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THE ROLE OF ICT TO CHANGE MISCONCEPTIONS OF SOME ASTRONOMY CONCEPTS IN CHILDREN OF PRIMARY SCHOOL

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Abstract: This study was designed to investigate whether the use of Information and Communication Technologies (ICT) would be fruitful to change several misconceptions of students about astronomy (the solar system, stars, etc.). It was developed with a group of 23 children, aged between eight and nine years old, who attended the 3rd grade of primary education in a school in Lisbon, Portugal. This research can be classified as an action-research project based on a quasi-experimental study in the context of teaching practice leading to a master´s degree qualifying the students to be teachers in the first six years of schooling. The research was developed in several stages, being initiated with the application of a questionnaire to identify misconceptions about astronomy. The result of this application confirmed that these misconceptions were similar to those already identified by other studies with children of the same age. Subsequently, ICT were used to design activities to promote conceptual change in order to provoke cognitive conflicts in the children about their own ideas when compared with scientific ones. After this intervention, the same questionnaire was applied in two different moments in order to evaluate possible changes. The first application was at the end of the school year, right after the above mentioned treatment; the second application took place at the end of September, in the following school year, after the summer school holidays. In both applications, a marked decrease of the misconceptions held by the children was revealed, which indicates that the use of ICT can be a relevant tool to promote a persistent conceptual change.

Keywords: Primary School; Misconceptions; Astronomy concepts

INTRODUCTION

Scientific concepts are ideas that can help us to understand how the world functions. However, each of us constructs, since childhood, their own interpretations of a large variety of phenomena based on daily experience. These interpretations are very often scientifically incorrect and are commonly called misconceptions (Martin, Sexton, & Gerlovich, 2002; Anderson, Fisher & Norman, 2002; Kose, 2008). When at school, these misconceptions for scientific phenomena interfere in the learning process of pupils. As Allen (2014) mentions, pupils at school do not absorb scientific ideas in a passive way but try automatically to connect their own knowledge with the new material that teachers approach during lessons. And even when facing new concepts for the first time in a formal learning context, these conceptions may also be constructed.

It is a naïf idea to think that these misconceptions can be easily changed, only by the correct explanation of scientific phenomena. On the contrary, they are resistant to change and have an impact in school learning (Carmichael et al., 1990; Santos, 1991). For Santos (1991), a proof of this resistance stems from the fact that these ideas return, even after an apparently rigorous and structured approach of the scientific contents in formal education and persist along adulthood. And Allan (2014), based on several studies, states that, since misconceptions are useful, consistent and good enough to explain everyday phenomena, their owners don´t feel the necessity to change their own ideas. Allan gives an example: The misconception that the Earth is closer to the sun during July (in summertime) makes apparently more sense than the real situation that our planet is in the furthest position from the sun during this time of the year. Rowell, Dawson & Lyndon (1990) also quote that pupils frequently conceive two different worlds, using the correct concept in the formal context but revealing the corresponding misconception in their daily life. The main problem is that the correct concept is frequently no longer necessary after leaving school.

In fact, to change pupils' misconceptions effectively is a very hard work and several steps are needed without a guarantee of success extended to all the pupils.

To start with, the identification of pupils' misconceptions can help teachers to better design learning activities in order to promote cognitive conflicts leading to their eradication. In fact, this initial process can prove essential to facilitate a meaningful learning of a scientific content. The strategies for this identification can include, for instance, addressing pupils directly about their own ideas, asking them to draw a concept, using concept maps, using scientific apparatus or promoting a role playing activity. The selection of these strategies depends a lot on pupils' age and on the nature of the concepts we want to identify, but the principle is quite simple: a learning process not focused on the teacher allows a greater exposure of pupils' thinking and an easier identification of the misconceptions that they have about several scientific ideas. But for this identification, teachers can also appeal to the results of a multitude of studies with students of different ages which have sought to identify misconceptions related to a variety of scientific issues.

It is true that learning is an idiosyncratic process and that a multiplicity of misconceptions can be generated. But, in practice, for each scientific concept, a few misconceptions are normally detected in different samples with different cultural contexts, even knowing that some ideas are in fact specific of a certain cultural reality (Allen, 2014).

To promote conceptual change Posner, Strike, Hewson & Gertzog (1982) claim the following conditions as essential: i) dissatisfaction – if the concept owned by pupils does not solve a current problem; ii) intelligibility – if the correct concept can be understood; iii) plausibility – if it works to solve present discrepancies, iv) applicability - if its applicability can solve future problems. To achieve these conditions it is also important to design powerful strategies and activities. It is in this context that the use of New Information and Communication Technologies (ICT) was considered as a potential tool for this purpose.

The main aim of the present research

The present research aimed at the following objectives:

- To verify the incidence of certain misconceptions that literature highlights as frequent in children of the 1st cycle of primary education related with the solar system, stars, etc.;
- To verify if activities based on Information and Communication Technologies (ICT) can help to change these misconceptions

According to Miranda (2007), ICT are a combination of computer technology with telecommunications that have on the Internet their form of greater expression. Nowadays, ICT are widespread in society, promoting important changes in our forms of communicating, as well as the way we access knowledge. Most children are acquainted with ICT and School feels that it should take advantage of this knowledge and of the skills associated with their handling, which are often developed at home and in other non-formal contexts.

Indeed, it is sometimes difficult to be aware of how ICT are already part of our daily lives and of how their integration has been taking place increasingly in the Portuguese education system. Even so, in Portugal, this integration has been uneven in the different cycles of schooling and slower in primary school (1st cycle). For this fact several factors can be identified, as the smaller investment of the political power in the first years of schooling, with reflection in the lack of equipment essential for the implementation of ICT activities, or the lack of teacher training related with their use.

All this divestment is contrary to the educational potential of ICT claimed by several authors. For instance, to Kozma (2005), the use of ICT in education has several advantages, like the following: (i) to facilitate access to education and knowledge; (ii) to focus on learning, increasing the digital literacy of citizens; (iii) to enhance integrated learning in the different areas of the curriculum (iv) to promote knowledge creation, technological innovation and the sharing of knowledge; (v) and it can also help to improve meaningful learning which can contribute to the desired conceptual change. Harlen & Qualter (2008) also highlight several benefits to teachers and learners by using ICT: teachers can have visual aids, explore ideas more effectively by using different types of software; pupils can interact and have an active role by discussing information and also presenting it in a more innovative way.

However, Solomon (1983) pointed out, more than three decades ago, that children's exposure to media can also promote misconceptions. Hence, the use of ICT does not seem to exempt the active role of the teacher, especially as a tutor of the learning process, also selecting the best strategies that lead to their use (Santrock, 2009).

METHOD

This study is an action-research project based on a quasi-experimental model. It was developed in a primary school of Lisbon between April and September of 2014 in the context of teaching practice, a curricular unit that is included in a master´s course qualifying students to be teachers in the first 6 years of schooling. Teaching practice occurs always in real contexts during a month and a half and in-service teachers yield their classes for this purpose. During this time, students teach all the areas of the curriculum, which include, beyond Science, Mother Tongue (Portuguese), History, Geography, Math and Artistic Expressions. At the same time, a research issue related with their practice should be designed and implemented.

At the beginning of teaching practice, each student must define, after a period of observation, their own intervention aims. In the present case, the teaching practice occurred in a 3rd grade class with 23 students, 17 female and six male aged between eight and nine years old. The children were from middle class, and their parents have either secondary or higher education. One of the aims was to promote the understanding of scientific concepts, deconstructing misconceptions in a persistent way. With this purpose the following objectives were defined:

-to identify misconceptions related with astronomy concepts in the class where teaching practice occurred;

-to use ICT activities, especially PowerPoint presentations, short videos from YouTube and interactive games, to discuss the above mentioned misconceptions, promoting cognitive conflicts in the pupils;

-to promote class discussions about the misconceptions, comparing right and wrong ideas;

-to verify changes in the misconceptions, after the intervention period.

The steps and the main aims of the study are presented in Table 1.

Table 1. The several steps of the present study.

List of the different steps
1st step – Literature revision Main aim: To identify the misconceptions related with the research theme in other studies
2nd step – Building of the questionnaire and its validation Main aim: To build a questionnaire based on several misconceptions related with the solar system, stars, etc. to verify their presence in the pupils
3rd step - First administration of the questionnaire (End of April) Main aim: To administrate the questionnaire before the period of teaching practice related with the theme
4th step - Analysis of children´s responses Main aim: To conform the presence of the same misconceptions revealed by literature
5th step – Design of the ICT activities and their implementation Main aim: To design ICT activities especially through the deconstruction of the misconceptions that are most common
6th step - Second administration of the questionnaire and analysis of children´s responses (End of May) Main aim: To verify possible changes after the teaching practice period
7th step - Third administration at the beginning of the next school year (End of September) Main aim: To verify the persistence of those changes

Several misconceptions about the solar system, stars, etc. in children of a similar age of the sample of the present study were identified in studies from Schoon (1989), Hapkiewicz (1992), Langhi & Nardi (2011) and Teixeira (2011), for instance. Based on these results, a questionnaire with open and closed questions was built. In this questionnaire, it was impossible to include all the misconceptions related with this issue. Therefore, the selection was related with the concepts present in the 1st Cycle curriculum, which are: the shape of the earth, the phases of the moon, the differences between stars and planets and the main characteristics of the solar system.

Before its administration, the questionnaire was validated by two experts in didactics and piloted with eight children of the same age and social characteristics. The questionnaire included the questions present in Table 2.

The questionnaire was applied (pre-test) to the sample at the end of April of 2014. The verification of the incidence of certain misconceptions was essential for a better selection of the didactic resources related with ICT to promote conceptual change. The resources were the ones already mentioned. The videos were always presented twice and a discussion was promoted between the two presentations of the same video. This discussion intended to focalize pupils in the understanding of scientific concepts with a higher incidence of misconceptions. After four weeks, at the end of May, the questionnaire was administered again (post-test1) to verify possible first changes in these misconceptions. Finally, at the end of September, in the following school year, the same questionnaire was administered again to verify the consistence of the conceptual change (post –test2).

Each questionnaire was quoted as follows: the value "1", for each right question, in which the student did not reveal a misconception and "0" in the opposite situation. In the multiple choice items, a reason was demanded and these answers were categorized by content analysis. An answer was only considered correct when the justification matched the chosen option.

Table 2. The questions included in the questionnaire.

Questions	Their nature
1.1.The Sun is ... (a planet, a comet, a satellite)	Multiple choice
1.2. The celestial bodies that own light are... (the planets, the stars, the comets, the asteroids)	Multiple choice
1.3. The phase of the moon that we observe is... (always the same, depends on the earth´s place)	Multiple choice
2.1. The solar system ends on the last planet. (True, False – Justify)	Multiple Choice Justification: Open question
2.2. The Earth is bigger than the Sun. (True, False – Justify)	Multiple Choice Justification: Open question
2.3. All the planets are rocky. (True, False – Justify)	Multiple Choice Justification: Open question
2.4. The stars have tips. (True, False – Justify)	Multiple Choice Justification: Open question
3. Given the position of the Sun and the planets, which of the schemes, A (geocentric model) or B (heliocentric model), represents the solar system?	Multiple Choice Justification: Open question

The global quotation of the questionnaires was compared for the first and second administrations and for the first and the third ones, applying the Wilcoxon signed-rank non-parametric test, since the pattern of responses not always followed a normal distribution. The level of significance adopted was $p<0.05$.

RESULTS

Table 3 presents the questions included in the questionnaire as well as the incidence of the wrong ideas (misconceptions) in the three moments of its administration.

In the pre-test, several children revealed the same misconceptions present in other studies. With a high incidence, 78% of the children thought that a moon phase varies with the place where we are on earth and 57% thought that stars have tips. In relation to the Earth size when compared with the Sun and the physic nature of the planets of the solar system, the percentage of incorrect answers was also high, now aided by the discrepancy between the option in a multiple choice item and its justification. Table 4 shows some of the justifications expressed by the pupils.

Table 3. Percentage results from the questionnaires (pre-test, post-test1 and post-test2). The sample consists of 23 children. The scientific conception is in bold.

Questions	Relative frequencies		
	Pre-test	Pos-test1	Pos-test2
1.1.The Sun is ...			
a planet.	9%	0%	0%
a comet	4%	0%	0%
a satellite.	4%	0%	0%
a star.	83%	100%	100%
1.2. The celestial bodies that own light are...			
the planets.	35%	0%	0%
the stars.	30%	100%	96%
the comets.	22%	0%	4%
the asteroides.	13%	0%	0%
1.3. The phase of the moon that we observe...			
is different from country to country .	35%	0%	4%
is different from continent to continent.	17%	0%	4%
is different in each hemisphere.	26%	0%	13%
is the same in the whole planet.	22%	100%	78%
2.1. The solar system ends on the last planet.			
True	26%	0%	9%
False	48%	100%	91%
Not scored. The justification does not match the chosen option	26%	0%	0%
2.2. The Earth is bigger than the Sun.			
True	35%	8%	4%
False	48%	88%	96%
Not scored. The justification does not match the chosen option	17%	4%	0%
2.3. All the planets are rocky.			
True	35%	0%	0%
False	43%	91%	96%
Not scored. The justification does not match the chosen option	22%	9%	4%
2.4. The stars have tips.			
True	57%	0%	0%
False	30%	100%	100%
Not scored. The justification does not match the chosen option	13%	0%	0%
3. Given the position of the Sun and the planets, which of the schemes, A or B, represents the solar system?			
Scheme A (geocentric model)	13%	0%	0%
Scheme B (heliocentric model)	87%	100%	100%

Table 4. Some of the misconceptions revealed by the children. Some of them are only reasons that can not exactly be considered misconceptions.

Questions	Some justifications
2.1. The solar system ends on the last planet.	→ The solar system begins in the first planet and ends in the last.
It´s true because…	→ I learnt it in a movie.
	→ They explained it to me like that.
2.2. The Earth is bigger than the Sun.	→ The sun is only a ball of fire.
	→ In fact they have the same size.
It´s true because…	→ The Earth is bigger.
	→ The Sun is smaller.
	→ Many people think that the sun is bigger. But from the Earth, we can see that the Sun is smaller
2.3. All planets are rocky.	→ Only those that are hit by comets are rocky..
It´s true because…	→ All planets have rocks.
	→ The planets are strong so they have rocks.
	→ The planets could not be composed otherwise.
2.4. The stars have tips.	→ I can see that they have tips.
	→ When I draw a star it has tips.
It´s true because…	→ The stars are pointy
3. Given the position of the Sun and the planets, which of the schemes, A or B, represents the solar system? Scheme A (geocentric) because…	→ It makes sense like that. → In this scheme the planets are in their right positions.

The justifications for the several items were somehow inconclusive. Children tend to justify their ideas without elaborating much, only saying that they learnt it like that or just because it makes sense like that. Even so, a few justifications are quite interesting and we highlight the following: "the earth is bigger than the sun because de sun is only a ball of fire"; "all planets are rocky because they are strong so they have rocks"; "The planets could not be composed otherwise" or "the stars have tips because when I draw one it has tips".

In the second moment (pos-test1), after the already mentioned treatment using ICT activities, there was a clear reduction of the expressed misconceptions. Even so, still 12% of the children continue to argue that the Earth is bigger than the Sun, and 9% claim that all planets are rocky. This decrease revealed to be consistent because in the results of the 3rd administration the percentage of children with misconceptions was also very small. Nevertheless, the percentage of children considering that the phase of the moon depends on our location on the Earth, as well as those who think that the terminus of the solar system is in the planet more distant from the Sun increased a little. But, at the same time, there was also a small decrease in the number of children stating that the Earth is bigger than the Sun and that all the planets are rocky.

The application of the Wilcoxon signed-rank test showed that the score differences between the first administration and the second, as well as between the first and the third were both statistically significant, respectively $z = -3{,}955$; $p < 0.001$ and $z = -4{,}163$; $p < 0.001$.

CONCLUSIONS AND IMPLICATIONS

This study helped to confirm that some of the misconceptions about the solar system, stars, etc., identified in previous studies, were also present in the children inquired. The complexity of these topics is one of reasons why these misconceptions are not easy to change. Consequently, Kavanagh, Agan & Sneider (2005), based on several studies, stated that a topic like the phases of the moon, for instance, should be addressed at the fifth or sixth grade level, and not below. But it seems that curriculum developers sometimes tend to ignore some of the results of educational research.

The good news are that the use of ICT activities, especially with animations and short films, but always accompanied by a systematic opposition of the aspects observed with the wrong ideas of the children, made it possible to deconstruct the majority of the misconceptions expressed by them, considering that they were at the third level of schooling and have to learn a complex issue. We also think that the already described active role of the teacher was also essential for the success of the intervention.

This study was not exempt of limitations. For instance, it was impossible to compare the results of the pupils of the sample with those from other classes submitted to a different research design or simply to a more traditional approach in which teachers tend to ignore the children´s misconceptions and don´t use ICT activities. After all, the success of the intervention was in part a surprise, since the time to explore science issues was scarce and during the teaching practice period all the curriculum areas were taught.

Independently of the good results, this study also allows to highlight the possibility of every teacher to include a research dimension in the course of their own practice, thus contributing to change at least some of the misconceptions expressed by children about different scientific topics.

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