Problem-solving performance in pre-service teachers: a case study on reading ability and formative feedback effect measurement

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General description on research questions, objectives and theoretical framework

Mathematical problem-solving performance and reading ability in students and pre-service teachers have been studied in numerous investigations (Boonen et al., 2014; Vilenius-Tuohimaa et al., 2008). In fact, authors such as Pólya (1945) and Puig & Cerdán (1989) have shown that reading and understanding problem statements are key phases of the problem-solving process. Besides that, the evolution of new technologies applied in education allow the design of computer-based assessment tools to provide feedback to students while learning, as well as recording its effects on understanding and processing information and learning outcomes. There are different types of feedback: (1) messages indicating whether the answer given by the learner is correct or incorrect, (2) messages with information showing the correct answer and finally (3) the so-called formative or success-oriented feedback that include explanations (Hattie & Timperley, 2007; Mory, 2004; Van der Kleij et al., 2015). This work presents the results of an exploratory experiment where pre-service primary school teachers have to solve Arithmetic Word Problems (AWP) using a technological environment. In particular, we consider as a research question if it is possible to use the student's reading time recorded in this environment to study reading ability in AWP and use it as a proxy to determine the complexity of AWP statements. To answer this question, we define two goals: G1: Determine reading ability as a measure of the problem complexity in AWP where two meanings of the fraction concept are involved: the fraction as an operator on a natural whole or fractional whole and the reconstruction of the whole and G2: Measure students problem-solving performance based on the type of feedback received after answering multiple-choice questions based on primary school problem statements related to the use of fractions.

Methodology

As an instrument for measuring the complexity of AWP we use Read&Learn (R&L), a technological environment (López-Iñesta et al., 2018; Sanz et al., 2020) for researching the students process in task-oriented reading situations. R&L records all user interactions with statements, questions and answers along with timestamps with a precision of milliseconds (ms). In the sample there are 111 prospective teachers enrolled at the University of Valencia (37 men, 74 women). 56 students were assigned randomly to the control group (only correct or error messages when solving problems) and 55 students to the experimental group (messages with success-oriented feedback).

The AWP considered are: P1. I have one-half of a pizza. Two-thirds of it is margherita. What fraction of the pizza is margherita?; P2. There are six hundred members, five sixths do gymnastics, two fifths of the rest do swimming, how many members do swimming?; P3. We have thirty candies. Two-thirds of them are strawberry flavored. How many strawberry candies do we have?; P4. There are thirty thousand inhabitants, if one third are from Valencia C.F. How many inhabitants are not from Valencia C.F.?

The hypothesis we consider are:

H1: the results obtained in P3 and P4 must be similar; both present the same mathematical concept, the fraction as an operator on a natural number (Hart, 1984).

H2: P1 and P2 results will show differences with P3 and P4; we suppose an increase in complexity, therefore, a worse performance of the solvers. Here, the fraction as an operator on a fraction in P2 (Perera, & Valdemoros, 2009) and the reconstruction of the whole is introduced in P1.

H3: the performance of the solvers who receive feedback during the solving process will be better than those students who do not receive it (Hattie, & Timperley, 2007; Mory, 2004).

Results and implications based on the research results

We have presented a novel proposal to measure the complexity of an AWP through the student reading ability of its statement against the probability of success. It is considered a proper measure since the distribution of success probabilities are inverse to reading ability (Sanz et al., 2020).

Numerically results are, P1: readings time (ms/word) 7391.37 ± 4667.84 and success probability 0.43; P2: readings time (ms/word) 12963.89 ± 8248.89 and success probability 0.82; P3: readings time (ms/word) 4672.17 ± 3612.28 and success probability 0.94; P4: readings time (ms/word) 2984.66 ± 2011.96 and success probability 0.90. These results allow us to answer H1 and H2. On the one hand, the results about P3 and P4 are similar (H1) and we affirm that there are no significant differences (p-values>0.05 in both cases). On the other hand, H2 is accepted because the results between P1 or P2 and the other problems remark that P1 and P2 are more difficult problems; these differences are statistically significant (p-values<0.05 in all cases).

Finally, the difference between Control and Experimental groups are analyzed (H3). It is observed that readings time is greater in the Control group than in the Experimental group. In the same vein, referred to success, it is those of the Experimental group who obtain the best results. The difference between groups being significant for P4. Thus, it is concluded that the feedback provides better results, and a faster reading of the statements. Definitely, it can be pointed out that the incorporation of feedback messages (Hattie, & Timperley, 2007; Van der Kleij et al., 2015) provided to students is of great importance as it is one of the most effective resources to increase student learning (Mory, 2004). Note that, readings time and success probability were not statistically different between men and women (p-values > 0.05), although reading times are longer for women and greater success for men. This remarks the inverse relation between both complexity measures.

Relation to the theme chosen

Number sense can be described as a good intuition about numbers and their relationships (Howden, 1989). Particularly, lack of fraction number sense is a pervasive problem for students and also to adults and prospective teachers (Utley, & Reeder, 2012). In this paper, we develop preliminary research to assess the knowledge of pre-service teachers and measure its performance when using a technological environment to solve AWP where different fraction meanings are involved.

References

Boonen, A. J. H., Van Wesel, F., Jolles, J., & Van Der Schoot, M. (2014). The role of visual representation type, spatial ability, and reading comprehension in word problem solving: An item-level analysis in elementary school children. *International Journal of Educational Research, 68*(4), 15-26.

Hart, K. M. (1984). *Ratio: Children's strategies and errors: A report of the strategies and errors in secondary mathematics project*. London: Nfer-Nelson.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of educational research, 77*(1), 81-112.

Howden, H. (1989). Teaching number sense. *The Arithmetic Teacher, 36*(6), 6-11.

López-Iñesta, E., Garcia-Costa, D., Grimaldo, F., & Vidal-Abarca, E. (2018). Read&Learn: una herramienta de investigación para el aprendizaje asistido por ordenador. *Magister: Revista miscelánea de investigación, 30*(1), 21-28.

Mory, E. H. (2004). Feedback research revisited. In D. H. Jonassen (Ed.), Handbook of research on educational communications and technology, pp. 745–784. Erlbaum Associates.

Perera, P. B., y Valdemoros, M. E. (2009). Enseñanza experimental de las fracciones en cuarto grado. *Educación matemática, 21*(1), 29-61.

Polya, G. (1945). *How to solve it*. Princeton University Press. Princeton, NJ.

Puig, L., & Cerdán, F. (1989). *Problemas aritméticos escolares.* Madrid: Síntesis.

Sanz, M.T., López-Iñesta, E., Garcia-Costa, D. y Grimaldo, F. (2020). Measuring Arithmetic Word Problem Complexity through Reading Comprehension and Learning Analytics. *Mathematics, 8*(9):1556. https://doi.org/10.3390/math8091556

Utley, J., & Reeder, S. (2012). Prospective elementary teachers' development of fraction number sense. *Investigations in Mathematics Learning, 5*(2), 1-13.

Van der Kleij, F. M., Feskens, R. C., & Eggen, T. J. (2015). Effects of feedback in a computer-based learning environment on students' learning outcomes: A meta-analysis. *Review of educational research, 85*(4), 475-511.

Vilenius-Tuohimaa, P. M., Aunola, K., y Nurmi, J. (2008). The association between mathematical word problems and reading comprehension. *Educational Psychology, 28*(4), 409-426.