Using ICT during preservice teachers' autonomous study

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***Abstract*—In this article we assess the implementation of four learning objects directed to different basic astronomy subjects. A questionnaire aiming at assessing preservice teachers' perception on the use of the learning objects in self-study was applied after an initial exploration of the learning objects in the classroom. This took place during a four-week teaching and learning of astronomy in a preservice teacher course. Most of respondents report positive impact both at emotional as well as at cognitive level. Some differences are reported in relations to the structure of the learning objects, which we discuss.**

Keywords—astronomy; ICT; preservice teachers

I. INTRODUCTION

The use of computer simulations in classrooms is a major topic of research in education within the larger field of ICT in education [1-4]. Despite the wide acceptance of the construct computer simulations [5,6], in this work the more general concept of leaning objects, "a self-contained resource, usually digital and/or web-based, that can be used and reused to support learning" (p. 261) [2] is more appropriate to describe the researched cognitive tools that we worked on. Related to the teaching and learning of science four main effects for the use of ICT are reported in the literature: a) promote cognitive acceleration, b) enable a wider range of experience, c) increase student's self-management and, c) facilitates data collection and presentation [4]. However, these affordances are not independent of the learning environments developed in particular settings. Namely infrastructure, professional pedagogical development and curricula as well how they relate are key factors in creating a suitable learning environment to the use of ICT [4,7].

In fact, to create a suitable learning environment where ICT makes a difference, as [8] defend, "teachers need to understand the relationship between the affordances of a range of ICT resources and the detailed knowledge of the concepts, processes and skills in their subject" (p. 727). To account for this purpose, a set of 4 learning objects where selected.

Astronomy is prone to enhance diverse problems at the teaching and learning of its content knowledge. The seasons and its relations to the distance of Earth from the Sun is a misconception held by most students before instruction as well by elementary preservice teachers [9]. Distances to distant stars are severely underestimated [10]. Seasonal effects such as Moon's phases and day-night cycle are poorly understood [11].

Several researches on the affordances provided by learning objects in teaching and learning astronomy at diverse grades and setting are reported in the literature [12-16]. Here we briefly discuss some of them.

In [14], the authors discuss the introduction of a learning object at a preservice elementary teacher program aiming at promoting the teaching and learning of moon phases. They had found "substantial positive gains in the preservice teachers' understanding of lunar phases" (p. 367), This outcome was accompanied by a positive attitude of the preservice teachers towards that specific learning object. Amplifying this study, these authors [15] could only achieve more modest conclusions related to the use of *Starry Night*™, for "all three groups [one group only used the learning object, the other used only nature to make observation and a third used a mix approach] made significant and substantial pre- to post-test gains, but demonstrated no significant differences among the three treatments" (p. 1085). The authors explain the findings through the characteristics of overall pedagogical intervention that follows sound principles reported in the literature. However, the fact that the group which used only the learning object could surpass weather conditions and make more observation in lesser time was a positive aspect towards the use of the learning object.

Reference [16] address the hypothesis that "exposure to simulated solar environments would be more effective in addressing solar system concepts, when compared to traditional instructional approaches" (p. 271). To probe it, the authors used an app previously installed in each student's iPad. Although the "instruction provided via the iPad was relatively brief, and largely implicit" (p. 278) they could observe gains where traditional approaches failed.

Despite our use of the learning objects was intended to overcome some of the mentioned shortcomings in the teaching and learning of astronomy, the present research does not intend to elicit to what extent the use of those learning objects succeed. We aim at understanding how given learning objects were perceived by teachers' students at a preservice teacher education course in Portugal and in their autonomous study of the subject matter of astronomy during a curricular unit where the teaching and learning of astronomy occur.

II. Methodology

This research was carried on at five classes of the first year of the Bachelor in Basic Education in a curricular unit of introduction to physical sciences in a Portuguese higher education institution. The teaching and learning of astronomy occur for a period of four weeks. The subject content cover the basic astronomy subjects such as night sky, seasons, Moon phases and solar system.

In the classes four digital leaning objects (Table I) on astronomy were shown and explored by the two teachers. Of these digital learning objects, two were interactive simulations focused each one in an astronomic phenomenon: one on seasons and the other on Moon phases. Both are available for free at the internet and were developed by the University of Nebraska-Lincoln. In addition, the teachers also explored with the students two other digital leaning objects, the *Stellarium* software which simulate the sky as seen from the Earth and the *Nasa's Eyes* software which simulate the Solar System. We decided for the above-mentioned learning objects for their scientific quality, ease of use and for being freely available.

After a first exploration in classroom of about ten to fifteen minutes in which the learning objects were presented and explored by the teachers, the students explored the Stellarium and the NASA's Eyes also for a time of about ten to fifteen minutes with teacher's support. Finally, they were asked to explore the four learning objects during the self-study.

TABLE I. LEARNING OBJECTS USED IN THE CLASSROOM

Learning object	***Phenomena at study***	***Developed by***	***URL***	***Time in class***	***Range***
A. Seasons and Ecliptic Simulator	Seasons	The University of Nebraska-Lincoln	http://astro.unl.edu/naap/motion1/animations/seasons_ecliptic.html	10-15 min	1 phenomenon
B. Lunar Phase Simulator	Moon phases	The University of Nebraska-Lincoln	http://astro.unl.edu/naap/lps/animations/lps.html	10-15 min	1 phenomenon
C. Stellarium Software	Night sky	Stellarium developer team	http://www.stellarium.org/	20-30 min	Multi phenomenon
D. NASA's Eyes Software	Solar system	Jet Propulsion Laboratory, NASA	https://eyes.nasa.gov/	20-30 min	Multi phenomenon

The learning objects were made available to the students: thru an URL available in classes' presentations and at the Moodle of the curricular unit. The two interactive simulations were more at disposal of the students since they are less software demanding and do not require installation.

Accomplished the teaching and learning period in astronomy and after a summative assessment, the students were asked to answer out of class a mixed questionnaire on-line, although with an overwhelming presence of closed questions intended to evaluate the autonomous use of the learning objects during the self-study. In particular, they were inquiry on the use (or not) of the learning objects, whether they like it or not and how they assess the relevance/importance of the learning objects for their own learning of the subject matter.

Questions related to the validity of the questionnaire are straightforward. At each question, students were reminder of which learning object we were talking about not only by its name but also by a print screen of the learning object thus connecting them to their own experience. The following questions were of immediate interpretations since they just asked if they liked it or not and similar questions. Related to the question which inquiry on the usefulness of the learning object to their learning they were reminder of the topic which each learning object intended to address. Moreover, the questionnaire was also subject to validation by experts.

III. Results

Of the 116 students who attended classes, 44 (38%) answered the questionnaire, almost all females. Most of the students used the first three leaning objects (77% the first and 55% the second and third), but only 32% used the fourth (Fig. 1); 20% used all the four leaning objects, 16% of the students did not use any of the four learning objects, while the rest 84% used at least one of them.

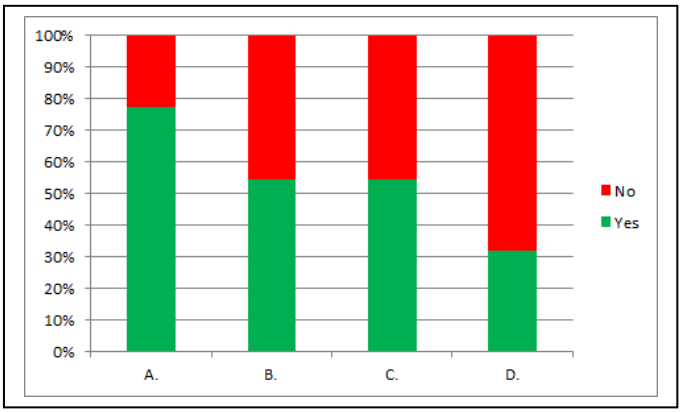

Fig. 1. Answers to the question: "*Did you explore the following simulation/software in your self-study?*"

A. Seasons and ecliptic simulator

77% of the students used the seasons and ecliptic simulator during their autonomous study. Most of them (53%) explored the simulation during less than 15 minutes, while 29% spend between 15 minutes and 30 minutes using it. The level of satisfaction regarding the use of the simulator was high (47% really liked using it and 53% liked moderately). Moreover, most students (71%) strongly believe that the simulator helped them understand the season's contents and 27% considered that it helped so-so. 23% of students did not use this simulator and the main reason reported (40%) was the fact that they considered they already understood the season's phenomena.

B. Lunar phase simulator

The majority of the students (55%) used the lunar phase simulator during their autonomous study. 38% of them

explored the simulator during less than 15 minutes, while 42% spend between 15 and 30 minutes. Most students (50%) really liked using the simulator and 46% liked moderately. Additionally, 62.5% of the students strongly believe that the simulator helped them understand the lunar phases and 37.5% believe that it helped so-so. 45% of students did not use this simulator and the main reasons were, students reported: “I forgot” (40%) and “I have already understood this topic” (35%).

C. *Stellarium*

The majority of the students (55%) used the Stellarium software during their autonomous study. 54% of the students explored the simulator during less than 15 minutes, 25% between 15 and 30 minutes and 13% between 30 minutes and one hour. The majority of these students (54%) really liked using the simulator and 42% liked moderately. Additionally, 50% of the students strongly consider that the simulator helped them understand astronomy contents and 46% believe that it helped so-so. 45% of students did not use this software and the main reasons reported were: “I could not get it to work on in my computer” (25%); “I didn´t have time” (25%) and “I forgot” (25%).

D. *NASA’s Eyes*

Only 32% of the students used the NASA’s Eyes software during their autonomous study. Most of them (50%) explored the simulation during less than 15 minutes, while 36% spend between 15 minutes and 30 minutes using it. 50% of the students really liked NASA’s Eyes software utilization and 43% liked it moderately. Moreover, most students (57%) strongly believe that the simulator helped them understand some astronomy concepts and 36% believe that it helped so-so. 68% of students did not use this software and the main reasons reported were: “I could not get it to work on in my computer” (40%); “I didn´t have time” (17%) and “I forgot” (17%).

Looking at the results globally and comparing the responses to the four learning objects, about 80% of students used 30 minutes or less, about 50% used 15 minutes or less (Fig. 2). The object that seems to be used less time is the second, and the others seem to have been used roughly the same time.

Almost all the students liked very or moderately exploring these resources, especially the first (100%). About 50% really liked exploring these resources, especially the third one (54%) (Fig. 3). More than 50% of students considered that exploration of the learning objects contributed very much to their learning on some astronomy topics, especially the first and also the second. Almost all the others consider that they contributed “so-so” (Fig. 4).

Furthermore, 27% of the students reported that they had also explored other digital resources (simulations, small movies or smartphone applications) during their autonomous study.

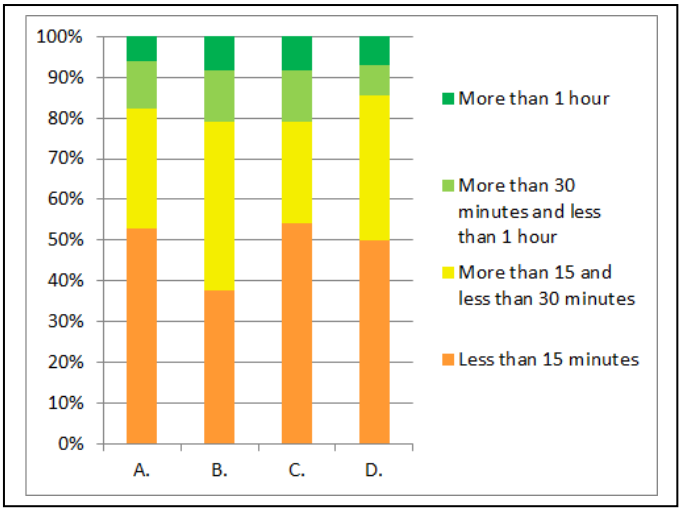

Fig. 2. Answers to the question: "*For how long, approximately, did you explore this simulation/software?*"

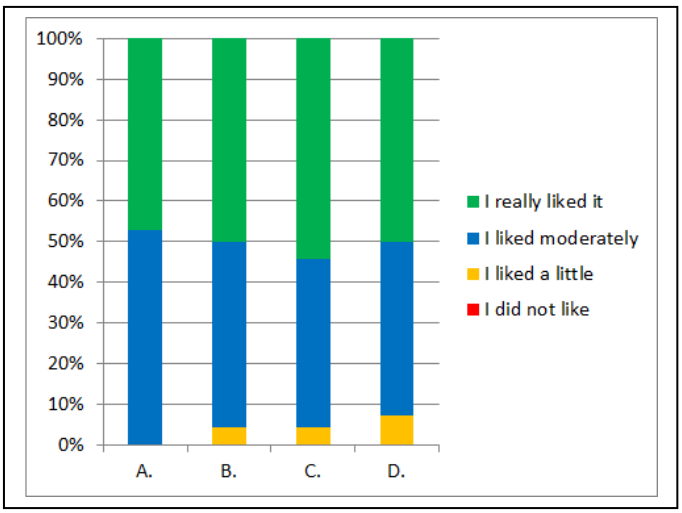

Fig. 3. Answers to the question: "*Did you like exploring this simulation/software?*"

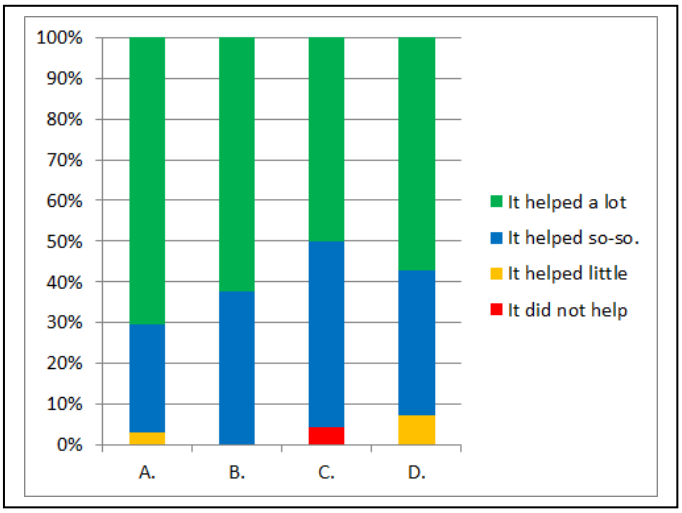

Fig. 4. Answers to the question: "*Do you think that exploring this simulation/software helped you to understand better...?*"

IV. Conclusions

Analyzing the results we can draw several conclusions. Some students explored all learning objects in their autonomous study and others did not explore any, while most students explored some, but not all. It seems that the encouragement given during the lessons, regarding the importance of such exploration to improve understanding of astronomy concepts, was not enough to motivate all the students.

The results show as well that the learning objects related to seasons, Moon's phases, and night sky (Stellarium) were the most used, whereas the NASA's Eyes stay at a great distance from the others three. One aspect that could account for this is the simplicity (subject target clearly defined) and availability of the two former learning objects (don't need for installation and lower software demanding). However, this didn't explain why Stellarium (55%) was much more used than NASA's Eyes (32%). To account for this later result several factors should be taken in account. NASA's Eyes has a much more complex layout since it presents at the beginning three options to explore: solar system, exoplanets and Earth. On the contrary, Stellarium is clear in its purposes: at its most default versions, a simulation of an Earth's surface, cardinal points and the location of the stars, sun, and other objects in relation to the observer are clearly presented. Another difference may have to do with difficulties in ICT skills. In the case of NASA's Eyes, a greater number of students (40%) report that they did not use this learning object because they were unable to install the software on their computer, compared to 25% in the case of Stellarium.

Related to the time students spend on the exploration of learning objects, it was found that generally students spent a very short time, less than 30 minutes, and in many cases less than 15 minutes. One hypothesis that could explain this result was the lack of a script with questions or activities to be answered by the students.

According to most of the students the learning objects used in this research were valuable resources to their learning of basic astronomy concepts. Almost all of students considered that exploration of the learning objects contributed very much or contributed "so-so" to their learning on some astronomy topics, especially seasons and moon phases simulators. The results show as well that almost all the students liked very much or liked moderately to explore these objects. In the case of Stellarium, 54% of the students reported that "really liked" using it (42% liked it "moderately") is accompanied by a good percentage of the students reporting positive cognitive outcomes (50% and 46% "strongly believes" and "moderately believes" that the use of Stellarium helped them in the subject learning.) Positive relations of students to the learning objects and better perceived cognitive outcomes agree with the literature [17].

The learning object on seasons was by far the most used. To account for this result we must keep in mind the difficulty of the subject. Is fair to infer that the difficulty associated with the overwhelming misconception that seasons result from the variation of the distance between Earth and Sun, triggers an additional interest in this learning object. The respondents claim to "really like" or "like moderately" with a figure of 100% summing the both answers. This correlate positively with the 71% of respondents which strongly believe that the simulator helped understand the seasons. The results on the learning object on Moon phases are similar in the structure albeit not so expressive as the seasons' learning object. For one side, they were learning objects with the same characteristics: simple to use, don´t need any download, not software demanding and with clear and more focused learning objectives.

This result can be worked out to inform the use of learning object in the near future related to the teaching and learning of basic astronomy concepts as well be extended to other science domains. More specifically, we will seek more learning objects with the characteristics of the two referred by the students as more useful in their self-study in order to amplify the possibilities offered to them in order to overcome prevailed misconceptions. This does not mean that learning objects with the characteristics of the Stellarium or the Nasa's Eyes will be put aside in future learning and teaching of astronomy.

In the case of learning objects like Stellarium, NASA's Eyes or similar ones, a different approach must be considered. In particular, a greater monitoring of the students than in the other two learning objects. The support in the installation process on personal computers, the creation of a guide with the main commands and the ask for little tasks with those learning objects in a way that students develop a more subject focused relation with them are paths that we should explore.

We could discuss if brief interactions by the pre-service teachers would allow for positive learning outcomes. Although this is not the main topic of this research is a relevant question that further research should answer. However, as [16] has managed to conclude that "students are able to build [intuitions about space scale] with minimal instructional support,(...). Even brief exposure to such experience is useful in helping students successfully address deep-seated misconceptions in phenomena covering a diverse range of concepts" (p. 276)

These are conclusions that will have a relevant impact on how the two teachers that carried on the lessons will look at these learning objects as self-study tools in forthcoming years.

References

[1] F. Costa, "Digital e currículo no início do século XXI," in Aprendizagem (in)formal na web social, P. Dias and A. Osório (Eds.), Universidade do Minho, 2011, pp. 119-142.

[2] C. Lemke, "Inovation through technology," in 21st century skills: Rethinking how students learn, J. Bellanca and R. Brandt (Eds.), Bloomingtom, IN: Solution Tree, 2010, pp. 243-272.

[3] N. B. Songer, "Digital resources versus cognitive tools: A discussion of learning science with technology," in Handbook of Research in Science Education, S. Abell and N. G. Lederman (Eds.), New York: Routledge, 2007, pp. 471-491.

[4] D. B. Zandvliet, “ICT learning environments and science education: Perception to practice,” in Second International Handbook of Science Education, vol. II, B. Fraser, K. Tobin and C.J. McRobbie (Eds.), 2012, pp. 1277-1289.

[5] T. de Jong and M. Njoo, “Learning and instruction with computer simulation: Learning processes involved,” in Computer based learning environments and problem solving, E. De Corte, M.C. Linn, H. Mandl and L. Verschaffel, (Eds), Berlin: Springer, 1992, pp 411–427. doi: 10.1007/978-3-642-77228-3_19.

[6] T. de Jong, “Instruction based on computer simulations,” in Handbook of Research on Learning and Instruction, R. Mayer and P. Alexander (Eds.), New York, NY: Routledge, 2011, pp. 446-466.

[7] A. McFarlane and S. Sakellariou, “The role of ICT in science education,” Cambridge Journal of Education, 32(2), 2002, pp. 219-232. doi: 10.1080/03057640220147568

[8] M.E. Webb, “Affordances of ICT in science learning: implications for an integrated pedagogy,” International Journal of Science Education, 27(6), 2005, pp. 705-735. doi: 10.1080/09500690500038520

[9] R.K. Atwood and V.A. Atwood, “Preservice elementary teachers' conceptions of the causes of seasons,” Journal of Research in Science Teaching, 33(5), 1996, pp. 553-563.

[10] B. Miller and W. Brewer, “Misconceptions of Astronomical Distances,” International Journal of Science Education, 32(12) 2010, pp. 1549-1560. doi: 10.1080/09500690903144099

[11] R. Trumper, “Teaching future teachers basic astronomy concepts: Seasonal changes - at a time of reform in science education”. Journal of Research in Science Teaching, 43(9), 2006, pp. 879-906

[12] K.C. Yu, K. Sahami and J. Dove, “Learning about the scale of the solar system using digital planetarium visualizations,” American Journal of Physics 85, 2017, pp. 550-556. doi: 10.1119/1.4984812

[13] C.H. Chen, J.C. Yang, S. Shen and M.C. Jeng, “A desktop virtual reality earth motion system in astronomy education,” Educational Technology & Society, 10 (3), 2007, pp. 289-304.

[14] R.L. Bell and K.C. Trundle, “The use of a computer simulation to promote scientific conceptions of Moon phases”, Journal of Research in Science Teaching, 45(3), 2008, pp. 346–372.

[15] K.C. Trundle and R.L. Bell, “The use of a computer simulation to promote conceptual change: A quasi-experimental study,” Computers & Education, 54(1), 2010, pp. 1078–1088.

[16] M.H. Schneps, J. Ruel, G. Sonnert, M. Dussault, M. Griffin and P.M. Sadler, “Conceptualizing astronomical scale: Virtual simulations on handheld tablet computers reverse misconceptions,” Computers & Education 70, 2014, pp. 269-280.

[17] S. Hidi and J. M. Harackiewicz, “Motivating the academically unmotivated: A critical issue for the 21st century,” Review of Educational Research, 70(2), 2000, pp.151-179.