Learning Guides: Tools to Mediate Student's Learning

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Abstract
In this work, some orientations are proposed to assist the construction of learning guides that can effectively support the exploration of digital interactive simulations, guiding students through their learning process by helping them to organize and structure knowledge. Then, a case study related to the Radioactivity thematic is presented. A short summary of the learning guide developed is provided and the results of its application in the classroom context are presented. Data was gathered by a chemistry teacher in two classes of 90 minutes each, having 30 students with an average age of 17 years old, at the Abade de Baçal High school located in the city of Bragança, Portugal. The competences and the learning results acquired by students were evaluated through the application of pre- and post-tests applied before and after the classes. A normalized gain of 0.64 was obtained.
The students' opinion about the digital resources used was also collected by means of questionnaires. A vast majority of students (>90%) found the digital resources used interesting and more efficient than books, considering that they promoted the interaction with a fellow student, centring the discussion on chemistry themes. 70.8% thought that the resources used facilitated their understanding of the studied concepts.
Evidence gathered suggests that the use of digital resources mediated by the teacher and by learning guides can enhance significant learning.

1. Introduction
When students are provided with a context of scientific and technological learning, which includes the exploration of chemical transformations supported by interactive digital tools, conditions are created that allow them to minimize the level of abstraction required by these phenomena.
Also, the science-technology contexts can create effective learning opportunities when the analysed situations are relevant to the students' personal experiences. They develop skills and attitudes that facilitate the establishment of direct links between what students learn and everyday situations. Also, the development of scientific knowledge is promoted because students are given the opportunity to explore concepts, formulate hypotheses, manipulate materials and establish transfers. A well formulated learning environment enhances student motivation giving relevance to their learning.
In this work, the use of digital resources, supported by learning guides, to promote the construction of scientific knowledge, will be exemplified. Moreover some orientations will be given on how to construct a learning guide.
Learning guides are mediation tools created to support the exploration of the software and guide students during their learning process by helping them to organize and structure knowledge in a global and transversal way. The main objective is that students, guided by learning guides, use computers and educational software to interact with scientific models by changing data and variables, engaging in the exploration of the physical situation, persisting in performing the task, showing initiative, taking control of their actions by making proposals, formulating new questions and managing to involve other students in accomplishing the task and exploring the situation. Figure 1 presents the articulation of the dynamics developed by both teacher and students, during the tasks' execution.

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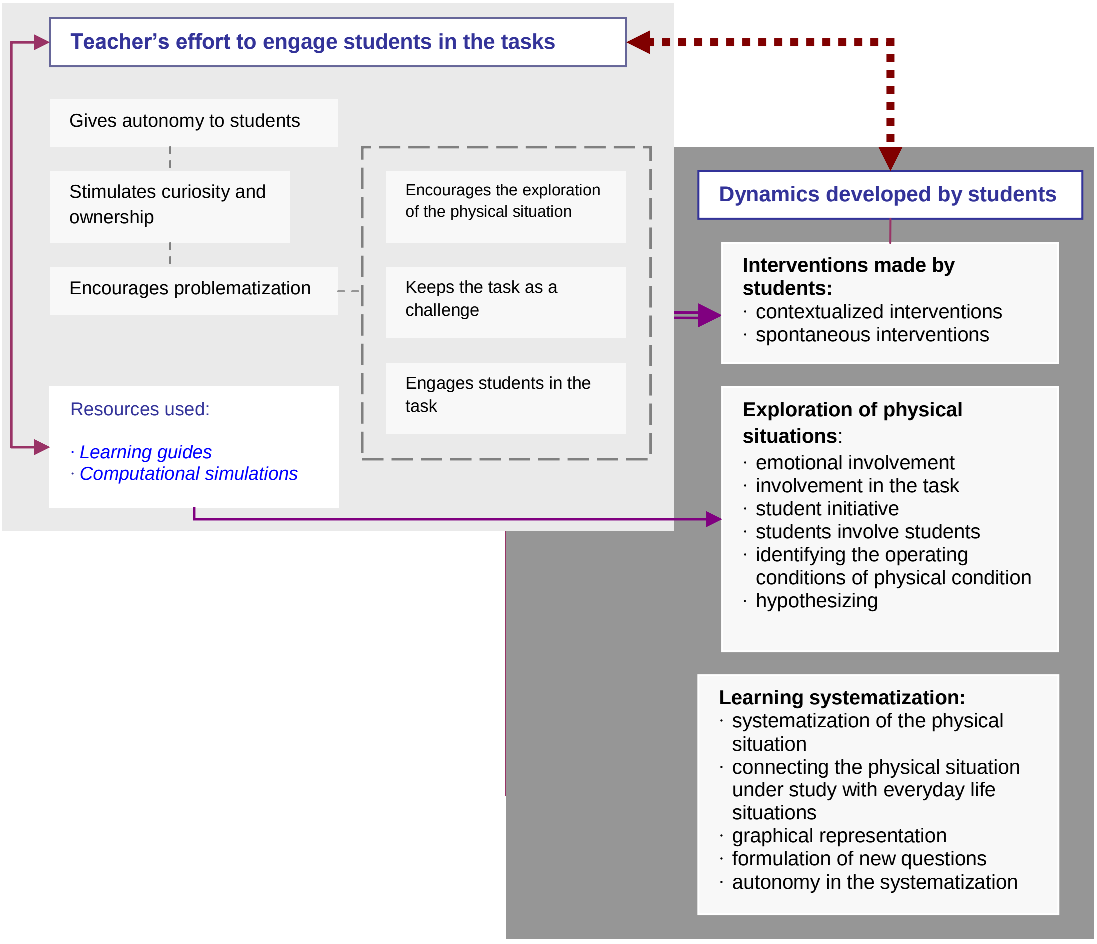

Fig. 1. Schematic view of the dynamics developed by teachers and students, during the tasks' execution [1].

The effectiveness of teacher mediation and its quality are determined by:

I. the didactic and scientific quality of the activities proposed to students;
II. the way teacher provides or circulates relevant information and structures the intended learning;
III. the dynamics developed by the teacher, in particular, how the work is organized and how the objectives are explained to students;
IV. the involvement of students in their learning (e.g. how students use their knowledge while exploring tasks);
V. the available resources and tools for learning mediation.

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2. Orientations to construct learning guides

From the experience developed, it is our opinion that the following orientations should be considered when developing learning guides:

- tasks proposed to students should be thought in accordance with the learning objectives previously defined;
- questions should be posed in a challenge mode, directed to the formulation of hypothesis, empowering students to be responsible for their own learning;
- questions should be short, simple and learning oriented, that is, objective and specific;
- questions should direct students to experimentation, selection and adjustment of variables, analysis of the physical situation under study, identification and problem solving, formulation of hypothesis, experimentation and new questions, in order to keep the student fully motivated.

A learning guide proposes tasks to students, formulated as a challenge, being structured in the following parts:

Challenge-Tasks

Guidelines are given and questions are formulated in the form of a challenge, to understand concepts, laws, and principles, guiding students in the exploration of physical situations. Conditions for the formulation of hypotheses are created from the analysed images and the interaction with the software is promoted to allow testing the formulated hypotheses.

To test

Laboratory intervention activities are proposed, combined with the exploration of interactive simulations, to be performed collaboratively. The objective is to stimulate students' autonomy and initiative. Tasks that establish the link between the macro and micro environment of chemical transformations are proposed.

To know more

The main objective of this final part of the learning guide is to awaken students to a comprehensive and interdisciplinary approach, valuing both skills and knowledge through its application to everyday life situations, therefore, attributing meaning and usefulness to scientific knowledge.

3. Case study: Radioactivity

In this section, a short summary of a learning guide is provided as an application example related to the "Radioactivity" thematic.

Learning guides are part of a larger research agenda that seeks to produce knowledge and tools to enhance student's learning and support teachers' mediation in the classroom.

The tools developed in this work were applied during the in-service training action for teachers, that took place at the Polytechnic Institute of Braganca, Portugal, developed in partnership with the Centre for In-Service Training of Teachers, in the context of the project "Chemistry is All Around Network". The focus of the training was "Experimental work in chemistry supported by the use of digital resources".

Chemistry high-school students of the 12th grade have been evidencing learning difficulties in the study of radioactivity because this field requires a high capacity of abstraction and does not allow for experimentation in the lab. In this case, the exploitation of interactive simulations supported by learning guides was the option adopted by the chemistry teacher at the Abade de Baçal Highshool located in the city of Bragança, Portugal. The class had 30 students with an average age of 17 years old, of which 20 are girls and 10 are boys.

3.1 Methodology used

3.1.1 Definition of the learning objectives

The following learning objectives were defined:

1) Promote a better understanding of the radioactivity concept.
2) Identify radioactive isotopes.
3) Schematically represent the radioactive decay of some nuclides.
4) Determine the period of decay from the half-life time.
5) Apply this knowledge to the dating of objects with hundreds or thousands of years.

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3.1.2 Selection of the simulations

The selection of the simulations was guided by the:

1) Appropriateness to the learning objectives and the tasks proposed to students.
2) Level of interactivity measured by the possibility given to each student of changing the values of variables and parameters.
3) Scientific origin, with priority given to the university and educational institutions platforms.

3.2 Development of the learning guide

In light of the objective of promoting learning centred in the student, the learning guide in paper and digital format includes challenges, proposals of activities/tasks and questions that have a certain level of flexibility in order to be analysed by students and their pairs in an autonomous way. They were conceived as a function of a conceptual scheme that includes questions that are: (i) structural and operative, involving the technologic and scientific learning environment, (ii) guided by the formulation of hypothesis and their verification, (iii) open and envisaging the refinement of learning, oriented towards the application to the radioactive alpha- and beta-decay. Specifically, the students were given the following challenges:

a) How does the radioactive decay work?
b) When do the atomic nuclei emit alpha radiation?
c) How is the dating of objects with hundreds or thousands of years done?
d) How can we determine when certain deposits of rock were formed? Establish the relation between the disintegration process of uranium-238 and the question asked.
e) In the Port Wine Cellars, a bottle of "Port Wine" with hundreds of years was found. Can you suggest a dating process to determine its age?

3.3 Digital resources used

Three interactive simulations available online at the Colorado University website http://phet.colorado.edu/ were used:

I. Alpha Decay Simulation (https://phet.colorado.edu/en/simulation/alpha-decay)
II. Beta Decay Simulation (https://phet.colorado.edu/en/simulation/beta-decay)
III. Radioactive Dating Game (https://phet.colorado.edu/en/simulation/radioactive-dating-game)

3.4 Data collection tools

The competences developed by students and the learning achieved were evaluated through the application of pre- and post-tests of knowledge of concepts developed before and after the class. The answers to the tasks developed were registered in the learning guide.

With the objective of collecting students' opinion about the effect of the resources used in their learning, the questionnaire provided by the project "Chemistry Is All Around Network" was applied.

3.5 Application to the training situation

Two classes of 90 minutes each were used. Students were organized in groups of two per computer. The computers of TIC classroom and data show were used when necessary. Teacher's mediation (as defined by [2] Lopes et al., 2008a e b) while the tasks were being performed and students were exploiting the simulations were centred on the dynamics developed by students. The teacher proposed the tasks as challenges, using the questioning, the formulation and the validation of hypothesis. She also stimulated learning and its links to the practical applications.

3.6 Analysis of results

Students' answers were marked by the teacher. The average mark was 17.5 values (in a scale of 0 to 20), the minimum mark was 14.6 and the maximum 19.0.

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The results of the pre- and post-evaluation tests of learning were analysed which allowed to determine the normalized gains (*g*). These totalled 0.64 when calculated using the formula ($g = Pos\text{-}Pre/100\text{-}Pre$).

The treatment of the questionnaire results allowed to summarize the characteristics of the learning environment and to analyse the students' opinion about the digital resources used. Results show that 95.8% of students considered the resources used interesting and evidenced their preference for simulations and videos. Furthermore, 91.7% of students considered the resources used more efficient than books and 70.8% thought that they had facilitated their understanding of the studied concepts. Finally, 91.6% considered that the resources used promoted the interaction with a fellow student and 95.8% said that they contributed to centring the discussion on chemistry themes.

The following evidence can be highlighted from the analysis:

I. Students evidenced autonomy in the development of knowledge at the individual level in this learning environment.
II. Students presented easiness in the interpretation of situations and physical phenomena during the use of digital resources but had difficulties in translating in the form of text their ideas and formulating the hypothesis.
III. The learning environment encouraged the formulation of questions, the exchange of ideas, problem solving, sharing and manipulation of information, learning between pairs and created opportunity for the formulation of questions that induced significant learning.

4. Conclusions

When students are given the opportunity to visualize the dynamics of chemical transformations that occur during a chemical reaction, in a learning environment that involves experimentation and exploration of computational simulations, supported by Learning Guides, their involvement, ownership of tasks, and the formulation of hypotheses is promoted and the high level of abstraction is minimized. This helps students understanding the dynamics of chemical transformations. In this way, autonomy is favoured during the construction of scientific knowledge, respecting the individual learning pace.

Digital resources are simply tools available to the scientific exploration that must be mediated by the teacher and Learning Guides to propitiate significant learning. The combination of interactive digital tools with laboratory work can, sensitively, improve the environment of the classroom and the quality of student learning.

5. References

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