Constructivism in Mexican Elementary School Education: Designing a Platform for Cooperative Learning

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Abstract—In Mexico, the conventional teaching approach, when applied specifically to elementary school, seems to fall short of attaining the overall quality objective. The main consequence of this problem is when teachers are not sure that their students really understand the dynamic nature of concepts and mechanism since an early age, particularly in elementary school. This paper presents a pedagogical/technological platform, based on constructivism ideas, as a means of making the learning process in elementary school more efficient and interesting. The constructivist platform presented here uses graphical simulators developed for Web 2.0 as a support tool, creating a teaching and learning environment in which practical experiments can be undertaken as each topic is introduced and explained.

Index Terms— Computer based education, pedagogy, cooperative learning, interactive platform, constructivist theory

I. INTRODUCTION

Nowadays, Latin America is composed by heterogeneous and fragmented societies which live between "pre and post modernity" in relation with the education. There is a lack of infrastructure and ideas that make it impossible to bring education for every child; moreover, when this education constitutes, considerably, the pillar for all countries around the world. The challenges in the educational sector have been affected by an increasing demand of services; it is necessary to improve the educational achievements and the necessity of innovation to participate in the possibilities of knowledge and information societies [2]. However, in spite of this situation, we are not paying attention to the advantages that could provide interaction with the different intellectual capabilities of students to improve the group learning and, by consequence, individual learning: something that has been denominated as: cooperative learning.

The cooperative learning has been used since the 70's when researchers proposed different approaches and studies to implement cooperative learning techniques with students at different ages and levels. Since then, the teacher was responsible for organizing, guiding and recording all activities of his students through support material as blackboards, books and templates, among others [20].

At the same time, many psychologists like [19] and [12] affirmed that the learning process was, fundamentally, an experience of social character where the language played a basic role as mediation tool not only between teacher and student; it was useful between all classmates too. The students learned how to explain, justify or argue their ideas against other students. According with Vygotsky: *"...in a cooperative scenario, the students interchange their ideas for coordinating them to achieve shared objectives. When the problems arise, the combination of activities with communication will conduce to learn"* [26]. Thus, the construction process for shared knowledge is a huge help in individual learning. In this sense, the cooperative learning is a social activity that involves a student community where the knowledge is shared and developed; according to [9] the knowledge social construction.

Cooperative learning has been defined as the acquisition of knowledge, abilities, and attitudes through the interaction among the group. Recently, formal methods in classrooms have been developed and implemented; all of these have the main objective to improve the learning process through learning modules. These modules, physically perceptible, use situation modeling and provide a specific representation of a topic. Usually, the learning modules include experiments in the classroom with demonstrations through oral presentations.

However, in a collective way, all students have to develop and acquire the necessary abilities for working as a team, they have to establish performance methods, generate alternatives, explain, justify and evaluate solutions; this process enables the existence of an effective collaboration [3]. In the last decade, IT development has stood out and new forms of society interactions have been created. With these, increasingly new IT systems have been developed with the intention of improving the cooperative interaction among users [21], [1], [28]. Moreover, different educative institutions which have adopted these technologies, have had to implement new methods for learning and teaching. Nevertheless, taking into account this influence and the impact of technological development on the society, nowadays our educational institutions are using a new set

of technologies for communicating and computing and they are discovering their potential to improve the pedagogic strategic effectiveness. Amongst them, one line of research that has produced some positive results makes use of the constructivist method of teaching. Although well established in other areas, e.g. mathematics, constructivism has only appeared relatively recently in computer science [24], [5], [25], [11].

In this paper we present a constructivism platform to be used and evaluated in the everyday of elementary education classrooms.

II. MEXICAN ELEMENTARY SCHOOL TEACHING

It is clear that one of the most important problems in Latin America is the education. According to UNESCO in 2006: *"...in Latin America, only two of ten students have access to higher education; the other eight does not do it because the higher costs or geographic impossibilities"* On the other hand, according with another report published by the ONU: *"...one of the objectives for 2015, is accomplish the establishment of universal elementary studies, particularly in developing countries"* This statements indicate that there is much work to do for countries like Mexico.

Mexico has been conscious for many decades, that one of the requirements needed to provide public services with quality for individual and communities, is to have enough human and material resources to satisfy the demand. However, the expansion of the physical infrastructure and human resources used in education has produced a critical reduction in student/teacher ratio. A course in elementary school that consists only of theoretical lectures and does not necessarily guarantee that the students will obtain a full comprehension and absorption of the many concepts introduced.

It is essential to reserve part of the academic program for interactive classes and practical exercises. This section presents and discusses the most common practices used in laboratories in many elementary school courses: (1) interactive environments and (2) the use of simulators.

A. Interactive environments

Some researchers propose "closed environments" supported by very interactive systems; in most cases, based on the constructivist learning perspective, the experience teaching, which emphasizes students' initiative construction, cooperation learning, emotion molding, and cultivation of practical ability [4][11][18][34][6][16]. These are exactly the innovative teaching methods with the contemporary development trends of teaching patterns. These proposals rely on supervised environments where students maintain direct contact with teachers and platform development by the use of interactive elements. But, besides the interactive factor, Chepegin et. al. [33] indicated that these environments must present functionality to change content presentation, links structure or links annotation.

From the educational point of view, interactive environments have many attributes of meaningful learning. For example, they stimulate students' intrinsic motivation to support active learning. The characteristics of rules, challenge, complexity, and practical exercises could foster students' skills of problem solving and advance the skill of self-regulation toward specific goals. The interactive environments also make students reflection through immediate feedback. Furthermore, the friendship or cooperation among students can promote social skill. According to [30], all of these characteristics of interactive environments, almost all possess the key features of a constructivist learning environment if matching with the appropriate learning content in and adequate learning structure.

B. Use of simulators

The key of constructivism theory is that student must be actively involved in the learning process. It is important that teachers, from Mexican' elementary schools, understand that the construction of knowledge acquisition occurs from knowledge that students already posses and differs from student to student. The role of the teacher is now to be a lead for the student [8]. We think that the simulators could be conceived to help in this task.

A simulator attempts to create a dynamic and simplified model of reality. We consider that in educational environments, its potential is far more efficient than other conventional tools. Within the domain of Mexico' elementary school there are rudimentary simulators supporting the teaching of various disciplines such as mathematics, social sciences, biology, nature sciences, and more. As examples of these we mention here: VERMIC [17], KidsPC Professional Educational Software, and the Enciclomedia Project [31] sponsored by the Public Education Secretary.

These rudimentary simulators are just simpler versions of real environments and do not necessarily mean that they are always easy to use. Each simulator has its own characteristics: some positive, some negative. Also, most of them demand considerable time to learn how to use them, and they do not explore the advantages of cooperative learning among young students at elementary school.

III. CONSTRUCTIVISM AS A THEORY OF LEARNING

The constructivist theory was originally conceived by Jean Piaget as a result of research that began in the 40's. Basically, Piaget' observations of how children construct their knowledge have, over the years, formed the basis for his work. Piaget developed many theories, describing the stages of a child's cognitive development. Supported by his extensive research work [22], Piaget established and analysis methodology that set the basis for his learning theory: the Genetic Epistemology.

Within the last 20 years, constructivism as a philosophical, epistemological and pedagogical approach has found a great deal of attention. Various authors have concentrated on various aspects of this approach (leading to variants like personal and social constructivism, or radical and pragmatic constructivism), but one of the most influential authors is Glasersfeld. Glasersfeld

discussed radical constructivism as a theory of knowledge and cognition [14] and its applications for teaching [13] [15].

According to [25], *"the classic pedagogic model at all levels of education is based upon the instructive model, where instructional sequences tackle the task of transferring the maximum amount of information between an active teacher and a passive learner"*. In general, the Mexican instructive model tends to be standardized and homogenized in a sense that the teaching process is mostly directed to the class as a whole, and not to individuals within the class.

One way to overcome these limitations imposed by the instructive model is to include concepts from the constructivist theory – teacher/instructor plays not only the classic role of transmitting knowledge the best as he can, but also serving as a "facilitator" of the learning process. In the constructivist model the student is the central focus of the whole process of knowledge construction. The development of his ability to work cooperatively in group/teams is equally relevant tasks for the teacher.

Learning requires self-regulation and the building of conceptual structures through reflection and abstraction. Problems are not solved by the retrieval of rote-learned "right" answers [27]. The constructivist theory stresses the need to understand the child student's thinking and to encourage them to reflect on their models as a means to improve them. Social interaction is an important stimulus for this reflection as well as motivating knowledge construction and adaptation in early ages.

A. A pedagogic model based on constructivist for elementary school

In pedagogic models based on the constructivist theory, the student should construct their own knowledge instead of passively absorbing it in a classroom or by consulting text books. Our idea is to develop interactive mechanisms within a constructivist platform under the constructivist model.

This way of learning demands that the student not only discovers the facts, but also creates mental models from them that result in the knowledge construction. The tasks for monitoring and stimulating the students to achieve their objectives are assigned to teachers, who should be, at the same time, conscious of the individual cognitive structures of each student, which makes the method pedagogically more complex that the classical method (see Figure 1).

The constructivist model recognizes the benefit achieved when students participate in tasks that enable the active construction of their own knowledge domain. In order to do this, we propose the development of a teaching platform based on solid grounding in Piagetian fundamentals. This platform attempts to remodel the interaction type with child students against the conventional teaching techniques used in traditional elementary schools.
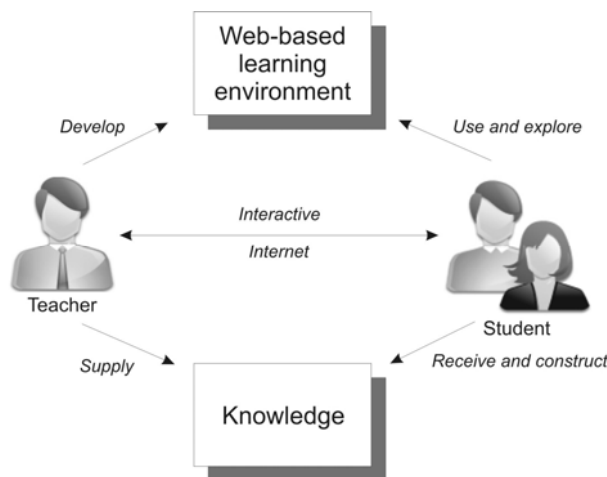

Figure 1.   Constructivist educational model.

According with Brooks and Brooks [19] and Lin [4] the comparative between conventional and constructivist model could be analyzed in physical classrooms (see Table 1), but we think that this could be extended to interactive platforms.

TABLE I
CONSTRUCTIVIST VERSUS CONVENTIONAL CLASSROOMS

Constructivist	Conventional
Students fundamentally work in group.	Students fundamentally work alone.
The way that students answer the questions is highly valued.	A high degree of importance is assigned to the established discipline for answering and participating in the classroom.
If a student does not know the answer, but he has an idea; he interacts with his group and improve their initial statement.	If a student does not know the answer, but he has an idea; he does not make a comment and avoids interaction.
Academic activity is fundamentally based on primary data sources and practices on computational devices.	Academic activity is fundamentally based on text books and exercises.
Evaluation is related to the teaching process and the student labour is carefully monitored by the teacher.	Learning process is dissociated from evaluation and the teaching process is normally accessed by means of tests and exams.
Learning emphasis is a multi-level learning for major and beyond major knowledge.	Learning emphasis is a simple study for major knowledge.
Teacher role mainly is constructer / facilitator of the classroom situation.	Teacher role mainly is speaker / evaluator.
Learning environment is unrestrained, innovational, flexible, positive and encouraging.	Learning environment is formulaic, restrictive and boring.
Evaluation focus on experimental results and examination score.	Evaluation focus on experimental process, recalling and reflection.

Considering these arguments, we analyzed the Piagetian theory and focused our efforts in the four stages established for children intellectual developing:

- *Sensor-motive Stage:* from birth to two years old. It is characterized by movements that allow children to focus their activities on determined objectives.
- *Pre-operational Stage:* seven or eight years old. The language acquisition is the most important

event in this period of time; its development modifies mental structures and relationships with other persons. Summarizing, thinking process in pre-operational stage is limited to primacy of perception.

- *Concrete operations Stage:* eleven and twelve years old. It is necessary to define the element that allows children to make concrete operations: the reversibility. This is the most representative characteristic of this period.

- *Formal operations Stage:* between twelve and thirteen years old. The stage coincides with physical changes and differs from the previous stage in emotional aspects. Children can formulate hypothesis that allow generating formal operations with concrete operations.

In this context, we propose a constructivist platform to establish an advantageous interaction between students within *concrete operations stage*, and computational tools and be capable of representing problems that simulates real situations.

IV. A CONSTRUCTIVIST PLATFORM

Many interactive courses for elementary school are based upon teacher presentation and explanation of basic components, rather than allowing the students to develop mental knowledge. This traditional model may turn elementary-level lessons into an extremely theoretical and boring process. The constructivist theory provides an alternative for developing pedagogic proposals, possibly leading to better learning outcomes than those obtained with traditional instructive models.

Our approach proposes a constructivism platform to support learning process, over which pedagogic models can be developed for the discipline at elementary school level. This constructivism platform follows these guidelines:

- Teaching process is conducted in an individualized manner; the teacher should pay close attention to each student's own assimilation capability.
- The teacher-student interaction has a strong emphasis on searching for practical questions.
- Group work is proposed as an environment to achieve cooperative learning.
- Students use the constructivist platform in the classroom and homework as a form of assembling situations difficult to generate in real systems.
- Teachers use the constructivism platform in conjunction with theoretical lessons; complex concepts may be better illustrated.

In [10] Jonassen proposed a model for designing constructivist learning environment on the Web, which surround a problem with related cases, information resources that support knowledge construction, cognitive tools, and social contextual support for implementation. Later, in [32] the Jonassen's model was reproduced and

modified for designing constructivist environments to improve learning process through on-line games.

Based on Jonassen's model, we propose an alternative model for developing an interactive platform to implement constructivist learning in elementary schools (see Figure 2).

The first step of our model is to incorporate the Web 2.0 learning mechanisms with certain characteristics related with the content. Second, our model forms an interactive scenario surrounded by tasks, topics, toolbars, games, tests, learning modules, communication interfaces, and a workspace. Also, the model triggers a cycle that includes learner evaluations and feedback. Finally, this engagement in interactive platforms leads to the achievement of constructivist learning.
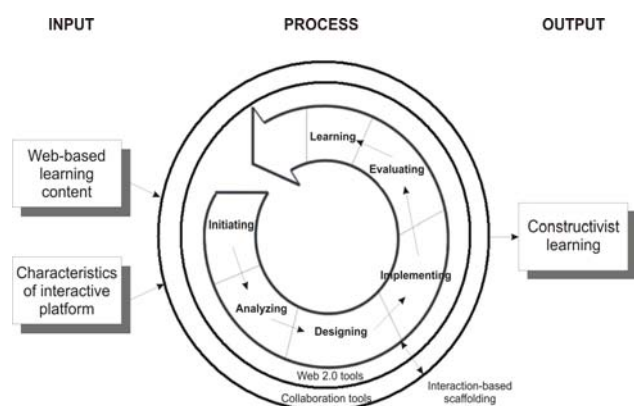

Figure 2. Model for developing interactive platform.

A. Description of our Constructivist Platform

The platform application is developed on Flex. Flex is a highly productive, free open source framework for building and maintaining expressive web applications that deploy consistently on all major browsers, desktops, and operating systems. While Flex applications can be built using only the free open source framework, developers can use Adobe® Flex® Builder™ software to dramatically accelerate development. Flex provides some adaptation features like for example including adaptive content by wikis, videos or games, and adaptive navigation support by tools and mechanisms.

The interactive platform developed has a constructivist approach, assessing the student knowledge and showing contents and activities adapted to the characteristics and learning style of students at elementary school.

Besides, the platform allows the students and teachers to autonomously create and consolidate knowledge, with permanent automatic feedback and support, through instructional methodologies and educational activities explored in a constructivist manner (see Figure 3).

The constructivist platform is based on progressive self-assessment (interactive exercises, task, and more) solved by children that evolve in difficult and topic. The configuration is set by the teacher but is individualized to each student's level of knowledge, competences, abilities and learning path. The platform provides a set of tools that teachers can configure according to the student's intellectual capabilities:

Figure 3. Constructivist platform for elementary schools.

- **Topic browser:** The purpose of the browser is that teachers can add or eliminate topics related with the course necessities. Platform actually includes topics of mathematics, biology, and history.
- **Toolbox:** The purpose of the toolbox is to enable the addition or elimination of activities, include elements to interact with the workspace, plan new events and evaluations, and establishment the course sequence.
- **Games/Test explorer:** The purpose of this explorer is to integrate games or test to periodical evaluations. Games are based on the Adaptive Hypermedia Application Model (AHAM) [29] according to a predefined model of the students that reflects their objectives, preferences, knowledge and competences. Also very important factors in teaching quality control and a necessary part of teaching process, are exercises and testing which are significant instruments checking children's meaning construction performance in the learning process. In the process of elementary teaching, games and tests are used to supervise and urge students to consolidate the knowledge learned.
- **Workspace:** The workspace is destined for interacting with the course contents or topics. A child most interact with the hypermedia objects and solve problems in virtual environments likes real situations. The primary function of teaching workspace is to collect, manage, search and use various teaching resources. The teaching workspace database can be organized according to the types of materials, whose attribute should be marked for each type so as to facilitate classified storage and retrieval. The establishment of a workspace is an effective way to create constructivism-learning environment.
- **Communication Interface:** The communication interface provides teachers and students with convenient and practical communication tools. The constructivist platform not only provides students with a message board in every learning activity of course content to easily raise questions based on a certain knowledge point at any time, but also provides relatively independent and improved question answering system to strongly support the normal operation of teaching activities based on predefined courses.
- **Learning Modules:** Via learning modules, teachers can assign homework, input and manage test questions and homework, while students can do their homework, self-test, check results and the statistic information of exercises or performance in workspace. The main function of learning modules is to organize learning resources of platform courses according to a certain educational measure theory, provide testing materials for the making of exercises and the assignment of homework and support the evaluation of children's learning achievement.
- **Tutorial wizard:** The teaching process under the guidance of constructivist learning theory is a teacher-led, student-centered teaching mode. The tutorial wizard represents in such areas as the guidance of learning methods, navigation of information resources, creation of learning scenarios, answering questions and the guidance of student's activity, while student's initiative reflects on such aspects as independent learning, collaboration, discussion, exploration, creation and theme research with platform resources.

Due to the complexity of knowledge and the difficulties of problem solving in certain situations of the concrete operation stage, it became necessary for children to carry out collaborative learning in our platform [23]. In such a collaborative learning environment, all the children can share the thought and wisdom of the entire learner group, that is, the entire learner group complete together the meaning construction of the knowledge they learned.

During the collaborative process of learner and teacher, the learner can get the workspace's guidance too, while the teacher can obtain the feedback information from the communication interface. In our constructivist platform, collaboration can be carried out between two learners or among many. It can be organized under the teacher's guidance or directly carried out face to face or through online workspace. As we shown in Table 1, in the process of collaboration and exploration, by means of a comparative analysis of different points of view on the same problem, loaded in the workspace, children can work beyond their own understanding, enriching their knowledge, while improving the ability of meaning construction in the process of organizing and restructuring various points of view (see Figure 4).
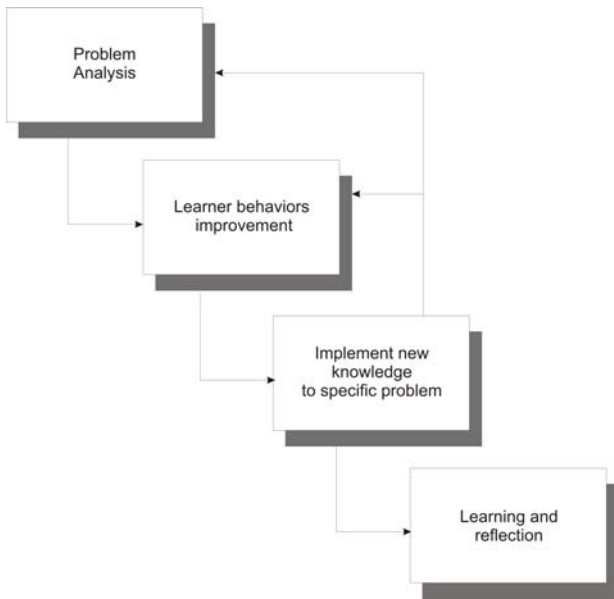
Figure 4. Constructivist learning cycle.

V. SOME EXPERIMENTAL RESULTS

An assessment in the third grade mathematics course in a public elementary school was performed on two different parts. To give us the opportunity to estimate the childrens' knowledge during six months we held two short examinations. Results in this examination did not count towards the final exam. However, participation in the childrens' group discussion through workspace was counted. The platform employs a sea simulator to learn more about basic mathematical operations like sums and subtractions.

A sea simulator was designed because it is a simple manner to explain some concepts related to biology and nature in the same course. The constructivist platform could also illustrate theoretical concepts in an intuitive and easy way, allowing the children to construct their mental model of knowledge. Currently, three more courses are using this simulator in the mathematics and biology topics. The platform classes take place as soon as the corresponding theory is given in the classrooms. Students work in threes in the computers lab. They work on tasks including practical exercises, specific simulated situations to be analyzed, and some theoretical questions to be answered with the help of the *tutorial wizard*. As the class evolves, children and the teachers discuss and exchange comments on their workspace results via the communication interface.

During 2009, at the end of each class, we solicited both quantitative and qualitative feedback from the students. The main objective was to assess the benefits of the constructivist platform in a traditional teaching environment. The evaluation consisted of eight questions that were submitted to fifty students of third grade at elementary school (see Table 2). These questions were in the form of a Likert scale [7]: "I disagree", "Do not agree nor disagree", "I agree", "I totally agree".

TABLE II
EXPERIMENTAL RESULTS

Question	Answer			
	Disagree	Do not agree nor disagree	Agree	Totally agree
The constructivist platform makes the understanding of mathematics' theoretical concepts more satisfying?			10.8%	88.2%
The constructivist platform helps motivate you to the subject?		9.8%	45.6%	45.6%
The constructivist platform helps your comprehension and absorption of the mathematics' theoretical concepts introduced?		4.1%	15.8%	80.1%
The constructivist platform bears and easy and clear interface?	7.5%	25.4%	54.3%	12.8%
The sea simulation is adequate for simulating real situations in maths and biology?	1.2%	5.3%	14.6%	78.9%
The empirical evidence of learning is according to the course difficulty?	4.2%	3.6%	46.1%	46.1%
The learning perceptions of students are correct?		4.7%	20.8%	74.5%
The activities implemented in the constructivist platform are related to social relations?		10.5%	44.1%	44.4%

In summary, the feedback of Table 2 shows that the majority of the children felt that learning with the constructivist platform was enjoyable, it sparked their interest in the problems, yielded a better comprehension of the mathematical concepts, and made it possible to configure and analyze real situations.

For question five, for example, most children answered that the platform helped them to understand and visualize the maths concepts and problems, and also that it had narrowed the gap between theory and practice in the classrooms. Some children asked for more topics in platform and some suggested improvements in our first version: "More virtual practices! The platform helps us a lot in understanding the maths concepts", "Great job! I though other games should be introduced in platform", "The idea is excellent, but the platform characters should be improved".

VI. CONCLUSION

The constructivist learning theory provides potent theoretical guidance to the interactive course design and the development of elementary teaching sources. In this

paper we present how the adoption of a constructivist platform opens excellent perspectives for improvements in Mexican elementary schools' teaching-learning process. As the constructivist platform described above, it provides an illustrated and simplified mechanism to represent and analyze problems and situations, called workspace. This tool encourages children to construct knowledge actively and intentionally in authentic contexts. Also, the constructivist platform and communication interface provide feedback that enables children for reflecting on the learning process and conversing with teacher and others students. This also means the constructivist learning environment, as described by Jonassen, can be fulfilled by our interactive platform. From an experiment which has been in use at a Central Elementary School, Mexico, the problems due to an unstructured subject, exhibiting a huge gap between theory and practice, were eliminated. However, a qualitative improvement of the whole teaching-learning process is expected.

In our experience, we think that a big pedagogic advantage in using such a platform, is the construction of a formal teaching-learning environment, where conventional expositive lectures and exercises and simulations with hypermedia objects can be combined. However, it is necessary to mention that our constructivist platform may be not following a formal pedagogic model. The reasoning behind that, is that the theoretical principle supporting the model used, is epistemological and not pedagogical. This is a common criticism of Piaget's theories which resides precisely in the absence of a clear and explicit pedagogy line. To avoid this problem, we implement cooperative learning, to apply it in the classroom and platform work; the constructivist thinking can be introduced to support knowledge construction, making it possible to experiment with other contents. The use of an interactive platform might also contribute to reducing the total time needed for theory presentation and explanation, perhaps extending the practical sessions, and possibly creating new scenarios for workspace. Future work is related to refine the proposed constructivist platform as a form of structuring a systematic pedagogical practice for teaching more contents at elementary-level school.

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