functioning of the digital pen.

Subcategories	Interpretative units
	They are helped to move objects (weights).
	They receive an explanation on how to charge the digital pen.
	They receive an explanation of the need to be connected to the internet to operate the LO.
	They receive incentives from the teacher to carry out the LO activity.
	They receive suggestions on how to start the LO activity.
	They answer the teacher's questions.
	They request explanations on how to charge the digital pen.
Interaction with other teachers	They pay attention to the speech of a teacher, from another discipline, who asked about the LO.
Interaction with the pedagogical team	They pay attention to the speech of the pedagogical team member.
	They receive incentives from the pedagogical team member.

Source: The authors (2018).

For the first subcategory - Interaction with their partner and other students - we identified seventeen interpretative units that, as explained above, represent actions manifested by students during the use of the digital board and the explored learning object, showing the occurrence of interaction among all students. At this point, we will make some comments regarding these actions carried out by the students in the classroom. The actions that appeared most frequently were: They assist classmates in the LO content, in the solution of the activity and in the movement of the objects (weights); they receive assistance from classmates on the activity and content of the LO, and also on possible solution strategies; they watch the other students do the activity; they respond to questions from classmates; they suggest solution strategies to classmates; they accept or not the strategy suggestions suggested by classmates; they discuss possible solutions; they indicate the error to the classmate; they tell the answer to their classmate. On the other hand, the less frequent, but equally important, actions were: they ask and receive help from students on how the digital pen works; they reject help from classmates during the performance of the LO activity.

The second subcategory related to the **interaction** category has the same number of interpretive units (seventeen) in relation to the first subcategory and shows the interaction with the teacher. It is possible to observe that a large part of the interpretative units or actions listed in Table 3 (row 2, column 2) refer to explanations from the teacher and the request for technical assistance to the teacher regarding technological resources so that students could perform the activities satisfactorily. At this point, two comments are needed on the actions of the classroom: as this learning object provided the students' the third experience with the digital board, they felt more comfortable to clarify some doubts regarding the components of the digital board and the functioning of the LO, which justified the occurrence of the following interpretative units: They ask if there is a need to be connected to the internet to operate the LO; They receive an explanation of the need to be connected to the internet to operate the LO; They request explanations on how to charge the digital pen; They receive an explanation on how to charge the digital pen. We also emphasize that although students had already used the digital pen several times, some still had difficulty in handling and using this component of the digital board, a fact that justified the

emergence of the interpretive unit: They receive help from the teacher on the functioning of the digital pen.

Still, we present some details regarding the last two subcategories present in Table 3, and which had the lowest incidence of interpretative units, but which, in our view, could not be left out: Interaction with other teachers (one interpretative unit) and Interaction with the pedagogical team (two interpretative units). Such incidence is justified by the fact described below: the teacher of another discipline and the member of the pedagogical team participated for a few minutes in one of the classes dedicated to the exploration of the LO **Weight Fair**. In the case of the first subcategory listed in this paragraph (third and penultimate of Table 3), it arose because one of the school teachers decided to go to the classroom to observe the students using the object in the DB, which provided the disclosure of the following action: They pay attention to the speech of a teacher, from another discipline, who asked about the LO. Regarding the second subcategory (fourth and last in Table 3), which is linked to the pedagogical team, we highlight two actions: They pay attention to the speech of the pedagogical team member; They receive incentives from the pedagogical team member.

Finally, returning to Table 3, we find that it contains 4 subcategories and 37 interpretive units, showing that the LO **Weight Fair** provided 37 different actions by students that reveal the occurrence of different types of interactions. We also observed that the subcategories of the **interaction** category with the highest number of occurrences were: Interaction with their partner and other students (17 interpretive actions/units) and Interaction with the teacher (17 interpretive actions/units). Therefore, it became evident that the simulation activity on the digital board led to the need for discussions between students and, also, between students and the teacher about the content covered (ordering numbers and comparison of masses) through the LO **Weight Fair** to think about possible hypotheses and solutions for the tasks to be performed.

In this perspective, we found that the exploration of the learning object on the digital board by the students allowed the insertion of interactions in the classroom, agreeing with Kalinke and Balbino (2016) that these and other technologies provide interaction. Therefore, the DB was used as an interaction tool which is one of the differentials provided by this technological equipment and its resources.

CONCLUSION

Conducting this research was a challenge both for researchers, who also acted as teachers, and for students, since the use of the digital board in the classroom required: dedication, reflection and research. There was also the need for a reframing by the teacher and students about the teaching and learning process of Mathematics, which made it possible to show interactivity and interaction, not always present in the classes of this discipline. The teacher valued the students' actions and expressions, no longer expecting them to be listeners, that is, having a passive attitude towards the construction of knowledge, assuming another role in teaching mediated by technologies. Consequently, the students became active subjects in the construction of their

own mathematical knowledge through the teacher's mediation. Thus, the teacher had the role of "mediating between the student and knowledge", as recommended by Charlot (2005, p. 90, our translation).

The learning promoted environment - a collaborative learning environment - made the classes more interesting and provided the collective construction of mathematical knowledge, since it provided a greater interaction between students and between students and the teacher, than what we commonly identify in math classes. In this sense, Shneiderman (2006, p. 132, our translation) also draws attention to the potential of this type of environment by stating that "these environments engage students and transform the teaching-learning process".

With regard to interaction (which arose spontaneously), we observed that the proposed activity - a simulation exercise on the digital board - led to the need for discussions: between students; between students and the teacher; between students and another teacher; between students and the pedagogical team. The resolution of this activity, demanded from students, actions such as: helping other students to move objects (weights), in the content of the LO, in the solution of the proposed activity; discuss possible solutions; indicate the mistake made to the classmates; tell the answer to their classmates; watch other students solve the activity; receive assistance from other students and the teacher about the LO activity, the LO content, how the digital pen works; receive help from other students on possible solution strategies; receive assistance from the teacher on how to move objects and how to load the digital pen; respond to questions from students and the teacher; pay attention to the teacher's explanation of the LO activities, the strategies used by other pairs of students during the performance of the LO activity; receive encouragement from the teacher and the member of the pedagogical team to carry out the LO activity; pay attention to the speeches of other teachers (of a teacher from another discipline) and of the member of the pedagogical team.

Likewise, interactivity also arose naturally due to the accomplishment of the tasks of the activity explored in the LO, whose solution required students to perform actions such as: move objects (weights) with the aid of the digital pen in the interactive mode and (or) with the *ultrabook's* mouse; use the digital pen in the interactive mode; select the ordering and/or level of difficulty of the activity with the aid of the digital pen and (or) with the *ultrabook's* mouse; sit in front of the *ultrabook* to pay attention to the activity; touch the DB receiver and the digital pen; risk an answer or seek a solution strategy for the activity; use the mobile phone for different actions; make drawings and (or) write on the blackboard, actions that helped students in solving the activity proposed by the simulation.

In future research we intend to analyze not only the students' actions, but also the teacher's actions when exploring with their students a LO on the DB. We also intend to establish a relationship between the actions of the teacher and students in order to investigate whether a set of actions by the teacher would trigger a set of corresponding student actions.

Explorando o objeto de aprendizagem feira dos pesos: uma experiência no ensino fundamental

RESUMO

A pesquisa cujos resultados apresentamos neste artigo teve por objetivo investigar se a utilização de um determinado objeto de aprendizagem por meio da lousa digital seria capaz de propiciar a interatividade e a interação entre os recursos tecnológicos, os estudantes e o professor. O artigo traz a descrição de um produto educacional e os procedimentos estabelecidos para sua exploração junto a um grupo de dez alunos de uma turma do 6º ano do Ensino Fundamental de um colégio da rede paranaense estadual de ensino que possuía esse equipamento tecnológico específico – a lousa digital – desde o ano de 2013. As atividades que compõem o objeto de aprendizagem – Feira dos Pesos – foram exploradas pelos alunos por intermédio de uma lousa digital. Nossa opção foi por uma abordagem qualitativa de investigação, pois a coleta de dados ocorreu durante aulas de Matemática no Ensino Fundamental, por meio de notas de campo e de gravações em vídeo realizadas pelos pesquisadores. Para a interpretação das informações coletadas pautamo-nos nos procedimentos da Análise de Conteúdo utilizando os procedimentos de organização, interpretação e análise, segundo os conceitos metodológicos e analíticos dos autores Moraes (1999) e Moraes e Galiazzi (2011). Tal processo analítico permitiu evidenciar indícios de interatividade (com a lousa digital, o objeto de aprendizagem, o *ultrabook*, o celular e o quadro negro) e de interação (com outros alunos, professores e integrante da equipe pedagógica) que surgiram naturalmente em decorrência da realização das tarefas da atividade explorada na lousa digital e no *ultrabook*.

PALAVRAS-CHAVE: Lousa digital. Objeto de aprendizagem. Interatividade e interação. Produto educacional.

NOTES

1 This LO can be found at the following email addresses: http://www.noas.com.br/ of the NOAS repository; http://objetoseducacionais2.mec.gov.br/ of the International Bank for Educational Objects (BIOE); http://www.proativa.virtual.ufc.br of PROATIVA, the repository responsible for its elaboration.

2 http://gptem5.wixsite.com/gptem/sobre-1.

3 The disclosure of the LO analytical results - Build a fraction - can be accessed in Vicentin and Passos (2017) and we indicate that the study of four other objects is in progress.

4 Translation by Sandro Lucas Reis Costa. E-mail: lucasrc_1995@outlook.com. Londrina State University (UEL), Londrina, Paraná, Brazil.

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