Effect of Reading on the Scientific and Mathematical Reasoning of Future Elementary School Teachers

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Abstract.

Future teachers should be prepared to teach Science and Mathematics when they finish their studies. Understanding scientific and mathematical concepts is necessary to develop reading and reasoning abilities, which should be improved through teacher training. In this research project, the goal is to measure reading speed and comprehension, scientific and mathematical reasoning and to test the correlations between these variables. The instruments used were three texts with questions from PISA: the first one in order to measure speed of reading and comprehension, the second to measure scientific reasoning and the third one to measure mathematical reasoning. The sample consists of 198 students in their first, second, third or fourth year of university, all of them studying to become elementary school teachers. The results, which are not satisfactory, indicate the need for improvement of their reading speed and scientific and mathematical reasoning. Moreover, the variables of this research show that the level of fourth year students is usually lower than the level of first year students.

Keywords: PISA, reading fluency, reading comprehension, reasoning abilities, university students

1. Introduction

Educational institutions state that professors should stimulate students reasoning, particularly verbal reasoning (NCTM, 2009; COSCE, 2011). In education, there is an interest in the argumentative competency, this capacity precedes symbolic reasoning (Solbes et al., 2010; Tabach et al., 2010). The tasks should be more open to the students' creativity. Not only students must apply a process, but also conceive it (Etkina & Van Heuvelen, 2004; Hofstein et al., 2008; Mendez & Slisko, 2017).

In the field of science, the features of this scientific and verbal language are noticed in some aspects regarding the vocabulary, the expression and the psycho-pedagogic implications. Thus, the start must be assumed from natural expressions known by the children. Since, psycho-educational consequences derived from the grade of precision-abstraction of the issues, exercises and problems that the students are going to find. And, their positive or negative effect regarding comprehension will depend on the verbal level that has been chosen.

Therefore, it is essential to choose those words which are more suitable to express concepts (Sanchez Huete & Fernandez Bravo, 2003).

1.1 Teacher training

It is well known that students reveal in numerous signs that they do not understand scientific concepts being unable to apply them in out-of-school contexts. In addition, students use intuitive knowledge about science phenomena that makes very difficult and sometimes impossible to learn scientific concepts. That intuitive knowledge, based on routine activities and superficial thinking, is made of alternative conceptions or preconceptions (PISA, 2013; Mayer, 1986). In order to try and remediate this troubling situation, many countries of the European Union (EU) are investing money in science education, introducing new teaching methodologies which promote active learning experiences and taking into account how people learn (Mialaret, 1977).

To reach this goal, it is necessary to modify the training of the prospective teachers. Special attention should be given to those teachers who will teach science in elementary grades. In general, at these grade levels, students do not have good understanding of science. Most importantly, teaching key concepts to these young pupils will serve as a base for understanding science in next stages (Johnson & Johnson, 1999; Mendez, 2013).

Concerning the contents, most of the prospective elementary teachers do not study science within a four-year period. Therefore, it is difficult that they remember what they have already "learned"; it indicates that they have not understood well enough the key concepts in previous schooling. In addition, they have to study simultaneously different subjects in the same semester.

To add more complications to the situation, some studies report that most of the in-service elementary teachers admit that they try to avoid some science topics due to a lack of confidence at the moment of explaining them (Mendez, 2012; Hänze & Berger, 2007; Desbien, 2012). In fact, the memories they have of science classes at school are related to textbooks and answers to the questions at the end of every chapter. Nevertheless, there are also a few teachers who enjoy teaching science and do several experiences that are based on the research (Johnson & Johnson, 1999; Mendez, Mendez & Anguita, 2018).

Therefore, this lack of a strong theoretical knowledge leads teachers to manage resolution of problematic situations as a routine matter. So, these problematic situations, that appeared in some workbooks or in the chosen course books, differ significantly from their experiences and concerns. Indeed, any occasion of imaginative participation which could arise from the classroom is left on the sidelines. Consequently, motivation which serves to refresh their necessities; and security, which allows the possibility of making a mistake as a means of investigation in the learning process, is dismissed because of the absence of fields with possibilities of creative action (Sanchez Huete & Fernandez Bravo, 2003).

1.2 The importance of logical reasoning

As matter of fact, in order to bring students closer to science and mathematics comprehension, academics must know how reasoning processes are necessary for: the comprehension of these concepts, the students' reasoning and the way to improve this former reasoning to facilitate comprehension. Consequently, teachers must expect students' level of knowledge regarding their stage of intellectual development (that is, preoperational, specific, formal, or post-formal) and their knowledge in specific subjects (Lawson, 2009; Mendez et al., 2017).

Thus, in order to favor abstract concepts, the way to develop certain abilities must be found, such as abilities of abstract or logical reasoning. This reasoning, is a creative process which possesses some recognizable elements. Firstly, a confusing observation takes place. Secondly, logical reasoning produces one or more hypothesis. Another possibility as well, might be the use of combinatory reasoning to create a list of every possible combination or hypothesis (Hand, Prain & Yore, 2001).

Moreover, this reasoning implies a creative thinking; in this way, both the development of the hypothesis and the following process (of which hypothesis is the right one) are facilitated in order to reach the final conclusion. As a result, the development of this ability might be encouraged through a method which provides reasoning, for instance mathematic problems (Veerman et al., 2002).

Ogan-Bekiroglu & Eskin (2012) reached the following conclusions about the relationship between the scientific reasoning and the conceptual knowledge:

The quantity and the quality of the students reasoning improved in time.

It is possible to predict their quantitative contribution, inspecting their qualitative contribution. Because, if a student make few quantitative contributions, their qualitative contribution will be lower as well, and vice versa.

When students are involved in thinking activities, their knowledge does not improve immediately. In other words, the development of knowledge in the reasoning process entails its appropriate quantity of time.

Former knowledge affects reasoning involvement. If students are familiarized with the concepts or they have scientific notions about those concepts before starting the reasoning, it is undeniable that they are much more involved in that reasoning and produce new elements.

Problematic qualitative and quantitative situations not only develop curiosity, but also demand reflection, teach how to analyze the results as well as to express them correctly, and they favor a better perception in the relationship between science and technology (Carrascosa et al., 2006). In addition, they facilitate an increase in the involvement, and they promote an improvement in the reasoning of both ideas and opinions, which facilitates access to knowledge.

Formal Reasoning is an important skill not only at the moment of making predictions, but also at the moment of learning science and mathematics. However, it is true that people's former ideas and the use of logical rules of reasoning have a great effect in learning. Moreover, it also exists a partial dependence between the procedures of learning and the conceptual content. Therefore, abstract reasoning is the skill that goes beyond the particular case and, that abstract concepts are especially important to learn and understand (Tobin & Capie, 1982).

1.3 The Concepts of Reading Comprehension and Fluency

Reading comprehension is the capacity to understand every word of a text in an exclusive and global manner, enabling the reader to interpret why he/she understands the text and to give it a true and observable meaning. Reading transcends the automation of an interpretative exercise to become a personal, differentiated action that is integrated in the subject, closer to the communicative identity of his/her language than to any type of automatism (Quintanal & Tellez, 2000).

Reading itself involves strategic decision making, and is an exercise of constant reflection. In Quintanal and Tellez's opinion (2000), the defence of reading as something strategic is what gives meaning to reading from the beginning:

Hence, for example, in the field of problem resolution, this was deemed to imply an initial process of knowing the message, interpreting the situation questioned, and proper knowledge of the question raised. Then, its execution would require obtaining the question in an automated manner, by virtue of the necessary mathematical combinations that would enable access to the answer. So knowing the problem (understanding it when it is read) implied that the appropriate resolution procedure was activated in the reader's brain. If that was not the case, the reader would have to focus on the contents of the message until it was properly understood (comprehension "equal to" interpretation of the resolution process).

This way, learning to resolve problems implied assimilating processes of interpretation and by virtue of programmed training, practicing for that purpose. And we can consider similar formulae that existed to resolve all the possible needs a reader would come across in his/her lifetime, first as a student and then as an adult.

To read is to understand, and to understand is to interpret. Quintanal (1999) explains what we mean when we speak of interpretation in connection with reading comprehension, what is interpreting a text and what steps are needed to carry out this process of text interpretation: A child's training only has one objective: to dispose of the necessary mechanisms to faithfully interpret the text. Command of these mechanisms will be based on a specific training plan. It does not occur spontaneously; it results from the action of education at school, from the results of the period of obligatory schooling.

However, the results are not uniform, or focused on a single direction. We can consider a classification of reading training comprising different components.

These components are the three levels which Quintanal (1999) highlights as a reader's authentic linguistic capacity, namely: fluid decoding, interpretative comprehension and structured integration.

First of all the student must be capacitated to fluidly go over the text. Fluidity is a term introduced in the teaching concept of reading to replace the concept of «speed», which only entails a decoding treatment of text: to use the smallest amount of time to visually go over a graphic line. Fluidity entails skilfully involving the eye with respect to speed, but also correctly identifying the text. For many years comprehension was considered the final objective of reading activity. Quintanal (1999) defines it as the ideographic correlation between the graphic text and the reader's mind, in such a way that the latter generates a personal "film" of the message depending on the interpretation provided by the code of the encoded message. The comprehension of a text is conditioned by the reader's previous circumstances and experience and its effectiveness depends on the student's linguistic knowledge (mainly of vocabulary and syntax). It later has repercussions on the metalinguistic level to assimilate textual information and provide an interpretation for said text.

Reading is not complete until the textual information reaches the level of knowledge. In some cases, the new information provided by the text is limited to the comprehension level, but it cannot be considered effective until it is integrated in the structure of knowledge, so that now we know something which we formerly ignored, but in addition it is connected to previous information. Indeed, understanding is to integrate the content of a text in the reader's mind in a personalised manner (Quintanal, 2015).

2. Methodology

The design of the research project is descriptive and correlational, as it seeks to determine the participants' level in the variables measured, to study their relations and establish possible influences between the variables.

2.1 Research objectives

- To find out the levels of reading fluency and comprehension

- To determine the level of scientific and mathematical reasoning

- To find possible relations between the variables under study

2.2 Participants

The sample is not probabilistic and incidental, since the students participating in the study belonged to different years of study of the Degree in Elementary School Teaching at the CES Don Bosco, affiliated with the Complutense University of Madrid. The sample consisted of 198 students, of which 75 were first year students, 51 second year students, 36 third year students, and 36 fourth year students. In respect to genders, 139 were women and 59 men, entailing percentages of 70.20 and 28.20 respectively.

2.3 Procedure

The participants gave their consent to filling out different questionnaires. The sessions to complete the tests lasted about one hour during the 2017-2018 academic year. The tests were administered in the following order: reading speed, reading comprehension, scientific reasoning and mathematical reasoning.

2.4 Instruments

Reading text and questionnaire for reading fluency and comprehension, taken from the Pisa tests, with the inclusion of a question added by the researchers (appendix 1). The maximum possible score was 6 points. For the reading fluency test, the number of words read per minute were counted.

Reading test and questionnaire for the reasoning test in science taken from the Pisa test (appendix 2). The maximum possible score was 3 points.

Reading test and questionnaire for the reasoning test in mathematics taken from the Pisa test (appendix 2).

3. Results

The statistical package SPSS 22 was used for the analysis of data.

An initial descriptive strategy presents the averages and standard deviation of the variables included in the research (Table 1).

Table 1: Basic descriptive items in reading comprehension and fluency

		Reading comprehension		Reading fluency	
Year	Gender	Average	Standard deviation	Average	Standard deviation
1st	Male	3.3	1.4	224	50.5
	Female	2.6	1.3	214	41.9
2nd	Male	3.6	0.7	227	61.3
	Female	3.5	1.1	202	41.8
3rd	Male	3.6	1.5	230	44.0
	Female	3.5	1.3	213	42.3
4th	Male	2.7	1.3	209	84.5
	Female	2.6	1.4	173	45.6

For the sample set of men (N=58) and women (N=139) there are no significant differences between the genders ($p>0.05$) in the reading comprehension variable on the basis of the mean difference test for independent samples (T of Student).

There are, however, statistically significant differences in reading fluency in favour of men ($p<0.05$), with an effect size (d)=0.457 which is considered medium-low.

If 1st and 4th years students are compared (T of Student) we find that:

a) There are no significant differences in reading comprehension ($p>0.05$)

b) There are significant differences in reading fluency ($p<0.05$) with an effect size (d)=0.7266 which is medium-high in favour of the first year students in comparison with the fourth year.

Table 2: Basic descriptive items in scientific and mathematical reasoning

		Scientific reasoning		Mathematical reasoning	
Year	Gender	Average	Standard deviation	Average	Standard deviation
1st	Male	2.4	0.7	1.7	0.6
	Female	2.3	0.8	1.5	0.7
2nd	Male	1.2	0.8	1.6	1.0
	Female	2.6	0.7	1.6	0.5

3rd	Male	2.3	0.7	1.2	0.7
	Female	2.3	0.6	0.9	0.4
4th	Male	2.1	1.0	1.4	0.8
	Female	2.3	0.8	1.2	0.8

In respect to gender there are no significant differences between men and women in the four academic years (p>0.05), or in scientific and mathematical reasoning on the basis of the mean difference test in independent samples (T of Student). Furthermore, there are no statistically significant differences (p>0.05) between the 1st and 4th academic year using the same statistical test.

Table 3: Matrix of correlations of the variables studied

		Reading comprehension	Reading fluency	Scientific reasoning	Mathematical reasoning	Age
Reading comprehension	Pearson's correlation Sig. (bilateral) N	1 198	-.002 .978 198	**.158*** .028 198	.031 . 668 195	-.020 .784 198
Scientific reasoning	Pearson's correlation Sig. (bilateral) N	**.158*** .028 198	.052 .471 198	1 198	**.222**** .002 198	-.067 .351 198
Mathematics reasoning	Pearson's correlation Sig. (bilateral) N	.031 .668 198	.084 .242 198	**.222**** .002 198	1 198	-.036 .621 198
Reading fluency	Pearson's correlation Sig. (bilateral) N	-.002 .978 198	1 198	.052 .471 198	.084 .242 198	-.031 .663 198
Age	Pearson's correlation Sig. (bilateral) N	-.020 .784 198	-.031 .663 198	-.067 .351 198	-.036 .621 198	1 198

Source: (TNR 10pt., italics)

*. The correlation is significant at the 0.05 level (2-tailed).

**. The correlation is significant at the 0.01 level (2-tailed).

No correlation exists between reading comprehension and fluency (-0.002). However, a slight correlation is found (0.158*) between scientific reasoning and reading comprehension. Though also low, a somewhat stronger relation is found between scientific and mathematical reasoning (0.222**). In respect to age no influence is found in any of the variables.

4. Conclusions

The levels of reading fluency and comprehension in the students of the Degree in Elementary Teaching leave room for improvement, given that the tests used in this research study are for

15 year old students (3rd ESO). Of all the variables studied only reading fluency appears to discriminate on the basis of gender and academic year.

Curiously, the first year student seem to enter university with better levels of fluency than the 4th year student. In this variable it seems that men have a little advantage over women. Nonetheless, as no relation is found between the reading fluency variable and reading comprehension for this simple, we can state that the difference is not relevant in respect to other competences.

On the other hand, it is noted that in all the variables analysed there are no differences between the first to fourth year students, with the exception of the one mentioned above. In fact, the trend is exactly the opposite of what would be expected. In other words, all the means are lower in the 4th year in comparison with the 1st year, although they are not statistically significant. This indicates that presumably the competences do not improve from the 1st to the 4th year, from a transversal approach.

The relations found between the variables are within the expected parameters. At these ages there is no visible relation between reading fluency and comprehension because it is likely that reasonably efficient levels of reading mechanics have been attained, improvement of which is not reflected in an increase of text comprehension.

The biggest relations are found between scientific and mathematical reasoning, probably due to the affinity of scientific-mathematical disciplines in the study programme prior to entering the university, and to common interests and competences involved in the two disciplinary fields.

In addition, we can conclude that certain aspect of the study programme of the future elementary school teachers should be modified in order to develop these competences which are essential in the field of education.

Acknowledgment

This paper is an output of the science project financed by CES Don Bosco and Santander Bank.

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For each work shown in the list of references must be a reference in the text. All citations in the text and all references must meet APA styles (American Psychological Association 6th edition – more information http://www.apastyle.org/).

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