



THE PRE-LEARNING STRATEGY IN SCIENCE USING A TEXTBOOK: A CASE OF CROATIA

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Abstract

Pre-learning resources are any activities a student might do in preparation for the lecture. This should include, as a minimum, reading of a corresponding material in the textbook. Based on the experience, this is difficult to encourage, and at the same time, researches have shown that students experience difficulties while learning from textbooks. A pilot research was carried out on a sample of nineteen teachers in order to determine the frequency of textbook usage within the pre-learning strategy for teaching chemistry and biology in primary and secondary schools. Data were collected through a questionnaire, and processed with descriptive and inferential statistics. The results indicate that textbooks with written materials, as well as online resources are quite rarely used within the frame of the pre-learning strategy, and there is no difference in textbook usage regarding the education level.

Keywords: *cognitive load, pre-learning activities, using a textbook, working memory capacity.*

Introduction

There are topics in teaching chemistry and biology that the students have the most difficulties in learning. The main reasons for learning difficulties in biology are the nature of the topic, teaching style, students' learning and studying habits, students' negative feelings and attitudes towards the topic, and a lack of resources (Çimer, 2012). The nature of the science makes chemistry inaccessible, but the difficulties are also enticed with methods by which we have traditionally taught, as well as methods by which students learn (Johnstone, 1984). The results of numerous researches over the last several decades have shown five main areas of difficulties in teaching chemistry and other natural science subjects: (a) the curriculum content, (b) working memory, (c) language and communication, (d) concept creation and (e) motivation (Taber, 2002). A. H. Johnstone (1989) was probably the first to recognize the working memory capacity as a key factor in learning difficulties.

According to the Cognitive Load Theory (CLT), information processing and knowledge building are limited with the working memory capacity, and instructional design can be used to reduce cognitive load (Sweller, 1988; Van Merriënboer & Sweller, 2005). Not only does the working memory have to store the received information, but at the same time, it also has to have enough space for its processing. In the given time, only a small amount of information will be processed or stored in the working memory, whereas excessive requirements result in overload which can stymie efficient information retention. The overloaded capacity does not leave space for thinking and organization, which results in cognitive overload, whereby mislearning, or no learning at all takes place (Alam, Zaman & Khan, 2014; Johnstone, 1989). Increasing the level of pre-knowledge by using pre-learning resources within the frame of the pre-learning strategy leads to efficient connecting of new information with the existing knowledge, as well as reducing working memory overload.

The concept of the pre-learning strategy is based particularly on ideas developed by D. P. Ausubel (1968) (preparing the mind for learning) and J. Sweller (1988) (CLT). The use of a pre-learning strategy has shown to be an efficient way of preparing students' minds, especially of those students whose fundamental knowledge and experience are insufficient, because it helps them focus their attention on new relevant information and connect it with their pre-knowledge (Sirhan, Gray, Johnstone & Reid, 1999). Pre-learning resources are any activities a student might do in preparation for the lecture. This could take a form of reading a textbook extract or Word document, listening to a podcast, performing an online activity, or completing a quiz. The key aspect is that pre-learning resources are integrated into the module design and into the lecture itself, so that it has an attributed sense of value by the student and teacher (Seery, 2010). Pre-learning activities can facilitate learning in three ways. Firstly, students learn basic terms before the lecture which can help them recognize misconceptions and activate pre-knowledge. Next, teachers can include pre-learning questions into the lecture itself and provide answers through discussions. And finally, it is more probable that students will participate more actively if they are familiar with the subject matter and feel secure in their knowledge. Therefore, pre-learning activities provide a basis for interactive learning without influencing the amount of the subject matter which can be processed during a lecture (Dindia, 2013).

The preparation of students for the lecture should include, as a minimum, reading of a corresponding material in the textbook. Based on the experience, this is difficult to encourage, and at the same time, researches have shown that students experience difficulties while learning from textbooks (Collard, Girardot & Deutsch, 2002). Significant researches indicate the advantages of learning through reading before the lecture, and using productive reading strategies which have specific and clear goals outlined (Seery, 2012). F. Kristine (1985) reports on the inclusion of using instructional activities during a chemistry lecture course. Students were asked to read a section of a textbook prior to the lecture and were asked questions at the start of the lecture. Students like such pre-learning assignments, and feel they encourage an in-class discussion. Collard et al. (2002) argue that engagement with the textbook and online assignment in teaching chemistry results in more active learning. In their research, the students received a task to read a section of the textbook and complete an online assignment prior to the lecture. The students agreed that this approach facilitated the understanding of the subject matter, and the teachers found that the nature of the lecture gradually evolved to more explanation and discussion.

T. T. Lineweaver (2010) developed a pre-learning online discussion assignment in order to encourage students to read the textbook prior to the lecture. Application of such tasks improves students' preparation for lecture and requires students to engage actively in the course material. If it doesn't improve the mastering of the subject matter significantly, online discussion at least enables students to interact with each other about lecture topics and the text outside the classroom, create their own examples, explain key terms in their own words, and apply the subject matter in everyday life. Heiner, Banet and Wieman (2014) discussed the implementation of targeted pre-reading assignments with an associated online quiz in two science classes, one physics and one biology. The results showed that students recognize positive effects of pre-readings, such as preparation for lecture, or gaining and checking their general knowledge. P. A. Connor-Green (2000) confirms that students do not often read the given text in the appropriate way, especially if the reading is not assessed formally. In order to encourage students to reading, information processing and critical reasoning about the material prior to class attendance, the teachers have to create a context in which the students will be motivated and rewarded.

In the Croatian education system, there is no relevant research which refers to the importance of using the pre-learning strategy with the goal to reduce students' cognitive overload. The aim of the pilot research is to determine the frequency of using textbooks within the frame of the pre-learning strategy for teaching chemistry and biology from three aspects – using a textbook with written materials, using a textbook with online resources (quiz, discussion), and determining possible differences for textbook usage in primary and secondary schools. This research intends to provide answers to the question: "How often do chemistry and biology teachers in primary and secondary schools use a textbook within the frame of the pre-learning strategy?" The following hypotheses are proposed:

H₁: Chemistry and biology teachers in primary and secondary schools use a textbook with written materials within the frame of the pre-learning strategy quite rarely.

H₂: Chemistry and biology teachers in primary and secondary schools use a textbook with online resources (quiz, discussion) within the frame of the pre-learning strategy quite rarely.

H₃: There is no significant difference in using a textbook with written materials for teaching chemistry and biology in primary and secondary schools.

H₄: There is no significant difference in using a textbook with online resources for teaching chemistry and biology in primary and secondary schools.

Methodology of Research

General Background

The conducted pilot research is the first stage of a more comprehensive research within a doctoral dissertation regarding the implementation of the pre-learning strategy into natural science education. This quantitative descriptive survey research allows the researcher to collect data about the frequency of using textbooks within the frame of the pre-learning strategy in the population of chemistry and biology teachers in primary and secondary schools. It is considered to be the appropriate design for this research because descriptive research provides a detailed, highly accurate picture of the specific details of a situation, social setting, or relationship. Survey research allows the use of a written questionnaire to gather information on the backgrounds, behaviours, beliefs, or attitudes of a large number of people (Neuman, 2013).

Research Participants

Participants were chemistry and biology teachers in primary and secondary schools (N=19) in one of the twenty Croatian regions. Ten primary school teachers (8 female, 80.0 % and 2 male, 20.0 %), and nine secondary school teachers (7 female, 77.8 % and 2 male, 22.2 %) participated in the research. The sample size is relatively small, but it covers the entire target population of chemistry and biology teachers in the selected region.

Instruments

A questionnaire was developed for the purpose of the entire research within a doctoral dissertation, based on the data on various pre-learning activities obtained through a literature review. The questionnaire also included questions that arose from the

researcher's personal and professional experience. It comprised 27 multiple choice claims divided into two units. The first unit contained the participants' demographic information (gender, age, study education, subject, educational level of teaching, work experience, number of students in the class), whereas the other unit comprised four parts dedicated to the research topic.

After the questionnaire was drafted, it was first proofread to check for spelling, grammar, and punctuation errors. Next, the questionnaire was sent to two academic researchers for their review, and they indicated that claims of the questionnaire were clear and easy to complete. Suggestions were made concerning the wording of the questionnaire's title, and the questionnaire was revised according to the given suggestions. Then, the questionnaire was sent to two chemistry teachers in secondary schools who thought that all ways of preparing students for the lesson were included, and that the questionnaire is easy and quick to complete.

This pilot research used the second topical part of the questionnaire with five claims which required from the participants to estimate the frequency of textbook usage within the frame of the pre-learning strategy:

1. Students reading a specific text in the textbook with key terms which will be processed with at the next lesson.
2. Students responding to given questions, with the help of the textbook, regarding key terms which will be processed with at the next lesson.
3. Students completing worksheets, with the help of the textbook, with key terms which will be processed with at the next lesson.
4. Students solving an online quiz, with the help of the textbook, with key terms which will be processed with at the next lesson.
5. Students participating in an online discussion in order to encourage textbook reading prior to the next lesson.

Procedure

The link to access the questionnaire was distributed by e-mail to chemistry and biology teachers from the entire region in spring 2017. With a note that the participation guarantees anonymity and confidentiality, the participants were asked to sincerely estimate the frequency of textbook usage as pre-learning activities in their teaching. They had to choose one of the six offered responses: 1-never, 2-sometimes, 3-usually, 4-often, 5-very often, 6-always. At the end of the questionnaire, the participants were asked to complete and write comments about the questionnaire in a form of an open-ended question, with the aim to enhance the questionnaire quality during this pilot research. The comments may involve critiquing directions and suggesting revisions to claim wording, overall questionnaire structure, criticizing directions and choices of the offered responses.

Data Analysis

Based on the set research hypotheses, the collected data were analysed with descriptive statistics (frequency distribution) and inferential statistics, for which the two-tailed non-parametric Mann-Whitney U-test of the SPSS software was chosen since it enables testing hypotheses on a small ($N_1=10$, $N_2=9$) and asymmetrically distributed sample.

Results of Research

Descriptive statistics analysis was carried out in order to check the frequency of using textbooks with written materials, as well as textbooks with online resources (quiz, discussion). The frequency of teachers' responses for data collected through the questionnaire on the entire sample was expressed in percentages (Figure 1).

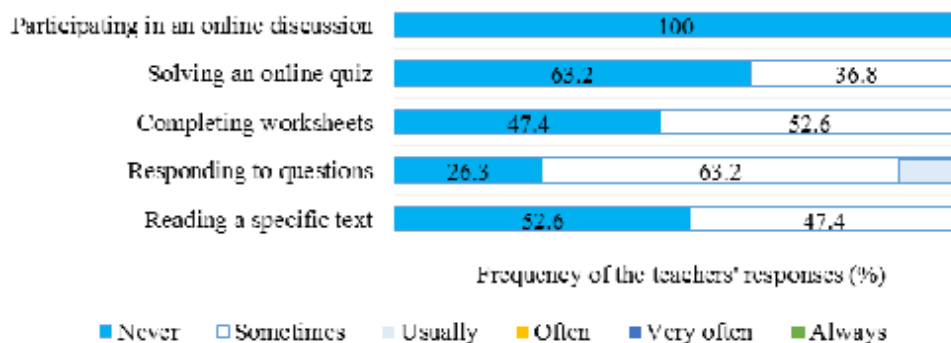


Figure 1: The percentage of teachers' responses for claims of the questionnaire "Frequency of using textbooks within the frame of pre-learning strategy" (N=19).

The results show that 52.6 % of the participants never assign a pre-reading activity to their students, whereas 47.4 % does that sometimes. Then, 63.2 % of the participants sometimes use activities of responding to given questions, 26.3 % never use them, whereas 10.5 % of the participants usually use this activity. Completing worksheets with key terms for the next lecture is the activity which 52.6 % of the participants sometimes assign to the students, whereas the rest of the participants never do that. Activities of pre-reading with an online quiz are sometimes carried out by 36.8 % of the participants, and participating in an online discussion, which requires preparation by studying textbook materials, is never used in the teaching practice. Throughout the entire questionnaire, the highest frequency response is for never, sometimes and usually, whereas other offered responses do not appear at all. Such findings indicate very poor usage of textbooks with written materials and online resources within the frame of the pre-learning strategy in teaching chemistry and biology which corresponds to the claims of the H_1 and H_2 hypotheses. Therefore, they are accepted.

For evaluation of differences in the teachers' responses regarding the level of teaching, the two-tailed non-parametric Mann-Whitney U-test was used for two independent groups: group 1 – primary school (N=10) and group 2 – secondary school (N=9). Regarding the small sample size and poor distribution, the level of significance is based on the exact distribution of a statistical test or Exact Sig. [2*(1-tailed Sig.)]. The test results clearly show there is no statistically significant difference ($U=112.0$, $N_1=10$, $N_2=9$, $p=.281$, two-tailed) in using textbooks with written materials for teaching chemistry and biology in primary and secondary schools, which corresponds to the claim of the null hypothesis. Therefore, the H_3 hypothesis is accepted at the level of significance $\alpha=.05$. Likewise, the test results show there is no statistically significant difference ($U=141.0$, $N_1=10$, $N_2=9$, $p=.932$, two-

tailed) in using textbooks with online resources for teaching chemistry and biology in primary and secondary schools, which corresponds to the claim of the null hypothesis. Therefore, the H_4 hypothesis is accepted at the level of significance $\alpha=.05$.

Chemistry and biology teachers in primary and secondary schools quite rarely use a textbook with written materials, as well as online resources (quiz, discussion) within the frame of the pre-learning strategy. The information on complete non-usage of online discussions as pre-learning resources is especially devastating, even though the research has shown that such activities enable achieving important outcomes in learning natural science subjects, e.g. creating own examples and applying the subject matter in everyday life (Lineweaver, 2010). In addition, according to the results, there is no difference in using textbooks with written materials and textbooks with online resources regarding the level of teaching chemistry and biology.

There are several limitations in what conclusions can be drawn from this research. The sample size is relatively small, so they can be methodologically questionable, and it is difficult to generalise the entire teacher population. However, by applying an appropriate statistical test, useful conclusions on the population could be extrapolated. In addition, the groups were not singled out from the target population randomly, which would obtain less mistakes in sampling and measuring. The convenient selection of the participants excluded potential issues in terms of organizing and conducting the pilot research. The choice to use a questionnaire allowed for acquiring large amounts of information relatively quickly and accurately. However, all conclusions must be considered within the context of limitations that arise from the nature of the survey research itself. There is no way to tell how truthful the participants are, they may be forgetful or not think within the full context of the situation, and respond based on their own interpretation of claims of the questionnaire.

Conclusions and Implications

According to the research results, it can be concluded that the pre-learning activities with textbooks and written materials, as well as textbooks and online resources are used at a negligible measure for teaching chemistry and biology in primary and secondary schools, and that there are no differences regarding the education level. Based on the research and the results obtained, it is possible to offer certain proposals for future research with the aim to determine the frequency of using pre-laboratory activities in teaching natural science subjects, which includes teachers on the territory of the entire country.

Some earlier research findings showed that pre-learning assignments encourage students to have an in-class discussion, and improve their understanding of the teaching material, which indicates that using a textbook as a pre-learning activity has its place in class. In order to encourage students to reading, information processing and critical reasoning about the teaching material prior to attending the lecture, it is necessary to use productive reading strategies which have specific and clear goals outlined, and the teachers must create a context in which the students will be motivated and assessed formally.

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Received 12 August 2017; Accepted 18 September 2017



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