

Learning Approaches and Reading Comprehension: The Role of Student Questioning and Prior Knowledge

Francisco Cano, Ángela García, Fernando Justicia,
and Ana-Belén García-Berbén

Universidad de Granada

Abstract

Students' learning approaches and reading comprehension are two constructs that, despite coming from different theoretical and research perspectives, may be interrelated. The present study investigates this link and the role played by students' questioning in relation to a typical science text and their prior knowledge. The participants were 449 ninth-grade science students and the path analyses showed that students' learning approaches at course level accounted for their reading comprehension and influenced questioning indirectly, via prior knowledge. Surface approach contributed (negatively), to a significant extent, to text comprehension, both directly and indirectly, whereas Deep approach contributed (positively) but only indirectly. These findings underline the mediating role of questioning in the relationship between students' learning approaches and reading comprehension, and highlight the importance of taking a broader view of the variables that can affect students' comprehension of science texts.

Keywords: Learning approaches, reading comprehension, students' questions, prior knowledge.

Resumen

Los enfoques de aprendizaje de los estudiantes y la comprensión lectora son constructos que, aunque provenientes de diferentes perspectivas teóricas y metodológicas, podrían estar relacionados. Este estudio analiza esa relación y el papel desempeñado por las preguntas de los estudiantes respecto a un texto típico de ciencias y por su conocimiento previo. Participaron 449 estudiantes de ciencias (cuarto curso de Secundaria) y el análisis de senderos (path analysis) mostró que los enfoques de aprendizaje de los estudiantes a nivel de curso explicaron su comprensión lectora e influyeron indirectamente sobre las preguntas, vía conocimiento previo. El enfoque superficial contribuyó (negativamente), directa e indirectamente, a la comprensión del texto, mientras que el enfoque profundo contribuyó (positivamente), pero sólo indirectamente. Estos resultados enfatizan el papel mediador de las preguntas así como la importancia de adoptar un punto de vista amplio sobre la comprensión de los textos de ciencias.

Palabras clave: Enfoques de aprendizaje, comprensión lectora, preguntas de estudiantes, conocimiento previo.

Acknowledgements: This research was funded by the Spanish Ministry of Science and Innovation (MI-CINN, EDU2011-27416).

Correspondence concerning this article should addressed to Ana Belén García-Berbén, Departamento de Psicología Evolutiva y de la Educación, Universidad de Granada, Facultad Ciencias de la Educación, Campus Cartuja, s/n 18071 Granada. E-mail: berben@ugr.es

Introduction

There is growing concern in numerous countries about two common problems: (a) students are tending to become increasingly surface and less deep in their approaches to learning (e. g., Biggs, 2001) and (b) they are experiencing serious difficulties in comprehending informational texts (e. g., Martínez & Barrenetxea, 2002), particularly those covering scientific material (e. g., Sanjosé, Fernández, & Vidal-Abarca, 2010). An interesting question that merits investigation is whether secondary students' approaches to learning could account for their reading comprehension.

To date, there is much research linking students' learning approaches and learning outcomes on the one hand (e. g., De la Fuente, Sander, & Putwain, 2013; Watkins, 2001), and reading comprehension, prior knowledge and questioning on the other (e. g., Ozuru, Dempsey, & McNamara, 2009; Taboada & Guthrie, 2006). However, there are still few large-scale correlational studies on how students' learning approaches at course level (e. g., science), in concert with questioning and prior knowledge, contribute to the prediction of reading comprehension. This study aims to contribute to the bridging of this knowledge gap by proposing a path model explaining these relationships.

Students' learning approaches and reading comprehension

Although the original naturalistic work on students' learning approaches came from interviews in a micro-context, a student relating to a task (interacting with a text), it soon led to the design of inventories to assess what a large number of participants usually do when learning and studying in a more general context (e. g., a course) (Biggs, 1993).

Researchers distinguished two major students' learning approaches – the deep and the surface, consisting of a combination of motivational and cognitive elements (Marton & Säljö, 1997). A deep approach implies the intrinsic purpose of understanding ideas for oneself and the use of strategies for creating meaning, whereas a surface approach is associated with the extrinsic purpose of coping with course requirements and the use of strategies focusing on routine memorisation (Biggs, 2001; Kember, Biggs, & Leung, 2004). According to Biggs's (1993) presage-process-product (3P) model of teaching and learning, students' learning approaches are process factors which depend on a number of personological and contextual presage factors (e. g., motivation, teaching) (e. g., De la Fuente et al., 2012; Elstad, Christophersen, & Turmo, 2012; Núñez, Paiva, Polydoro, Rosário, & Valle, 2013), which also influence cog-

nitive, affective and behavioural learning outcomes (product) (e. g., De la Fuente et al., 2013; Watkins, 2001).

Although in general, studies which have tested this model (e. g., Biggs, 2001; Rosário et al., 2005) found that the deeper the students' learning approaches, the higher the quality of their learning outcomes, there has been little research on how students' learning approaches at course level are related to their reading comprehension.

Reading comprehension is a complex process that demands motivation as well as cognition because it is the result of an interactive process between the text (e. g., text difficulty), the context of the reading situation and the reader (e. g., purpose or goal, prior knowledge, questioning) (e. g., Retelsdorf, Köller, & Möller, 2011). Reading comprehension plays a crucial role in the educational process and can be assessed in different ways (Escribano, Elosúa, Gómez-Veiga, & García-Madruga, 2013; Pearson & Hamm, 2005), off-line tests administered after reading being more suitable with a large number of participants.

For commonly used theoretical models, such as Kintsch's (1998) construction-integration model, readers build a mental representation of text from their goals, long-term memory (knowledge, experience) and ideas in the form of propositions. This representation is organised at several levels of com-

prehension (e. g., text-based, situational model). An in-depth understanding of a text requires readers both to obtain a network of propositions directly derived from the text (text-based) and to grasp its global meaning from an integration of the information provided by the text with their goals, prior knowledge and experience (situational model) (Kintsch, 1998; McNamara, Kintsch, Songer, & Kintsch, 1996).

From this short review, two conclusions may be inferred. First, students' learning approaches and reading comprehension are two distinct constructs that although coming from different theoretical and research perspectives, share some general characteristics. Thus, both are complex processes which (a) play an important role in the teaching-learning process, and (b) depend on the interplay between a number of cognitive and motivational factors influencing the nature of the text (task)-reader (learner) interaction. Second, some kind of relationship might exist between them, in the sense of students' learning approaches operating as a perceptual-cognitive framework related to the purposes and strategies adopted by learners when reading.

Previous research on this relationship has been limited and, in addition, weakened by three elements: (a) much research on students' learning approaches has focused more on study processes and

levels of learning than on reading comprehension itself, two interrelated but not identical constructs (see Marton & Säljö, 1997); (b) some authors, e. g., Kirby, Silvestri, Allingham, Parrila, and La Fave (2008), found that reading comprehension, measured through a standardised test, correlated negatively with surface approach and positively with deep approach. However, these correlations were both small in size and non-significant, which might be due to the small sample used; and (c) other researchers (e. g., Oded & Walters, 2001; Zhang, 2001) not only tended to use a small number of participants, but assessed reading learning strategies rather than learning approaches and labelled them as deep or surface (e. g., Rao, Gu, Zhan, & Hu, 2007) even though they did not include learning motivations.

Prior knowledge and questioning

Relevant prior knowledge plays a crucial role in text comprehension, particularly with scientific texts, which often have conceptual gaps (e. g., Goldman & Bisanz, 2002). An in-depth understanding requires readers to activate this knowledge to generate accurate inferences and to integrate and assimilate new information from text (e. g., McNamara & Kintsch, 1996).

Research has provided evidence that (a) the more relevant

knowledge readers have, the more successful is their comprehension and learning from text (see Fox, 2009, for a review) and (b) prior knowledge is the strongest predictor of reading comprehension (e. g., Tarchi, 2010), “even after controlling for strategy use, inference, vocabulary and word reading” (Cromley, Snyder-Hogan, & Luciw-Dubas, 2010, p. 694).

However, the empirical evidence linking prior knowledge and students’ learning approaches seems thin, despite being included in Biggs’s (1993) 3P model, and far from conclusive (e. g., Hazel, Prosser, & Trigwell, 2002). Nevertheless, since academic success is generally expected to be related to students’ learning approaches, positively to deep approach and negatively to surface approach (Watkins, 2001), differences in students’ learning approaches should lead to better or worse prior knowledge (and questioning), respectively.

Questioning is referred to as a comprehension-fostering cognitive strategy (Rosenshine, Meister, & Chapman, 1996), which plays a fundamental role in meaningful learning (Chin & Osborne, 2008; Núñez et al., 2011a). According to the PREG model of question asking (Otero & Graesser, 2001; Sanjosé, Ishiwa, & Otero, 2009; Sanjosé, Torres, & Soto, 2013), question generation depends directly on the discrepancy (inconsistency or incompatibility) between the text input and the

reader's prior knowledge (e. g., a contradiction) and indirectly on the reader's goals.

Students' questions have been categorised in different ways (see Chin & Osborne, 2008, for a review). However, the majority of studies have proposed binary levels of question type such as basic and wonderment (Scardamalia & Bereiter, 1992): The former appear to seek basic orientation information, whereas the latter reflect a desire to extend knowledge.

Miyake and Norman (1979) were the first to examine the relationship between prior knowledge and question-asking, but they operationalised the latter mainly in quantitative terms (i. e., number of questions asked). Although this relationship might be explained by different factors (e. g., activation of prior knowledge), Taboada and Guthrie (2006) confirmed their conceptual level hypothesis. In their investigation, third and fourth-grade students browsed a multiple text pack (on two specific biomes within the field of ecology, e. g., Ocean and Forest) for two minutes, generated questions about the topic and carried out a text comprehension task. They found that questioning levels (four types or levels, which were transformed into a continuous measure of questioning quality) were clearly aligned with reading comprehension (six levels) even after controlling for the effect of prior knowledge (e. g., for Grade

4, questioning accounted for 2% of the variance over and above prior knowledge, which explained 16%). In a later study, Taboada (2012) found a similar result after taking into account language proficiency, general and science vocabulary.

Although students' learning approaches might be linked to prior knowledge and reading comprehension, and these last two to questioning, to the best of our knowledge, little research has studied students' learning approaches and question generation jointly. In initial studies on students' learning approaches, there are some references to questioning, but leaving it in the background. For example, Marton & Säljö (1997, p. 49) state, "one of the problems with a surface approach is the lack of such an active and reflective attitude toward the text... (whereas) a significant component of a deep approach is that the reader/ learner engages in a more active dialogue with the text. It is as if the learner is constantly asking himself questions of the kind "How do the various parts of the text relate to each other?" Chin and Osborne (2008) mentioned reading comprehension and students' learning approaches in their review of literature, but separately, relating the former to the effects of teaching questioning skills and the latter to question generation, and quoted the work of Chin, Brown and Bruce (2002). These authors found that "wonderment questions were as-

sociated with a deep approach to learning science while basic information questions were related to a more surface approach” (p. 541). This study, however, has two limitations. It focused on only six target students, who represented extreme learning approaches, rather than the usual larger samples, and prior knowledge was not taken into account.

The present study

The present research aimed to propose a path model explaining the interplay between students’ learning approaches at course level and reading comprehension of a science text and the role played by questioning and prior knowledge (see Figure 1).

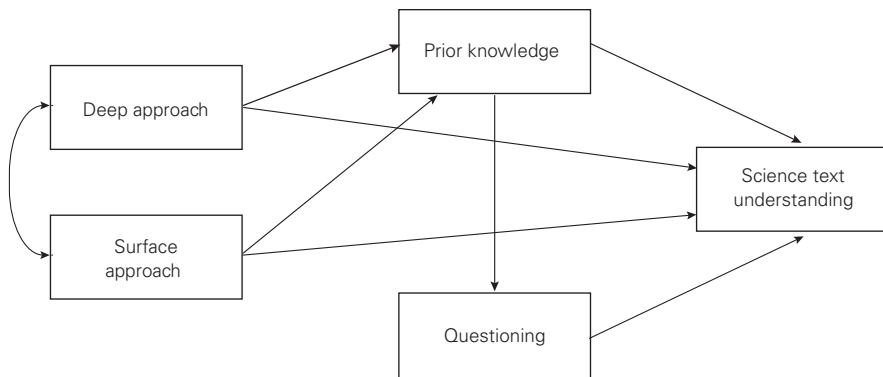


Figure 1. The proposed path model of the influences of approaches to learning on prior knowledge, questioning and science text understanding.

Overall, taking together Biggs’s (1993) and Kintsch’s (1998) theoretical models, we expected that students’ learning approaches would predict their reading comprehension in as far as their different purposes and strategies are associated with different kinds of text representation: surface learners settle for a shallow representation at the text base level, whereas

deep learners insist on constructing a rich situation model. Regarding prior knowledge and questioning, it is expected (a) that the former would depend on students’ learning approaches and make the largest contribution to reading comprehension (e. g., Cromley et al., 2010; Kintsch, 1998; Watkins, 2001); (b) that questioning would depend directly on prior knowledge (e. g.,

Otero & Graesser, 2001; Sanjosé et al., 2013; Taboada & Guthrie, 2006) and indirectly on students' learning approaches, in as far as the latter would operate as a perceptual-cognitive framework related to the different readers' goals, which are indirectly related to questioning (Sanjosé et al., 2009); and (c) that according to conceptual level hypothesis (Taboada & Guthrie, 2006) and constructionist perspective (e. g., Kintsch, 1998), the higher the questioning quality, the richer the situational representation and consequently the better the reading comprehension. In summary, it is hypothesised that students' learning approaches are related to science text comprehension and that this link is partially mediated by prior knowledge and questioning.

Method

Participants

These were ninth-grade students ($n = 449$) enrolled in science classes, from eleven schools in an urban district, who participated with parental permission. Girls accounted for 42% of the sample and boys for 58%, and their average age was 14.43 ($SD = .68$).

Measures

The Revised two-factor version of the Learning Process Question-

naire (R-LPQ-2F, Kember, Biggs, & Leung, 2004) was slightly modified to specifically assess learning approaches within a science class, included 22 items and the answers were grouped into four subscales: *surface motive*, *surface strategy*, *deep motive*, and *deep strategy*, corresponding to the two learning approach dimensions, *deep* and *surface*, proposed by its authors. Items were answered on a Likert-type scale ranging, from 1 (never or rarely true of me) to 5 (always or almost always true of me). The Cronbach's alpha values were .82 for *deep approach*, and .57 for *surface approach*; the latter being lower than desirable but still within the acceptable range for measures developed and used for research purposes (Nunnally, 1978). Some ancillary analyses were carried out to compute the average variance extracted, composite reliability, and the omega reliability (McDonald, 1999). Their respective values were .36, .67, and .56 for *surface approach* and .48, .86, and .83 for *deep approach*.

Science comprehension passage. Participants were instructed to read an 840-word passage on meteorology and then to answer questions without referring back to the source text. The same passage was used in O'Reilly and McNamara's study (2007), and they considered it "a typical science text" (p. 162), i. e., it is a common and representative concept of a science course, which does not rely

too much on mathematical ability. Further, they ensured a wide assessment of text comprehension by creating 20 questions of different formats and categories. We used the same measure of general comprehension, i. e., the proportion of comprehension questions answered correctly.

Participants' answers to these questions were scored according to their format. A marker scored as correct or incorrect the responses to multiple-choice questions, which obtained an alpha level of $\alpha = .71$ using the Spearman-Brown formula adjusted for 30 items. Two independent markers scored the responses to open-ended questions for 25% of the participants, using scoring keys created by the authors mentioned. After corroborating a strong inter-marker agreement (weighted kappa = .84), the second marker scored the remaining participants' responses (Cronbach's alpha = .77).

Prior knowledge was represented by students' depth of prior knowledge about the content of the passage (topic) and the concepts discussed in it and was assessed with 15 multiple choice questions to which answers were not provided in the text. Reliability for the answers to these questions was $\alpha = .69$ using the Spearman-Brown formula adjusted for 30 items.

Questioning was defined as in Taboada's studies (Taboada & Guthrie, 2006; Taboada, 2012),

i. e., it refers to students' question generation about the content of the text before reading to facilitate its understanding. "*Please browse the text for two minutes, look at text features (e. g., heading, section titles, illustrations) and write any questions you have. They could be focused on clarifying basic information about the topic or on things you wonder about or need to know to advance your understanding of the topic (questions that would challenge experts in the field)*".

Procedure

These four measures were administered to all participants during class time, in the following order and timescale: students' learning approaches questionnaire (15 minutes), question generation, science passage, and question answering (35 minutes), and prior knowledge test (10 minutes). This last was given after both questioning and reading the passage, so as to not to prime any related concepts (O'Reilly & McNamara, 2007).

Student's questions were categorised into two broad types: basic information questions and wonderment questions (Chin & Brown, 2000; Scardamalia & Bereiter, 1992) and a measure of questioning quality was obtained by using an adaptation of the procedure described by Taboada and Guthrie (2006). Two independent markers classified the types of question generated by 25% of the partici-

pants, and reached 95% agreement. The second marker classified the remaining participants' questions.

Results

Preliminary analyses and descriptive statistics

Table 1 presents the matrix of correlations among all the individ-

ual differences measures collected in this study and their descriptive statistics: means, standard deviations, observed range, skewness and kurtosis.

An examination of these statistics indicated that (a) all scores were normally distributed with skewness and kurtosis values within acceptable ranges, and, thus, considered appropriate for use in parametric statistical analyses, and

Table 1

Descriptive Statistics and Zero-order Correlations among the Study Variables

	1	2	3	4	5	M	SD	R	S	K
1. Deep approach	—	-.257**	.224**	.126**	.204**	29.63	7.64	55/11	.20	-.03
2. Surface approach		—	-.157**	-.119*	-.210**	35.16	5.58	50/16	-.20	.14
3. Prior knowledge			—	.198**	.470**	0.50	0.18	1/0	.01	-.17
4. Questioning				—	.216**	1.30	0.37	3/0	.13	.73
5. Text comprehension					—	0.30	0.15	.98/.03	.83	.64

Note. M = means; SD = Standard deviations; R = Observed range; S = Skewness; K = Kurtosis

(b) the associations between the variables were all statistically significant and their magnitude was small to moderate.

Path analysis of the association between students' learning approaches and science text comprehension

Path analysis, a type of structural equation models (SEM), was used to test a recursive model of the association between two exogenous variables: deep and surface

students' learning approaches, and three endogenous variables: science text understanding, prior knowledge and questioning, the latter two considered as mediators (see Figure 1 in the Introduction). This analysis is an observational rather than a manipulative or experimental technique for modelling a theoretically hypothesised relationship among observed variables (Keitz, 1988), and is used not so much to search for causation among these variables, but to analyse the strength of the relationships among them.

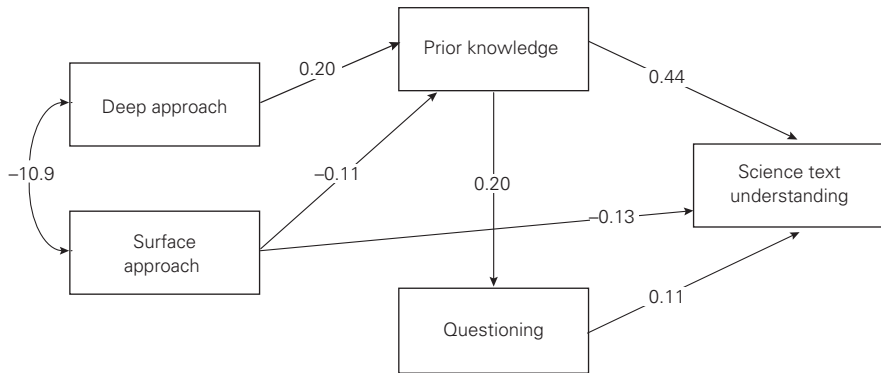


Figure 2. The final model showing the standardised parameter estimates of the association between learning approaches, prior knowledge, questioning and science text understanding.

The indices of overall fit of the partially mediated hypothesised model, obtained by using the LISREL 8.20 program (Jöreskog & Sörbom, 1998), suggested that the initial model would serve the data reasonably well, but that the direct path between deep approach and text comprehension (see Figure 1 in the Introduction) did not reach statistical significance at the .05 level ($t = 1.70$). This model was therefore refined, eliminating this path, and resulted in an acceptable fit: Chi-square (χ^2) = 8.05, $p < .05$; Goodness of Fit Index (GFI) = .99; Adjusted Goodness of Fit Index (AGFI) = .96; Standardised Root Mean Square Residual (RMR) = .08; Root Mean Square Error of Approximation (RMSEA) = .06; Non-Normed Fit Index (NNFI) = .92. The standardised parameter estimates for the model, all significant at the

0.05 level, are displayed in Figure 2.

An examination of the different contributions (direct, indirect and total) to endogenous variables (Table 2), revealed that surface approach had significant both direct (-0.13) and indirect (-0.05) contributions (via questioning) to text comprehension. Deep approach, however, contributed to it only indirectly (.09) (via prior knowledge). Although deep and surface approaches showed indirect contributions to questioning (.04 and -.02, respectively) and the latter and prior knowledge influenced text comprehension, prior knowledge made by far the largest contribution: .46 (i. e., .44 of direct, plus .02 of indirect). This model explained 26% of the variance in reading comprehension, 6% of the variance in Prior knowledge and 4% of the variance in Questioning.

Table 2

Decomposition of the Standardised Contributions of Exogenous Variables on Endogenous Variables (X → Y) and of Endogenous Variables on Endogenous Variables (Y → Y), from Path Analysis

Endogenous variables(Y)	X	X	Y	Y
	Deep approach	Surface approach	Prior knowledge	Questioning
Direct				
Prior knowledge	.20	-.11		
Questioning			.20	
Text comprehension		-.13	.44	.11
Indirect				
Prior knowledge				
Questioning	.04	-.02		
Text comprehension	.09	-.05	.02	
Total				
Prior knowledge	.20	-.11		
Questioning	.04	-.02	.20	
Text comprehension	.09	-.18	.46	.11

Since other rival models could fit the same data, two alternative models, one mediated and the other non-mediated, were tested. However, they showed a worse fit to the data: $\chi^2 = 126.14$, $p > .05$; GFI = .90; AGFI = .75; RMR = .11; RMSEA = .08; NNFI = -.09, for the mediated model; and $\chi^2 = 17.01$, $df = 3$, $p < .05$; GFI = .99; AGFI = .94; RMR = .08; RMSEA = .21; NNFI = .84, for the non-mediated model.

Discussion

The present study investigated the pathways between students' learning approaches at science course level and reading comprehension of a typical science text as well as the role played by student-generated questions in relation to the text and relevant prior knowledge.

The first contribution of this research is to show that self-report measures of students' learning

approaches, referring to the general context of a science course and obtained through a questionnaire, account for their understanding of a typical science text, assessed according to current models of reading comprehension, such as Kintsch's (1998) construction-integration model. Although this result is partly in line with previous researchers' findings (e. g., Marton & Säljö, 1997; Rao et al., 2007), it goes further because we used appropriate measures of students' learning approaches at course level and updated measures of reading comprehension and, in addition, it stems from a larger sample, which would probably explain why Kirby et al.'s (2008) results were not statistically significant.

The second contribution of this investigation is the proposal and testing of a path model that explains the relationship between students' learning approaches and reading comprehension of a science text, in concert with prior knowledge and questioning. This model accounts for a consistent 26 per cent of the variance in reading comprehension and reveals that prior knowledge and questioning partially mediate the links between students' learning approaches and reading comprehension. This is in agreement with the general hypothesis proposed. Students' learning approaches contribute significantly to prior knowledge (deep approach positively and surface approach negatively) (e. g., Wat-

kins, 2001) and via the latter to questioning quality (e. g., Otero & Graesser, 2001; San José et al., 2009; Taboada & Guthrie, 2006). In their turn, prior knowledge and questioning are positively related to science text understanding (e. g., Kintsch, 1998; Taboada, 2012; Taboada & Guthrie, 2006). Thus, the deeper the students' learning approaches, the greater their prior knowledge, the quality of the questions they generate and their text understanding.

Contrary to expectations, the path between deep approach and text understanding was not statistically significant. This may be explained in part because deep approach is significantly correlated with prior knowledge, the major determinant of reading comprehension (Cromley et al., 2010; Kintsch, 1998), which might lead to underestimating its importance. Moreover, the fact that the source text was not available during question answering may have increased the contribution of prior knowledge, as suggested by Ozuru et al. (2009). The problem of the importance of some of these variables, including that of deep approach, mentioned above, being underestimated would be examined by partitioning explained variance into unique and common contributions, e. g., by means of commonality analysis (see the list of statistical software compiled in 2012 by Kraha, Turner, Nimón, Zientek, & Henson).

Our findings on the link between students' learning approaches and question quality lend support to our assumption that the former would function as a perceptual-cognitive framework related to the different readers' goals, which are indirectly related to questioning (e. g., San José et al., 2009). Thus, if learners usually try to maximise understanding and the use of strategies for creating meaning (deep approach), they will insist on activating prior knowledge and constructing a rich situation model, which may lead them indirectly to generate high quality questions (e. g., those involving inferences). These findings seem to be in contrast to those of Chin et al. (2002), which reported a direct relationship between students' learning approaches and the questions they generated. This divergence may be explained by the fact that they chose only six target students, who represented extreme learning approaches, and not the considerable number of participants we used. This might have led to a strong tendency of regression towards the mean in our students' scores.

The present study has several potential limitations. First, the design was correlational and variable-centred, which means that results must be interpreted in terms of associations (correlations or predictions) rather than causal relations and that no attention was given to the subtle effects of various levels of variable combinations (e. g.,

learning approaches) within subjects. Second, the reliability of responses to surface approach items was below the level required for academic decisions about an individual student, although in line with those reported in the literature (Rosário et al., 2005; Watkins, 2001) and acceptable for research purposes (Nunnally, 1978). Third, students' learning approaches were measured using self-report instruments rather than observational methods or structured interviews.

Future studies would categorise individuals into groups whose members have similar patterns of learning approaches and would use a combination of variable-centred and person-centred analyses of the variables, as recommended by some authors (e. g., Bergman, 2001). Amongst these variables it would be worth including some others such as achievement goals and readers' beliefs, as suggested by Fox (2009), and self-concept and causal attributions, as suggested by Núñez et al. (2011b), given their links with the investment of effort and strategy use, and extending the analyses to other subjects.

The results of the study may, in spite of the limitations mentioned, have some interesting implications. From a theoretical point of view, our findings enrich the research on text comprehension (e. g., O'Reilly & McNamara, 2007; Ozuru et al., 2009) by providing evidence on two key points.

First, it is not only students' prior topic-related knowledge and the questions they generate that seem to contribute to their reading comprehension for science texts, but also additional variables such as how they approach their learning in science. These approaches merge motivational and cognitive elements that seem to be close to readers' goals. Second, students' prior knowledge and questioning quality seem to partially mediate the relationship between students' learning approaches and science text comprehension. Therefore, although the constructs of students' learning approaches and reading comprehension come from different theoretical and research perspectives, they appear to be intertwined and together provide a more complete picture of students' comprehension of science texts.

From a practical point of view, our results raise two important points. First, they contribute to our understanding of how students set about learning on their science courses and suggest that promoting the quality of students' generated questions might lead to an improvement in their understanding of a typical science text. This might provide some relevant information for a wide assessment of both their reading comprehension in general and their difficulties in comprehending science texts in particular, and also suggest

a more holistic approach to teaching reading comprehension. Second, it seems important for teachers to adopt a broad and integrated view of reading comprehension and to be aware that understanding of a typical science text depends on a number of student-related factors, such as their prior knowledge, learning approaches and questioning, in which teachers could play a role. Obviously, the correlational design used and the analyses carried out permit only a partial verification of the model proposed and do not prove causation. However, the model does highlight some links between variables, links that have been confirmed in other studies. Thus, teachers could help students improve their reading comprehension by activating their prior relevant knowledge (e.g., Brown, Van Meter, Pressley, & Schuder, 1996; Spires & Donley, 1998) and training them in the generation of questions (e. g., Rosenshine et al., 1996). Moreover, although text-related factors were not manipulated in the present study, teachers should take into account the links between these factors and reading comprehension. There is abundant evidence that the latter may also be improved by choosing texts that foster the reader's active processing and inferential activity (Gilbert, Martínez, & Vidal-Abarca, 2005) and are student-accessible (McTigue & Slough, 2010).

References

- Bergman, L. R. (2001). A person approach to adolescence: Some methodological challenges. *Journal of Adolescent Research, 16*, 28-53. <http://dx.doi.org/10.1177/0743558401161004>
- Biggs, J. B. (1993). What do inventories of students' learning-process really measure? A theoretical review and clarification. *British Journal of Educational Psychology, 63*, 3-19.
- Biggs, J. B. (2001). Enhancing learning: A matter of style or approach? In R. J. Sternberg & L. F. Zhang (Eds.), *Perspectives on thinking, learning, and cognitive styles* (pp. 73-102). Mahwah, NJ: Erlbaum.
- Brown, R., Van Meter, P., Pressley, M., & Schuder, T. (1996). A quasi-experimental validation of transactional strategies instruction with low-achieving second-grade readers. *Journal of Educational Psychology, 1*, 18-37. <http://dx.doi.org/10.1037/0022-0663.88.1.18>
- Chin, C., & Brown, D. E. (2000). Learning in science: Comparison of deep and surface approaches. *Journal of Research in Science Teaching, 37*, 109-138. [http://dx.doi.org/10.1002/\(SICI\)1098-2736\(200002\)37:2<109::AID-TEA3>3.3.CO;2-Z](http://dx.doi.org/10.1002/(SICI)1098-2736(200002)37:2<109::AID-TEA3>3.3.CO;2-Z)
- Chin, C., Brown, D. E., & Bruce, B. C. (2002). Student-generated questions: A meaningful aspect of learning in science. *International Journal of Science Education, 24*, 521-549. <http://dx.doi.org/10.1080/09500690110095249>
- Chin, C., & Osborne, J. (2008). Students' questions: A potential resource for teaching and learning science. *Studies in Science Education, 44*, 1-39. <http://dx.doi.org/10.1080/03057260701828101>
- Cromley, J. G., Snyder-Hogan, L. E., & Luciw-Dubas, U. A. (2010). Reading comprehension of scientific text: A domain-specific test of the direct and inferential mediation model of reading comprehension. *Journal of Educational Psychology, 102*, 687-700.
- De la Fuente, J., Sander, P., & Putwain, D. (2013). Relationship between undergraduate student confidence, approach to learning and academic performance: The role of gender. *Revista de Psicodidáctica, 18*, 375-393. doi: 10.1387/Rev Psicodidact.7078
- De la Fuente, J., Zapata, L., Martínez-Vicente, J. M., Cardelle-Elawar, M., Sander, P., Justicia, F.,... García-Berbén, A. B. (2012). Regulatory teaching and self-regulated learning in college students: confirmatory validation study of the IATLP scales. *Electronic Journal of Research in Educational Psychology, 10*, 839-866.
- Elstad, E., Christophersen, K. A., & Turmo, A. (2012). The influence of parents and teachers on the deep learning approach of pupils in Norwegian upper-secondary schools. *Electronic Journal of Research in Educational Psychology, 10*, 35-56.
- Escribano, C. L., Elosúa, M. R., Gómez-Veiga, I., & García-Madruga, J. A. (2013). A predictive study of reading comprehension in third-grade Spanish students. *Psicothema, 25*(2), 199-205. doi: 10.7334/psicothema2012.175

- Fox, R. (2009). The role of reader characteristics in processing and learning from informational text. *Review of Educational Research*, *79*, 197-261. <http://dx.doi.org/10.3102/0034654308324654>
- Gilabert, R., Martínez, G., & Vidal-Abarca, E. (2005). Some good texts are always better: Text revision to foster inferences of readers with high and low prior background knowledge. *Learning & Instruction*, *15*, 45-68. <http://dx.doi.org/10.1016/j.learninstruc.2004.12.003>
- Goldman, S. R., & Bisanz, G. (2002). Toward a functional analysis of scientific genres: Implications for understanding and learning processes. In J. Otero, J. León & A. Graesser (Eds.), *The psychology of science text comprehension* (pp. 19-50). Mahwah, NJ: Erlbaum.
- Hazel, E., Prosser, M., & Trigwell, K. (2002). Variation in learning orchestrations in University biology courses. *International Journal of Science Education*, *24*, 737-751. <http://dx.doi.org/10.1080/09500690110098886>
- Joreskog, K., & Sorbom, D. (1997). *LISREL 8.20 for Windows*. Chicago, IL: Scientific Software International Inc.
- Keitz, T. (1988). Path analysis: An introduction for school psychologists. *School Psychology Review*, *17*, 343-362.
- Kember, D., Biggs, J., & Leung, D. Y. P. (2004). Examining the multidimensionality of approaches to learning through the development of a revised version of the Learning Process Questionnaire. *British Journal of Educational Psychology*, *74*, 261-280. <http://dx.doi.org/10.1348/000709904773839879>
- Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. Cambridge, England: University Press.
- Kirby, J. R., Silvestri, R., Allingham, B. H., Parrila, R., & La Fave, Ch. B. (2008). Learning strategies and study approaches of postsecondary students with dyslexia. *Journal of Learning Disabilities*, *41*, 85-96. <http://dx.doi.org/10.1177/0022219407311040>
- Kraha, A., Turner, H., Nimon, K., Zientek, L. R., & Henson, R. K. (2012). Tools to support interpreting multiple regression in the face of multicollinearity. *Frontier in Psychology*, *3*, 1-16. <http://dx.doi.org/10.3389/fpsyg.2012.00044>
- Martínez, M. A. E., & Barrenetxea, I. G. (2002). Dificultades de comprensión lectora en estudiantes universitarios. Implicaciones en el diseño de programas de intervención. *Revista de Psicodidáctica*, *10*, 59-74.
- Marion, F., & Säljö, R. (1997). Approaches to learning. In F. Marion, D. Hounsell & N.J. Entwistle (Eds.), *The Experience of Learning. implications for Teaching and Studying in Higher Education* (pp. 39-58). Edinburgh: Scottish Academic Press.
- McDonald, R. P. (1999). *Test theory: A unified treatment*. Mahwah, NJ: Lawrence Erlbaum.
- McNamara, D. S., & Kintsch, W. (1996). Learning from texts: Effects of prior knowledge and text coherence. *Discourse Processes*, *22*, 247-288. <http://dx.doi.org/10.1080/01638539609544975>
- McNamara, D., Kintsch, E., Songer, N., & Kintsch, W. (1996). Are good texts always better? Interactions of text coherence, background knowledge, and levels of understanding

- in learning from text. *Cognition and Instruction*, 14, 1-43. http://dx.doi.org/10.1207/s1532690xci1401_1
- McTigue, E. M., & Slough, S. W. (2010). Student-accessible science texts: elements of design. *Reading Psychology*, 31, 213-227. <http://dx.doi.org/10.1080/02702710903256312>
- Miyake, N., & Norman, D. A. (1979). To ask a question, one must know enough to know what is not known. *Journal of Verbal Learning and Verbal Behaviour*, 18, 357-364. [http://dx.doi.org/10.1016/S0022-5371\(79\)90200-7](http://dx.doi.org/10.1016/S0022-5371(79)90200-7)
- Núñez, J. C., Cerezo, R., Bernardo, A., Rosário, P., Valle, A., Fernández, E., & Suárez, N. (2011a). Implementation of training programs in self-regulated learning strategies in Moodle format: Results of an experience in higher education. *Psicothema*, 23, 274-281.
- Núñez, J. C., González-Pienda, J. A., Rodríguez, C., Valle, A., Gonzalez-Cabanach, R., & Rosário, P. (2011b). Multiple goals perspective in adolescent students with learning difficulties. *Learning Disability Quarterly*, 34, 273-286.
- Núñez, J. C., Paiva, O., Polydoro, S., Rosário, P., & Valle, A. (2013). Approaches to teaching in high school when considering contextual variables and teacher variables. *Revista de Psicodidáctica*, 18, 25-46. doi:10.1387/RevPsicodidact.6215
- Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.
- Oded, B., & Walters, J. (2001). Deeper processing for better EFL reading comprehension. *System*, 29, 357-370.
- O'Reilly, T., & McNamara, D. S. (2007). The impact of science knowledge, reading skill, and reading strategy knowledge on more traditional "high-stakes" measures of high school students' science achievement. *American Educational Research Journal*, 44, 161-196. <http://dx.doi.org/10.3102/0002831206298171>
- Otero, J., & Graesser, A. C. (2001). PREG: Elements of a model of question asking. *Cognition and Instruction*, 19, 143-175. http://dx.doi.org/10.1207/S1532690XCI1902_01
- Ozuru, Y., Dempsey, K., & McNamara, D. S. (2009). Prior knowledge, reading skill, and text cohesion in the comprehension. *Learning and Instruction*, 19, 228-242. <http://dx.doi.org/10.1016/j.learninstruc.2008.04.003>
- Pearson, P. D., & Hamm, D. N. (2005). The assessment of reading comprehension: A review of practices—Past, present, and future. In S. G. Paris & S. A. Stahl (Eds.), *Children's reading comprehension and assessment* (pp. 13-69). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Rao, Z., Gu, P., Zhang, L., & Hu, G. (2007). Reading strategies and approaches to learning of bilingual primary school pupils. *Language Awareness*, 16, 243-262. <http://dx.doi.org/10.2167/la423.0>
- Retelsdorf, J., Köller, O., & Möller, J. (2011). On the effects of motivation on reading performance growth in secondary school. *Learning and Instruction*, 21, 550-559. <http://dx.doi.org/10.1016/j.learninstruc.2010.11.001>
- Rosário, P., Núñez, J. C., González-Pienda, J., Almeida, L., Soares, S., & Rubio, M. (2005). El aprendizaje escolar examinado desde la pers-

- pective del "Modelo 3P" de J. Biggs. *Psicothema*, 17(1), 20-30.
- Rosenshine, B., Meister, C., & Chapman, S. (1996). Teaching students to generate questions: A review of the intervention studies. *Review of Educational Research*, 66, 181-221. <http://dx.doi.org/10.3102/00346543066002181>
- Sanjosé, V., Fernandez, J. J., & Vidal-Abarca, E. (2010). Importance of information processing skills on the comprehension of scientific texts. *Infancia y Aprendizaje*, 33, 529-541. <http://dx.doi.org/10.1174/021037010793139581>
- Sanjosé, V., Ishiwa, K., & Otero, J. (2009). Influence of reading goals on question generation. In *AIED: 14th International Conference on Artificial Intelligence in Education Workshops Proceedings*, pp. 53-57.
- Sanjosé, V., Torres, T., & Soto, C. (2013). Effects of scientific information format on the comprehension self-monitoring processes: question generation. *Revista de Psicodidáctica*, 18, 293-311. <http://dx.doi.org/10.1387/RevPsicodidact.4623>
- Scardamalia, M., & Bereiter, C. (1992). Text-based and knowledge-based questioning by children. *Cognition and Instruction*, 9, 177-199. http://dx.doi.org/10.1207/s1532690xci0903_1
- Spires, H. A., & Donley, J. (1998). Prior knowledge activation: Inducing engagement with informational texts. *Journal of Educational Psychology*, 90, 249-260. <http://dx.doi.org/10.1037/0022-0663.90.2.249>
- Taboada, A. (2012). Relationships of general vocabulary, science vocabulary, and student questioning with science comprehension. *Instructional Science*, 40, 901-923. <http://dx.doi.org/10.1007/s11251-011-9196-z>
- Taboada, A., & Guthrie, J. T. R. (2006). Contributions of student questioning and prior knowledge to construction of knowledge from reading information text. *Journal of Literacy Research*, 38, 1-35. http://dx.doi.org/10.1207/s15548430jlr3801_1
- Tarchi, C. (2010). Reading comprehension of informative texts in secondary school: A focus on direct and indirect effects of reader's prior knowledge. *Learning and Individual Differences*, 20, 415-420. <http://dx.doi.org/10.1016/j.lindif.2010.04.002>
- Watkins, D. (2001). Correlates of approaches to learning: A cross-cultural meta-analysis. In R. J. Sternberg & L. F. Zhang (Eds.), *Perspectives on thinking, learning, and cognitive styles* (pp. 165-195). Mahwah, NJ: Erlbaum.
- Zhang, L. J. (2001). Awareness in reading: EFL students' metacognitive knowledge of reading strategies in an input-poor environment. *Language Awareness* 10, 268-288.

Francisco Cano. Associate Professor of Educational Psychology at the University of Granada. His main lines of research are: (a) learning strategies and approaches, and (b) self-regulation and learning patterns. He has participated in national research projects (MC&T, MEC) and international projects (Learning patterns in transition, Institute for Education and Information Sciences Antwerp).

Ángela García. Doctoral student at the University of Granada. Her main line of research is learning approaches, self-regulation and reading comprehension.

Fernando Justicia. Professor of Educational Psychology at the University of Granada. His main lines of research are: (a) learning strategies and self-regulation; (b) prevention of antisocial behaviour in children and development of intervention programmes. He has participated in national research projects (MC&T, MEC) and international projects (Learning patterns in transition, Institute for Education and Information Sciences Antwerp).

Ana Belén García-Berbén is Associate Professor of Developmental and Educational Psychology at the University of Granada (Spain). Her main lines of research are: (a) learning approaches and self-regulation; (b) the teaching-learning process in Higher Education. She has participated in national research projects (MC&T, MEC) and international projects (Learning patterns in transition, Institute for Education and Information Sciences Antwerp). She has published both in Spain (*Psicothema*, *Infancia&Aprendizaje*) and abroad (*European Journal of Psychology of Education*, *British Journal of Educational Psychology*)

Received date: 04-10-2013

Review date: 16-12-2013

Accepted date: 20-01-2014

