

## The use of chemistry learning materials within the pre-learning strategy: findings from a teachers' survey

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**Abstract:** The pre-learning strategy includes activities oriented at students' preparation prior to the class. Using such activities increases the pre-knowledge level which allows linking new information with the existing knowledge more efficiently and consequently reduces working memory overload. Research results indicate frequent use of various learning materials within the frame of the pre-learning strategy. The main purpose of this research is to determine the frequency of chemistry learning materials (CLMs) use within the frame of the pre-learning strategy in Croatian secondary schools. The quantitative descriptive survey research was conducted on a sample consisting of 77 high-school chemistry teachers and 62 vocational school chemistry teachers from all regions in Croatia. Data were collected through an online questionnaire and processed with descriptive and inferential statistics. According to the obtained results, it is most common that teachers use their own materials (Word, PowerPoint) and text/image chemistry learning materials for students' preparation prior to the chemistry class. Audio-materials (podcasts), audiovisual materials (screencasts) and digital materials are represented insufficiently. The frequency of use of chemistry learning materials does not differ between high-school and vocational school chemistry teachers'.

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## INTRODUCTION

The traditional pattern requires teachers to adjust a large amount of subject matter by introducing most of it in class, thus limiting the time available for active engagement. It is clear that there would be more time for active learning in class if more knowledge-level information could be moved out of class (Moravec, Williams and Aguilar-Roca, 2010). By providing students with some information prior to the class, the amount of new information presented during class time is reduced (Seery, 2012a). There is evidence that various pre-learning activities that introduce new material can increase student performance compared with traditional lectures (Seery, 2010).

In this paper, the term *pre-learning* refers to pre-class (Long, Logan and Waugh, 2016), pre-lecture (Kinsella,

Mahon and Lillis, 2017) or "to present lecture material in advance of class" (Day and Foley, 2005). According to Cognitive Load Theory (CLT), information processing and knowledge building are limited by the working memory capacity (Sweller, Van Merriënboer and Paas, 1998). Increasing the level of pre-knowledge by using pre-learning activities 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 use of a pre-learning strategy has shown to be an efficient way of preparing students' minds because it helps them focus their attention on new relevant information and connect it with their pre-knowledge. This especially benefits the

students whose fundamental knowledge and experience are insufficient (Sirhan, Gray and Johnstone, 1999).

Pre-learning activities could take the form of reading a textbook excerpt or Word document, listening to a podcast (audio file), performing an online activity or completing a quiz. The key aspect is that pre-learning activities are integrated into the module design and into the class itself, so they are attributed with a sense of value by students and teachers (Seery, 2010). The pre-learning strategy is an opportunity to effectively include learning materials in the chemistry teaching in accordance with the teaching syllabus. Research results at an undergraduate level indicate frequent use of pre-learning worksheets and narrated PowerPoint videos (Moravec *et al.*, 2010), three types of videos and text-formatted materials (Long *et al.*, 2016), a combination of audio/video/PowerPoint materials (Collard, Girardot and Deutsch, 2002; Day and Foley, 2006), podcasts (audio files) (Seery, 2012b), and a short audiovisual material (Seery and Donnelly, 2012). In Alam, Zaman and Khan's study (2014), pre-lecture assignments were practiced to minimize the load on working memory at a secondary school level.

In the scientific literature, there is a lack of research analysing the use of pre-learning activities with the aim of reducing the cognitive load during classes in secondary chemistry education. This research is the first part of a more comprehensive study within a Ph.D. project regarding the implementation of the pre-learning strategy into secondary chemistry education. The main purpose of this research was to determine the frequency of using various chemistry learning materials (CLMs) within the frame of the pre-learning strategy in the secondary chemistry teacher population. Findings from this research should provide a direct insight into the actual practice of teachers and their priorities in the selection of certain CLMs in chemistry teaching, thus preparing the way for methodological intervention strategies.

This research shall answer the following questions:

1. How often do chemistry teachers use different types of CLMs within the frame of the pre-learning strategy?
2. Is there a difference in the frequency of using different types of CLMs for teaching chemistry in high schools and vocational schools?

## EXPERIMENTAL

This quantitative descriptive survey research enables the collection of data about the frequency of using CLMs with a self-administered online questionnaire. Once obtained, the responses are immediately stored in a database, which enables easy data handling and reduces the possibility of data errors. A nationwide questionnaire survey was administered to the population of secondary-school chemistry teachers in the Republic of Croatia.

### Research Participants

The sampling frame consisted of 573 secondary chemistry teachers from 21 regions in Croatia whose email addresses were obtained upon a request from the

education advisor database. A sample of 139 of the targeted chemistry teachers (response rate = 24.3 %) completed the online survey, but an ideal representation with regard to the number and gender of chemistry teachers in each region could not be achieved.

Most of them were in the City of Zagreb region (25.9 %) and the fewest in the Karlovac region (0.7 %). The data presented in Table 1 show that the majority of the participants were female (89.2 %). A total of 66.2 % of the participants had a master's degree in chemistry education whilst others were chemical engineers with additional pedagogical training. About a half of the participants (55.4 %) were high-school chemistry teachers.

**Table 1:** Demographic characteristics of the participants

| School types      | N   | Gender |      | Teacher Education |          |
|-------------------|-----|--------|------|-------------------|----------|
|                   |     | Female | Male | Teacher           | Engineer |
| High-school       | 77  | 68     | 9    | 59                | 18       |
| Vocational school | 62  | 56     | 6    | 33                | 29       |
| Total             | 139 | 124    | 15   | 92                | 47       |

### Research Instrument

The Using Chemistry Learning Materials Questionnaire (UCLMQ) was constructed for the purpose of this research, based on the data obtained from a review of the existing literature, and it was made with the free web survey tool Google Docs. The questionnaire also included items that arose from the researcher's personal and professional experience. UCLMQ consisted of 10 items; the first four items were designed to gain insight into demographic characteristics of chemistry teachers (region, gender, teacher's education, and school type). The remaining five closed-ended items required participants to estimate the frequency of the use of various CLMs:

1. Teachers create learning materials themselves (Word, PowerPoint) for students' preparation prior to the class.
2. Students' preparation with text/image materials prior to the class.
3. Students' preparation with digital materials prior to the class.
4. Students' preparation with audiovisual materials prior to the class.
5. Students' preparation with audio-materials prior to the class.

The Likert six-point scale of frequency (1-never, 2-sometimes, 3-usually, 4-often, 5-very often, 6-always) was chosen (Burušić, 1999). In the last open-ended question, the teachers were asked to state whether they prepared students for classes using types of CLMs not mentioned above.

The credibility of the applied instrument was assured by considering test validity and reliability. The first version of UCLMQ was reviewed by two university chemistry professors and two high-school chemistry teachers.

UCLMQ was revised according to their recommendations. The next step in the development of the instrument was the pilot research (March 2017) focused on the quality control of the questionnaire and the gathering of data for its optimization (Figure 1). Five questionnaire items, which provide information about the frequency of the use of various CLMs, were used as a basis for determining the internal consistency. The internal consistency was calculated using the Cronbach's  $\alpha$  coefficient, which was found to be 0.755. The results indicated that the scale had an acceptable level of reliability.

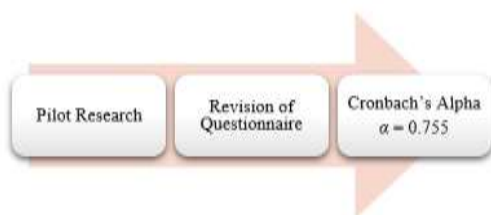


Figure 1: The development of the Using Chemistry Learning Materials Questionnaire

### Data Collection

In the present research, an email invitation with a link to access UCLMQ was distributed to 573 secondary-school chemistry teachers at the same time. During June and July 2017, UCLMQ was completed online by 139 chemistry teachers. They completed the questionnaire at their own pace, chosen time and preferences. Prior to filling out UCLMQ, teachers had to read the introductory text in which the research purpose, result process, and instructions for completing UCLMQ were stated.

Teachers had to click on one of six response options, which took a maximum of five minutes for all items. The online questionnaire offered two solutions: one in which the participant could participate alone and only once, and the other one where responding was required to move on to the next question. The time frame for completing the web survey was not limited. The researcher was available via email for addressing any issues or comments regarding the survey questionnaire throughout the timeline of the research.

Participation in this survey research was completely voluntary. All participants were informed of the research purpose, research contents, and benefits such as their contribution to the advancement of the education research. Confidentiality and anonymity were a priority for the participants of the current research.

### Data Analysis

The collected data were analysed using the statistical package IBM SPSS Statistics 21.0 where descriptive and inferential analyses were employed. Descriptive statistics was employed to describe the general data of this research. For the purpose of revealing any differences between the frequency in the use of CLMs at high schools and vocational schools, inferential analyses such as the non-parametric two-tailed Mann-Whitney U-test was used. This test was chosen since it enabled the testing of hypotheses on small and asymmetrically distributed samples.

## RESULTS AND DISCUSSION

The descriptive statistics analysis was carried out in order to investigate the frequency of the use of CLMs in secondary chemistry education. The frequency distributions of teachers' responses, expressed in percentages, were calculated for the data collected with UCLMQ on the overall sample (Figure 2).



Figure 2. The percentage of the teachers' responses for claims of UCLMQ (N=139)

The majority (83.5 %) of the teachers who participated in the research indicated that either they did not use digital materials or that they used them sometimes, which implied once or twice per semester. Furthermore, 87.0 % of the participants indicated they used audiovisual materials either never or sometimes prior to the class. Audio-visual materials with key terms for the next class are used sometimes by 28.8 % of the participants, whereas 63.3 % of the participants never use them. Interestingly, one-third of teachers often to very often create learning materials themselves (Word, PowerPoint) for students' preparation prior to the class whereas 20.0 % of teachers create materials for each chemistry class. In addition, the teachers also had an opportunity to add their own comments about CLMs. There were no new suggestions for using learning materials. However, they most commonly expressed dissatisfaction with technical difficulties (e.g., "Working in a classroom without computer equipment") and being overloaded with the teaching syllabus (e.g., "Too lengthy and too detailed subject matter (I have 2 years to teach what high-school students learn in 4 years) for me to be able to have the time to introduce students with the terms from the following lesson").

For the evaluation of differences in the teachers' responses regarding the school types, the two-tailed non-parametric Mann-Whitney U-test was used for two independent groups: group 1 – high-school (N=77) and group 2 – vocational school (N=62). The results reported in Table 2 show the highest mean rank (MR) values for high-school teachers in designing their own materials (MR=73.50), and the use of digital materials (MR=73.20). The Mann-Whitney U test (N<sub>1</sub>=77, N<sub>2</sub>=62) indicates that the observed differences were not statistically significant.

**Table 2.** The results of the Mann–Whitney U test (two-tailed) of statistically significant differences

| Item | Chemistry learning materials | Group           | Mean Rank      | U      | Z      | p    |
|------|------------------------------|-----------------|----------------|--------|--------|------|
| 1    | Teachers materials           | high vocational | 73.50<br>65.65 | 2117.5 | -1.168 | .243 |
| 2    | Text/image materials         | high vocational | 70.75<br>69.07 | 2329.5 | -0.261 | .794 |
| 3    | Digital materials            | high vocational | 73.20<br>66.02 | 2140.0 | -1.136 | .256 |
| 4    | Audiovisual materials        | high vocational | 69.24<br>70.94 | 2328.5 | -0.273 | .785 |
| 5    | Audio-materials              | high vocational | 70.47<br>69.41 | 2350.0 | -0.182 | .856 |

It can be noted from the obtained information that chemistry teachers use different types of learning materials which they have created themselves for students' preparation prior to the class, but they most commonly apply text/image materials (worksheets, PowerPoint) described in the previous research (Moravec *et al.*, 2010). On the other hand, the lowest frequencies in use appeared with the use of audio-materials although studies show that the use of audio files (podcasts) provides supporting resources to enhance student learning (Seery, 2012b). With our teachers the use of audiovisual materials (screencasts) is insignificantly higher than the use of audio-materials even though they have been mostly researched in the international scientific literature within the framework of the pre-learning strategy (Seery and Donnelly, 2012). According to the results, there is no statistically significant difference in the frequency of using CLMs between chemistry teachers in high schools and vocational schools. There were several limitations that should be taken into account when drawing conclusions from this research. Although the self-administered online questionnaire permits increased anonymity, there was no way to tell how truthful the participants were, they could have forgotten something or not think within the full context of statements of the questionnaire. The second limitation was the fact that the entire population was not sampled since the email addresses of 573 teachers were obtained on request from the education advisor database. The obtained sample of 139 teachers is not an accurate representation of the entire population of secondary chemistry teachers, and as such cannot be used as a basis for generalisations. However, by applying appropriate statistical tests, useful conclusions on the population could be extrapolated.

## CONCLUSIONS

This survey research was aimed at using CLMs for secondary chemistry teaching. UCLMQ was offered to get a direct insight into how often secondary chemistry teachers use CLMs in their classes. According to the research results, it can be concluded that teachers most commonly use their own materials (Word, PowerPoint) and text/image CLMs for students' preparation prior to the class. Audio-materials (podcasts), audiovisual

materials (screencasts) and digital materials are represented insufficiently in teaching chemistry in secondary schools. The frequency of high-school chemistry teachers' use of CLMs does not differ from vocational school chemistry teachers' use. 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 learning materials in teaching natural sciences subjects, which includes larger sample sizes on the territory of the entire country.

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### **Summary/Sažetak**

Strategija predučenja uključuje aktivnosti usmjerene na pripremu učenika prije nastave. Primjena takvih aktivnosti povećava razinu predznanja što omogućuje učinkovitije povezivanje novih informacija s postojećim znanjem, a time i smanjenje opterećenja radne memorije. Rezultati istraživanja ukazuju na čestu uporabu različitih materijala za učenje u okviru strategije predučenja. Glavna svrha ovog istraživanja je utvrditi učestalost primjene materijala za učenje kemije u okviru strategije predučenja u hrvatskim srednjim školama. Kvantitativno deskriptivno anketno istraživanje provedeno je na uzorku od 77 gimnazijskih nastavnika kemije i 62 nastavnika kemije strukovnih škola iz svih hrvatskih županija. Podaci su prikupljeni pomoću online upitnika i obrađeni deskriptivnom i inferencijalnom statistikom. Prema dobivenim rezultatima, za pripremu učenika prije nastave kemije nastavnici najčešće koriste vlastite materijale (Word, PowerPoint) i tekstualno/slikovne materijale. Audiomaterijali, audiovizualni i digitalni materijali nedovoljno su zastupljeni. Učestalost primjene materijala za učenje kemije ne razlikuje se kod nastavnika u gimnazijama i strukovnim školama.