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Evaluation of Context-Level Effect on Students' Performance and Perceived Cognitive Load in Chemistry Problem-solving Tasks

Dušica Milenković[1], Mirjana Segedinac[1], Tamara Hrin[1] and Gordana Gajić[2]
[1]*Faculty of Sciences, University of Novi Sad*
[2]*Primary school Jovan Jovanović Zmaj in Sremska Kamenica*

Abstract

This study was conducted with the aim to examine the effect of context on perceived cognitive load and students' achievements in problem-solving tasks. It included 161 eighth-grade students. The tasks in the test, which was used as a measuring instrument for assessing knowledge, were designed at three levels of complexity: without context, with moderate and with rich context. Each task was followed by a 7-point Likert-type scale, as a measure of perceived cognitive load. The analysis of obtained results showed that the highest average achievement was reached in the group of tasks without context, followed by the group of tasks with moderate context, while the group of context-rich tasks was characterized by the lowest achievement. Furthermore, the results have shown that there is a statistically significant difference between achievement in tasks without context and tasks with moderate context, as well as between achievement in tasks without context and context-rich tasks, while there was no statistically significant difference between achievement in tasks with moderate and context-rich tasks. Similar results were obtained for the perceived cognitive load, thus indicating that context-rich tasks abound in information and therefore impose high cognitive demands on learners. These findings may represent a significant contribution to the still under-researched area of context-based assessment thus paving way for further research in this area, such as investigating the influence of prior knowledge or motivation on solving context-rich tasks.

Key words: *context-rich tasks; perceived cognitive load; tasks with moderate context; tasks without context.*

Introduction

We live in an age of rapid technology development with a tremendous increase in the amount of available information, and science itself follows that trend. Due to the expansion of scientific discovery, the teaching process is also becoming informative in character, as new pieces of information are constantly being added to the existing knowledge base. Consequently, learning efficiency is gaining more importance nowadays. Since the main purpose of education is training children for further education and life, as well as for lifelong learning, shortcomings of traditional teaching should be removed by increasing students' activities in the educational process. The increase of students' motivation is stated as particularly important (Devetak & Glažar, 2010; Jurišević et al., 2008). Ahmed & Pollitt (2007) state that question writers often use context-rich tasks to motivate students and keep their interest in science.

Context-rich Tasks

Context-rich tasks are more complex than traditional tasks and are designed to reflect real-life situations. They include more information than needed, and require students to remember and apply some previously adopted information, that is, to use their own experience during problem-solving. Such tasks encourage students to consider scientific knowledge in the context of real objects in the real world, and problem-solving process as a series of decisions. In addition, these problems involve application of fundamental scientific concepts for the qualitative analysis of the problem, rather than the repeated use of derived formulas (Heller et al., 1992; Heller & Heller, 1999). During the construction of a context-rich task, one should bear in mind that the context should not be placed in the real world in order to provide an interesting decoration; on the contrary, context should be an integral part of the task (Ahmed & Pollitt, 2007).

However, despite the positive impact that context can have on students' motivation as well as on concretization of teaching materials, from the aspect of Cognitive learning theory, context-rich tasks may lead to an increase of the cognitive load, thus reducing the effectiveness of the learning process. According to Ahmed & Pollitt (2007), three sorts of demands may be considered. The first is language. Since context-rich tasks contain plenty of text, the students' reading ability during the problem-solving process is being checked. Besides, an additional load can be added by terminology, as it may include so-called "adult" concepts (Ahmed & Pollitt, 2007). The second is familiarity, because some students are more familiar with certain real world contexts than others. Therefore, those who are more familiar with context will be able to select the necessary information more easily, while those students who are not familiar with the context will probably consider it as the content they failed to learn. Attention may present the third additional demand as context-rich tasks often contain extra information that is irrelevant for the solving process; thus, in order to address them students need to select relevant data.

It is worth mentioning that most of the published work in the field of contextual approach deal with the evaluation of context-based teaching, rather than context-based assessment. Taasoobshirazi & Carr (2008), in an overview of context-based physics instruction and assessment, state that there are only four studies (Enghag, 2004; Heller & Hollabaugh, 1992; Park & Lee, 2001; Rennie & Parker, 1996) that have examined students' motivation, problem solving, or achievement when comparing context-based assessment and traditional assessment in classrooms where only traditional teaching methods have been used. Nevertheless, in only one of these studies achievement is measured directly and with a sufficiently large sample size for statistical analysis. Therefore, it may be concluded that there is a lack of information in the abundant context-based learning theory concerning context-based assessment and that more research on this issue needs to be done.

Beside achievement, research about context-based approach and assessment should include the investigation of the perceived cognitive load as well. Namely, according to Pass et al. (2003), the power of certain instructional condition can be determined solely if the measured performance level is associated with the level of perceived cognitive load and vice versa. Bearing in mind that people have a limited working memory capacity, consideration of the cognitive load concept and modes in which the cognitive load can be reduced is essential for the development of methods that will lead to an effective teaching and meaningful learning process, thus allowing permanent acquisition of knowledge, applicable in diverse situations (Tindall-Ford et al., 1997).

Cognitive Load Theory

The Cognitive load theory is based on the human cognitive architecture, which consists of a limited working memory with partly independent processing units for visual/spatial and auditory/verbal information to interact with relatively unlimited long-term memory, rather than on the existence of the scheme and automation (Polock et al., 2002). According to Sweller et al. (1998), there are three types of cognitive load – *intrinsic* which refers to the natural complexity of the taught material (Ayres, 2006; Kalyuga, 2009; Moreno & Park, 2010; Sweller et al., 1998), *extraneous* which comes from the manner in which information is presented to students (Kalyuga, 2009; Sweller, 1994; Sweller, 2003) and *germane* which is caused by various cognitive activities that lead to an increase of the total cognitive load, but at the same time contribute to improvement of learning process and increase of students' motivation (Kalyuga, 2009).

In respect of the measurement of the cognitive load, Brünken et al. (2003) differentiate between two basic techniques – *objective and subjective*, which are further divided into *direct* and *indirect*. Despite the very good quality of data obtained by objective techniques (analysis of the behavior and physiological parameters such as heart rate or cardiovascular indicators, techniques of pupils' monitoring or measurement of brain activity), their technical complexity, limitations on the duration

as well as frequent measurements make these techniques difficult to implement in real and authentic learning environments in the classroom (Brünken et al., 2003). On the other hand, indirect subjective assessment, which has been used in this research, is primarily related to scaling of the invested mental effort as a method of making an indirect assessment of perceived difficulty of the learning material (Paas, 1992). Despite controversial beliefs regarding the self-efficacy of reviewing mental processes, research has shown that students are able to assign a numerical value to the perceived level of mental effort (Paas, 1992). Paas et al. (1994) suggest that one-dimensional scales in which students assess mental effort are the most reliable and the most sensitive for relatively small differences in cognitive load. The majority of the scales that are used for the assessment of mental effort are defined in the range 1-7 or 1-9, as a Likert scale in the interval from very low to very high cognitive load (Musallam, 2010).

Research Focus

The aim of this research was to examine context-level effect on students' achievements and perceived cognitive load, measured as subjective assessment of mental effort, in chemistry problem-solving tasks.

Research Methodology

Research Problem

Although much research is currently available in the field of context-based learning, the field of context-based assessment has been, to date, insufficiently investigated. Thereby, there is insufficient evidence for the claim that a context-based assessment could lead to the improvement of achievement and more research in the area of context-based assessment is needed. Within this research, we wanted to examine students' achievements and perceived cognitive load to obtain more information about the effectiveness of context-based assessment. In addition, we wanted to examine whether the amount of context has an impact on the students' achievements and perceived cognitive load. Therefore, the research questions have been formulated in the following manner:

Q1: Are there statistically significant differences in students' performance in the different groups of tasks (without context, with moderate context and context-rich tasks)?

Q2: Are there statistically significant differences in students' perceived cognitive load in different groups of tasks (without context, with moderate context and context-rich tasks)?

Sample of Research

The sample is of a convenience sampling type. It consisted of 161 primary school students (50.3% females; 49.7% males) taught by one chemistry teacher. The students'

age was between 14 and 15, and they all attended eighth grade of the same primary school "Jovan Jovanović-Zmaj", Sremska Kamenica, Serbia. The sample represented an urban population of a mixed socioeconomic status.

Instrument and Procedures

This research was conducted as non-experimental investigation of a state. Namely, the teacher has trained students in the common, traditional, manner whereupon the testing was carried out. Within traditional teaching, the teacher conduced classes in the usual manner combining monologue and dialogue methods, after which the students attempted to solve a number of problem tasks planned by the curriculum. It is important to emphasize that teaching was solely traditional and did not include aspects of teaching based on the context.

In this study, a knowledge test was used as a measuring instrument for the assessment of performance and a Likert-type scale as a measuring instrument for the evaluation of the perceived cognitive load. The test consisted of 18 tasks, which were designed in three levels of the context complexity: tasks without context, tasks with moderate context and context-rich tasks. The complexity of the context was varied with the amount of important additional information in the task. Important additional information was mostly related to knowledge from everyday life that students are familiar with, such as application of certain substances, preparation for various purposes, consequences of the use or excessive use, or related to data processed during the regular teaching, such as properties of substances, their occurrence in nature, or some historical facts. Considering the amount of important additional information in the context, there were three different groups of tasks, i.e. three subtests within the test:

- tasks without context, which had no important additional information (Subtest 1)
- tasks with moderate context in which the number of pieces of important additional information varied from two to three (Subtest 2)
- context-rich tasks in which the number of pieces of important additional information was from four to six (Subtest 3).

All the tasks in this study were open-ended tasks and belonged to the teaching topic *Solutions and Solubility*. This topic was chosen due to the relation with the real life situations as the concepts in this field, including the mass percentage, are widely used in various aspects of life and students can often encounter them in everyday life.

Tasks No. 1, 7, and 13 refer to calculating substance solubility using the data for its solubility and given mass of solvent. Tasks No. 2, 8, and 14 refer to determining the mass percentage of the solution using data for mass of the solute and mass of the solvent. Tasks 3, 9 and 15 refer to determining the mass of the solute using the given mass of the solution and its mass percentage. Tasks 4, 10 and 16 refer to determining the solution mass percentage formed by adding the given mass of solute in a given mass of solution of a known mass percentage. Tasks 5, 11 and 17 refer to determining the mass percentage of solution formed by adding given mass of water in the solution

of the given mass percentage. Tasks No. 6, 12 and 18 refer to determining of the mass percentage of solution formed by mixing two solutions of the given mass and given mass percentage.

Regarding the learning outcomes for teaching topic *Solutions and Solubility* in terms of problem solving tasks, students are expected to know how to calculate the mass percentage of the solution, as well as to understand the expression of quantitative composition of the solution through the mass percentage. Therefore, it is evident that the presented tasks are in line with the expected learning outcomes.

All students were solving the test during three school classes in April 2012. Each correctly solved task was scored with one point, and incorrect with zero points, so the maximum possible achievement on the test was 18 points. It is worth noting that each of the tasks in Subtest 1 had the corresponding task in the Subtest 2 and in the Subtest 3, with identical solving procedures, but with the difference in the amount of information that comprise the context.

As a measure of perceived cognitive load a Likert scale was used. The Likert scale descriptors were: extremely easy, very easy, easy, neither easy nor difficult, difficult, very difficult and extremely difficult. These descriptors were coded numerically from 1–7, so that descriptor 'extremely easy' fits the code 1, 'very easy' fits the code 2, 'easy' fits the code 3, 'neither easy nor difficult' fits the code 4, 'difficult' fits the code 5, 'very difficult' fits the code 6 and descriptor 'extremely difficult' fits the code 7.

The authors have applied the pre-test and post-test assurance parameters according to the model described in Segedinac et al. (2011). Within pre-test assurance parameters, these authors evaluated the meaningfulness of test items' requirements, the diversity of test items, the usage of terminology, and the length of sentences used in the test items in addition to validity. These pre-test quality assurance parameters were estimated by four experts – one university professor and two researchers in the field of chemistry education, and one chemistry teacher in primary education, prior to conducting the research. According to the evaluators' assessments, the tasks requests had been defined clearly and precisely, the tasks were diverse, and terminology adjusted to the age of students. Sentences in the text were of appropriate length, which is of particular importance for tasks with moderate and rich context, since long sentences in combination with additional relevant information, which comprise context, could present a hindering factor. Post-test assurance parameters were evaluated by statistical analysis of the test results. Besides the basic statistical test parameters, reliability as Cronbach's alpha was also calculated. Test item difficulty was calculated as the percentage of the group which answered the item correctly and test item discrimination was calculated by using item analysis between the groups of 27% most successful and 27% least successful students as proposed by Ebel & Frisbie (1991).

Data Analysis

The data obtained from the instruments were analyzed using the software packages Statgraphics Centurion XVI and IBM SPSS Statistics 20. It included Kruskal-

Wallis one-way analysis of variance and post-hoc pairwise comparisons after K-W. Kruskal-Wallis would determine whether the differences between analyzed variables (i-achievements, ii- perceived cognitive load) are statistically significant, while the post-hoc tests would determine which values are statistically significant.

Research Results

As a measure of internal consistency, the Cronbach's alpha coefficient for each subtest has been calculated.

The obtained values for achievement (α_{s1}=0.84; α_{s2}=0.83; α_{s3}=0.81) indicate good reliability while obtained values for perceived cognitive load (α_{s1}=0.92; α_{s2}=0.91; α_{s3}=0.90) indicate excellent reliability. Values for test item difficulty are in the range of 36–88%, while the test item discrimination is in the range of 0.45–0.93.

Table 1 provides descriptive statistics of the test results for measuring total achievement (T_a), total perceived cognitive load (T_{cl}), achievements in the subtests ($S1_a$ – subtest 1 achievement; $S2_a$ – subtest 2 achievement; $S3_a$ – subtest 3 achievement) and perceived cognitive loads in the subtests ($S1_{cl}$ – subtest 1 perceived cognitive load; $S2_{cl}$ – subtest 2 perceived cognitive load; $S3_{cl}$ – subtest 3 perceived cognitive load).

Table 1

Descriptive statistics for test and subtest achievements and perceived cognitive load (N=161)

Parameter	T_a	T_{cl}	$S1_a$	$S1_{cl}$	$S2_a$	$S2_{cl}$	$S3_a$	$S3_{cl}$
Minimum	0	18	0	6	0	6	0	6
Maximum	18	126	6	42	6	42	6	42
Average	11.21 (62.28 %)	68.17	4.24 (70.68 %)	20.81	3.55 (59.17 %)	23.16	3.43 (57.17 %)	24.20
SD	5.90	23.37	1.99	8.01	2.16	8.16	2.08	7.99
Stnd. Kurtosis	–2.85	–1.41	–1.47	–1.08	–3.28	–1.66	–3.30	–1.32
Stnd. Skewness	–2.78	–0.36	–4.52	0.61	–1.95	–0.60	–1.70	–0.63

Looking at the performance of students, it can be noted that it decreases with the growing complexity of the context. In tasks without context students made an average achievement 70.68%, in tasks with moderate context the average achievement was 59.17%, while the lowest achievement was accomplished in context-rich tasks (57.17 %). Similar results were obtained for perceived cognitive load. Students assessed subtest 1 with the total average load 20.81 (3.47 per task). Subtests 2 and 3 were evaluated with similar perceived cognitive load 23.16 and 24.20, or 3.86 and 4.03 per task, respectively.

In order to determine whether the obtained results come from a normal distribution, the Saphiro-Wilk test and Levene's test of homogeneity of variances were performed on achievement and perceived cognitive load for each subtest. This test showed that the results from both groups could not be considered as normally distributed. Therefore, with the aim to determine whether the differences in achievements and

perceived cognitive load for the three groups of tasks are significant, a corresponding nonparametric test, Kruskal-Wallis one-way analysis of variance was performed. *P-values* obtained by this analysis are less than 0.05 (0.0003 for achievements and 0.0008 for perceived cognitive loads), indicating a statistically significant difference in achievement as well as in perceived cognitive load among different groups of tasks (without context, with moderate and rich context).

In addition, in order to determine which values are significantly different from others, we performed post-hoc pairwise comparisons after K-W. The results are summarized in Table 2.

Table 2

Results of post-hoc pairwise comparisons after K-W

Contrast	S1–S2		S1–S3		S2–S3	
Parameter	A	CL	A	CL	A	CL
Adj. Sig.	0.008*	0.028*	0.000*	0.001*	1.000	0.833

A-achievement; CL-perceived cognitive load; *- statistically significant difference

Results of nonparametric post-hoc pairwise comparisons show that there is a statistically significant difference in achievements between tasks without context (S1) and tasks with moderate context (S2), as well as in achievements between tasks without context and context-rich tasks (S3), while there was no statistically significant difference in achievements between tasks with moderate and context-rich tasks. Likewise, the same test shows that there is a statistically significant difference in perceived cognitive load between tasks without context (S1) and tasks with moderate context (S2), as well as in perceived cognitive load between tasks without context and context-rich tasks (S3), while there was no statistically significant difference in achievements between tasks with moderate context and context-rich task.

Hereinafter, in Table 3 we provide an example of three tasks and a brief comment. These tasks, according to the complexity of the context, belong to different categories, but they have an identical problem-solving procedure.

As previously mentioned, all of the three presented tasks have the same problem-solving procedure, but a different amount of additional information providing the context. The first task contains only the information necessary to solve the problem and therefore belongs to the group of tasks without context. The second task, beside necessary information, includes three additional pieces of information. The first refers to the type of compound class; the second refers to a certain property of the mentioned substance – solubility and the third refers to its application in medicine. Since this task comprises three additional pieces of information, it belongs to the group of tasks with moderate context. The next task, in addition to the above information, contains one additional piece of information and that is occurrence in nature. Therefore, since this task contains four additional pieces of information, it belongs to the group of context-rich tasks.

Table 3
Examples of tasks without context, with moderate and rich context

without context	What is the mass percentage of sugar in a solution that is created by adding 10 grams of sugar to 400 g of 25 % solution of sugar?
moderate context	Mannitol is a sugar alcohol which is highly-soluble in water. In emergencies, when it is necessary to quickly lower the elevated pressure in the skull i.e. the patient's brain, they should be given a 10 % aqueous solution of mannitol. In 200 g of 5 % mannitol solution, 20 g of pure mannitol is added. Is the mass percentage of the resulting solution higher or lower than the one which is commonly used for therapeutic purposes?
rich context	Mannitol is a sugar alcohol, highly-soluble in water. It is found in a wide variety of natural products, particularly in the juice of the ash plant and some algae. It is used in medicine as a 10 % aqueous solution and it is given in emergency situations, through infusion to patients with high blood pressure in the brain, or high blood pressure. Could the mannitol solution, obtained by adding 9 g of pure mannitol to 150 g of a 5 % aqueous solution, be used for therapeutic purposes?

Regarding the difficulty indices for the given tasks, the following results were obtained – 0.62 for the task without context and 0.52 for both tasks with moderate and rich-context indicating that both tasks regardless of the amount of context were equally difficult for students. In addition, all three tasks have very good discrimination indices, 0.82, 0.89 and 0.91 respectively.

Discussion

The conducted research showed that the increase in context volume led to the decrease in students' achievements and increase in students' perceived cognitive load, bating the differences between students' achievements and differences between students' perceived cognitive load in tasks with moderate and rich context which are shown to be non-significant. It can be concluded that the volume of the context causes considerably lower students achievements and considerably higher perceived cognitive loads, concurrently. The results obtained for perceived cognitive load suggest that students are aware of the task difficulty and the cognitive load imposed by contexts of varied complexity.

It is important to note that the majority of students who did not manage to solve context-rich tasks have not been successful in solving tasks with moderate context either, and the majority of students who have been successful in solving tasks with moderate context have also been successful in solving context-rich problems.

Such tasks are rich in information and in order to successfully solve them students need to extract the relevant information and focus attention on them, which requires investment of additional mental effort. These tasks are assessed by students as difficult and are classified into the category of tasks with a high cognitive load.

To our knowledge, there has been very little research on the effect of context in science questions. Moreover, the obtained findings are inconsistent. In the work of

Heller and Hollabaugh (1992), achievements in tasks with and without context have not been directly measured, but the authors came to the result that contextualized questions directed students to the principles and laws necessary to solve a problem, while traditional questions directed them to the use of formulas and equations. On the contrary, Kotovsky et al. (1985) as well as Mevarech and Stern (1997) found that students have significantly higher achievement in tasks without context compared to the enriched context tasks. These authors explain the occurrence as distraction of attention from the request. Besides, they state that a real-life context leads to the activation of some simple models, rather than to abstract thinking. Our study with three levels of context complexity provided similar results. Possible reasons can be found in several physiological processes which, according to Ahmed & Pollitt (2007), occur while students answer questions. These are: reading, searching, matching, creating and writing answers. According to these authors, the context could have a significant effect on the first phase, since during this phase a number of mental representations is being formed, many of which are irrelevant to the problem-solving process. It means that students are required to distinguish between necessary and unnecessary pieces of information which cause a significantly higher cognitive load. Our study, in which perceived cognitive load in tasks of varying degree of context complexity is being measured, confirms this statement.

Another phenomenon related to the phase of reading, which we consider important to mention, is a problem with functional reading.

Reading with comprehension is not an area in which students from Serbia are good at. In support to these statements, the results of PISA testing (OECD, 2010) will be briefly discussed. Certain similarities can be noted between PISA tasks and contextualized tasks used in this study. Namely, the PISA framework for assessing students' reading literacy is focused on skills that include finding, selecting, interpreting and evaluating information from a full range of texts associated with everyday life situations. Similarly, contextualized tasks include additional, everyday life information, and for their successful realization, it is required that students possess previously mentioned skills.

The results of the PISA testing from 2009 show that 33.9 % of students in Serbia are below the level 2, which is considered as basic level at which students begin to demonstrate the reading skills and competencies that will enable them to effectively and productively participate in life, work and social activities. On the overall reading scale (OECD, 2010) with 442 points our students have accomplished significantly lower achievement than the OECD average, which is 493 points. Accordingly, the cause of students' lower achievements in tasks with moderate and rich context in this research can be found in the poor functional literacy of the respondents. As a result, students could be poorly motivated and discouraged by tasks with longer text and thereby give up sooner and declare such tasks as very difficult.

Conclusions

Since the previous research which was related to the efficiency of context-rich tasks dealt mainly with the testing of students' performance, with this research we wanted to make a contribution to current studies and thereby, beside performance, we have examined the mental effort that students invest while solving various tasks without context, with moderate and rich context, in order to collect information about the cognitive load caused by context.

The obtained results, which indicate that context-rich tasks are the cause of students' lower achievement and at the same time a cause of higher cognitive load, have significant theoretical implications. Namely, it would be important to further examine how the ability of functional reading affects solving context-rich tasks. Furthermore, the relationship between the level of students' prior knowledge and success in solving context-rich tasks should be examined, as well as between the level of students' prior knowledge and mental effort while solving such tasks. Finally, it is essential to examine the deeper motivational factor of context in chemistry teaching i.e. to what extent should chemistry be present in context and to what extent should it be present in concept in order to foster the learning process.

Nevertheless, this study has several limitations that should be noted. The first limitation is related to the very nature of contextualized tasks. Namely, the construction of such tasks can always lead to familiar shortcomings, as it is possible that some are more familiar with certain contexts and some are less familiar. Other limitations are reflected in the research sample and content investigated as this study included only one primary school in the Republic of Serbia and only one teaching topic – *Solutions and Solubility*. Thereby, in future research, more schools (more teachers) should be included and more topics covered.

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Dušica Milenković
Faculty of Sciences, University of Novi Sad
Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia
dusica.milenkovic@dh.uns.ac.rs

Mirjana Segedinac
Faculty of Sciences, University of Novi Sad
Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia
mirjana.segedinac@dh.uns.ac.rs

Tamara Hrin
Faculty of Sciences, University of Novi Sad
Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia
tamara.hrin@neobee.net

Gordana Gajić
Primary school Jovan Jovanović Zmaj in Sremska Kamenica
Školska 3, 21208 Sremska Kamenica, Serbia
gocahem@gmail.com

Evaluacija utjecaja razine konteksta na učenička postignuća i samopercipirana kognitivna opterećenja u problemskim zadatcima iz kemije

Sažetak

Ova je studija provedena s ciljem ispitivanja utjecaja konteksta na samopercipirana kognitivna opterećenja i učenička postignuća u problemskim zadatcima. Njome je obuhvaćen 161 učenik osmog razreda osnovne škole. Test je korišten kao mjerilo za procjenu znanja. Zadatci na testu bili su dizajnirani u tri razine kompleksnosti – bez konteksta, s umjerenim i bogatim kontekstom. U okviru svakog zadatka nalazila se ljestvica Likertova tipa sa sedam stupnjeva za mjerenje samopercipiranog kognitivnog opterećenja. Analiza dobivenih rezultata pokazala je da je najviše prosječno postignuće ostvareno u skupini zadataka bez konteksta, zatim u skupini zadataka s umjerenim kontekstom, a najniže je prosječno postignuće ostvareno u skupini zadataka s bogatim kontekstom. Nadalje, rezultati su pokazali da postoji statistički značajna razlika u postignućima u zadatcima bez konteksta i zadatcima s umjerenim kontekstom, kao i između postignuća u zadatcima bez konteksta i zadatcima s bogatim kontekstom, a da razlika u postignućima u zadatcima s umjerenim i zadatcima s bogatim kontekstom nije statistički značajna. Slični rezultati dobiveni su za samopercipirana kognitivna opterećenja, što upućuje na to da zadatci bogati kontekstom obiluju informacijama i stoga učenicima nameću visoke kognitivne zahtjeve. Ti pokazatelji mogu predstavljati važan doprinos do sada nedovoljno istraženom području kontekstualiziranih zadataka, otvarajući put za daljnja istraživanja u tom području, kao što su ispitivanja utjecaja predznanja ili motivacije na rješavanje zadataka bogatih kontekstom.

Ključne riječi: *samopercipirano kognitivno opterećenje; zadatci bez konteksta; zadatci bogati kontekstom; zadatci s umjerenim kontekstom.*

Uvod

Današnjica je obilježena vrlo brzim razvojem tehnologije i golemim porastom broja raspoloživih informacija, a taj trend prisutan je i u znanosti. Uslijed ekspanzije

znanstvenih otkrića nastava počinje dobivati informativni karakter jer se na postojeća znanja stalno dodaju nova, zbog čega na značenju sve više dobiva učinkovitost učenja. Budući da je osnovni smisao obrazovanja osposobljavanje djece za daljnje školovanje i život kao i za cjeloživotno učenje, slabosti tradicionalne nastave treba otkloniti povećanjem aktivnosti učenika u odgojno-obrazovnom procesu. Kao osobito važno navodi se povećanje motivacije učenika (Devetak i Glažar, 2010; Jurišević i sur., 2008). Ahmed i Polit (2007) smatraju da se pisci zadataka često koriste zadatcima bogatim kontekstom kako bi motivirali učenike i održali njihovo zanimanje za znanost.

Zadatci bogati kontekstom

Zadatci bogati kontekstom su složeniji od tradicionalnih i dizajnirani tako da reflektiraju prave životne situacije. Oni obuhvaćaju više informacija nego što je potrebno za njihovo rješavanje i zahtijevaju od učenika da se podsjete i primijene neke prije usvojene informacije i znanja, odnosno da se tijekom rješavanja koriste vlastitim iskustvom. Takvi zadatci potiču učenike na to da razmatraju znanstvene spoznaje u kontekstu realnih objekata u stvarnom svijetu, a da rješavanje problema sagledavaju kao niz odluka. Takvi zadatci podrazumijevaju korištenje osnovnih znanstvenih koncepata za kvalitativno analiziranje problema, prije nego manipuliranje matematičkim formulama (Heller i sur., 1992; Heller i Heller, 1999). Tijekom konstrukcije zadataka s kontekstom potrebno je voditi računa o tome da kontekst ne treba biti smješten u stvaran svijet kako bi osigurao zanimljivu dekoraciju, već treba biti sastavni dio zadatka (Ahmed i Pollitt, 2007).

Međutim, unatoč pozitivnom utjecaju koji kontekst može imati na motivaciju učenika kao i konkretiziranje zadataka, promatrano s aspekta kognitivističkih teorija, zadatci bogati kontekstom mogu u znatnoj mjeri doprinijeti povećanju kognitivnog opterećenja, odnosno smanjenju učinkovitosti učenja. Prema Ahmed i Pollitt (2007) mogu se razmatrati tri dodatna tipa zahtjeva koji se nameću učenicima pri rješavanju zadataka s kontekstom. Prvi je jezik, budući da zadatci bogati kontekstom istodobno obiluju tekstom, pa se pri rješavanju zadatka provjerava i sposobnost učeničkog čitanja. Osim toga dodatno opterećenje može stvoriti i terminologija, koja može sadržavati i takozvane koncepte „odraslih" (Ahmed i Pollitt, 2007). Drugi je bliskost, jer su pojedini konteksti iz stvarnog svijeta nekim učenicima manje, a nekima više poznati. Tako će oni kojima je kontekst poznat, lakše moći izvršiti selekciju potrebnih informacija, a učenici kojima nije poznat kontekst će vjerojatno smatrati gradivom koje su propustili naučiti. Pozornost može biti treći dodatni zahtjev, jer zadatci bogati kontekstom često sadrže i veći broj irelavantnih informacija, pa je za njihovo rješavanje potrebno obaviti selekciju podataka. Važno je napomenuti da se većina publiciranih radova u području kontekstualnog pristupa bavila evaluacijom nastave uutemeljene na kontekstu, prije nego kontekstualiziranim zadatcima. Taasoobshirazi i Carr (2008) u jednom preglednom radu o instrukciji i ocjenjivanju utemeljenom na kontekstu u fizici navode da do sada postoje svega četiri studije (Enghag, 2004;

Heller i Hollabaugh, 1992; Park i Lee, 2001; Rennie i Parker, 1996) koje su se bavile ispitivanjem učeničke motivacije, rješavanjem problema i postignućima usporedbom tradicionalnih i kontekstualiziranih zadataka primjenom samo tradicionalnog oblika podučavanja. Međutim, samo u jednoj od tih studija postignuće je mjereno izravno i s dovoljno velikim uzorkom za statističku analizu. Može se, dakle, zaključiti da u obimnoj teoriji učenja utemeljenoj na kontekstu postoji nedostatak informacija o primjeni kontekstualiziranih zadataka i da su u ovom području potrebna daljnja istraživanja.

Osim postignuća istraživanja u području učenja i poučavanja utemeljenog na kontekstu trebalo bi također uključiti i istragu samopercipiranog kognitivnog opterećenja. Naime, prema Pass i sur. (2003) učinkovitost neke instrukcijske strategije može se odrediti jedino ako se rezultati dobiveni za učeničke performanse dovedu u vezu sa samopercipiranim kognitivnim opterećenjem i obrnuto. Imajući na umu da ljudi posjeduju ograničeni kapacitet radne memorije, razmatranje teorije kognitivnog opterećenja i načina na koje bi se kognitivno opterećenje moglo reducirati od bitne je važnosti za izučavanje i razvijanje metoda koji će voditi učinkovitoj nastavi i smislenijem procesu učenja, omogućavajući stjecanje trajnog znanja, primjenjivog u različitim situacijama (Tindall-Ford i sur., 1997).

Teorija kognitivnog opterećenja

Teorija kognitivnog opterćenja temelji se na kognitivnoj arhitekturi učenika, koja se sastoji od ograničene radne memorije s djelomično neovisnim jedinicama za obradu vizualnih / prostornih i auditornih / verbalnih informacija koja interreagira s relativno neograničenom dugoročnom memorijom, zatim na postojanju shema i automatizaciji (Polock i sur., 2002). Prema Sweller i sur. (1998) postoje tri tipa kognitivnog opterećenja – *unutarnje*, koje se odnosi na prirodnu kompleksnost materijala koji se uči (Ayres, 2006; Kalyuga, 2009; Moreno i Park, 2010; Sweller i sur., 1998), *vanjsko* koje potječe od načina na koji su informacije prezentirane učenicima (Kalyuga, 2009; Sweller, 1994; Sweller, 2003) i *efektivno* koje je prouzrokovano različitim kognitivnim aktivnostima koje vode prirastu ukupnog kognitivnog opterećenja, ali istodobno doprinose i poboljšanju učenja i prirastu motivacije učenika (Kalyuga, 2009). U pogledu mjerenja kognitivnog opterećenja Brünken i sur. (2003) razlikuju dvije osnovne tehnike – *objektivnu* i *subjektivnu*, koje dalje dijele na *izravne* i *posredne*. Unatoč vrlo dobroj kvaliteti podataka koji se mogu dobiti objektivnim tehnikama (analizom ponašanja i fizioloških parametara kao što su srčani rad ili krvni pokazatelji, potom tehnikama praćenja zjenica ili mjerenja moždane aktivnosti), njihova tehnička kompleksnost, ograničenja zbog trajanja i čestih mjerenja čine te tehnike teško primjenjivim u realnom i autentičnom školskom okruženju (Brünken i sur., 2003). S druge strane posredne subjektivne mjere, koje su korištene u ovom istraživanju, odnose se prije svega na skaliranje uloženog mentalnog napora kao metode posrednog ocjenjivanja percipirane teškoće pri učenju nekog materijala (Paas, 1992). Unatoč

kontroverznim shvaćanjima u pogledu učinkovitosti samoprocjene mentalnih procesa istraživanja su pokazala da su učenici sposobni dodijeliti numeričku vrijednost uočenoj razini mentalnog napora (Paas, 1992). Paas i sur. (1994) navode da su jednodimenzionalne ljestvice kojima učenik procjenjuje mentalni napor najpouzdanija i najosjetljivija metoda za procjenjivanje relativno malih razlika u kognitivnom opterećenju. Većina ljestvica koje se koriste za procjenu mentalnog napora definira se u rasponu od 1 do ili od 1 do 9, kao Likertova ljestvica u intervalu od vrlo niskog do vrlo visokog kognitivnog opterećenja (Musallam, 2010).

Cilj istraživanja

Cilj ovog istraživanja jest sagledavanje utjecaja razine konteksta u problemskim zadatcima kemije na učeničko postignuće i samopercipirano kognitivno opterećenje.

Metodologija istraživanja

Problem istraživanja

Iako su provedena brojna istraživanja u području učenja utemeljenog na kontekstu, područje kontekstualiziranih zadataka još uvijek nije dovoljno istraženao. Prema tome ne postoji dovoljno dokaza za tvrdnju da bi zadatci bogati kontekstom mogli voditi povećanju performansi učenika, pa su neophodna daljnja istraživanja u tom području. Ovim istraživanjem željeli smo ispitati učenička postignuća i samopercipirana kognitivna opterećenja kako bismo dobili informacije o učinkovitosti kontekstualiziranih zadataka. Osim toga, željeli smo ispitati ima li količina konteksta utjecaj na ispitivane varijable. Stoga smo istraživačka pitanja oblikovali na sljedeći način:

P1: Postoje li statistički značajne razlike u uspješnosti učenika u različitim skupinama zadataka (bez konteksta, s umjerenim i bogatim kontekstom)?

P2: Postoje li statistički značajne razlike u učeničkom percipiranju kognitivnog opterećenja u različitim skupinama zadataka (bez konteksta, s umjerenim i bogatim kontekstom)?

Ispitanici

Uzorak je biran prigodno. Čini ga 161 učenik osnovne škole (50,3 % ženskog spola; 49,7 % muškog spola) kojima je predavao jedan nastavnik kemije. Učenici su bili u dobi između 14 i 15 godina i svi su pohađali osmi razred osnovne škole „Jovan Jovanović-Zmaj", Sremska Kamenica, Srbija. Uzorak je činila pretežno urbana populacija mješovitog socioekonomskog statusa.

Instrumenti i procedure

Istraživanje je provedeno kao neeksperimentalno ispitivanje stanja. Naime, nastavnik je poučavao učenike na uobičajeni, tradicionalni način, nakon čega je provedeno testiranje. U sklopu tradicionalne nastave nastavnik je izvodio nastavu na uobičajen način kombinirajući dijalošku i monološku metodu, nakon čega su učenici pristupili

rješavanju brojnih problemskih zadataka predviđenih kurikulom. Važno je istaknuti da je nastava bila isključivo tradicionalna i nije uključivala aspekte nastave utemeljene na kontekstu.

U ovom istraživanju korišten je test kao mjerilo za ocjenu performansi i ljestvica Likertova tipa za procjenu samopercipiranog kognitivnog opterećenja. Test se sastojao od 18 zadataka, koji su bili dizajnirani u tri razine složenosti konteksta: zadatci bez konteksta, zadatci s umjerenim i bogatim kontekstom. Kompleksnost konteksta varirana je brojem bitnih dodatnih informacija u zadatku. Važne dodatne informacije odnosile su se uglavnom na znanja iz svakodnevnog života, s kojima su učenici upoznati, kao što su primjena određenih tvari, priprema za određene svrhe, posljedice uporabe ili prekomjerne uporabe, ili su bile u vezi s podatcima obrađenim tijekom redovite nastave kao što su svojstva nekih tvari, nalaženje u prirodi ili neke povijesne činjenice. Prema broju važnih dodatnih informacija u kontekstu zadatci su podijeljeni u tri skupine, odnosno tri subtesta unutar testa:

- Zadatci bez konteksta, koji ne sadrže bitne dodatne informacije (subtest 1)
- Zadatci s umjerenim kontekstom u kojima broj bitnih dodatnih informacija varira od dva do tri (subtest 2).
- Zadatci bogati kontekstom u kojima je broj bitnih dodatnih informacija od četiri do šest (subtest 3).

Svi zadatci u ovoj studiji bili su otvorenog tipa i pipadali su nastavnoj temi Otopine i topljivost. Ta tema odabrana je upravo zbog povezanosti s realnim životom i životnim situacijama, jer su pojmovi iz tog područja, uključujući postotni sadržaj otopine, široko rasprostranjeni u različitim aspektima života i s njima se učenici mogu vrlo često susretati u svakodnevnom životu.

Zadatci broj 1, 7 i 13 odnose se na izračun topljivosti tvari na temelju podatka za topljivost tvari i zadane mase otapala. Zadatci broj 2, 8 i 14 odnose se na određivanje postotnog sadžaja otopine na temelju zadane mase rastvorka i mase otapala. Zadatci broj 3, 9 i 15 odnose se na određivanje mase otopljene tvari na temelju zadane mase otopine i zadanog postotnog sadžaja otopine. Zadatci broj 4, 10 i 16 odnose se na određivanje postotnog sadžaja otopine nastale dodavanjem zadane mase otopljene tvari u zadanu masu otopine zadanog postotnog sadržaja. Zadatci broj 5, 11 i 17 odnose se na određivanje postotnog sadržaja otopine nastale dodavanjem zadane mase vode u zadanu masu otopine zadanog postotnog sadržaja. Zadatci broj 6, 12 i 18 odnose se na određivanje postotnog sadržaja otopine nastale miješanjem dviju otopina zadanih masa i zadanih postotnih sadržaja.

U pogledu očekivanih ishoda za nastavnu temu otopine i topljivost, točnije za problemske zadatke, od učenika se očekuje da mogu izračunati postotni sadržaj otopine kao i razumjeti izražavanje kvantitativnog sastava otopine preko postotnog sadržaja. Dakle, može se uočiti da su prikazani zadatci u skladu s očekivanim ishodima.

Svi učenici test su rješavali tijekom dva školska sata, u travnju 2012. godine. Svaki točno riješen zadatak vrednovan je s po jednim bodom, a netočan s nula bodova, pa je maksimalno moguće postignuće na testu bilo 18 bodova. Važno je napomenuti da

je svaki zadatak u subtestu 1 imao odgovarajući zadatak u subtestu 2 i odgovarjući zadatak u subtestu 3, s identičnom procedurom rješavanja, ali s razlikom u broju bitnih dodatnih informacija koje grade kontekst.

Za mjerenje samopercipiranog kognitivnog opterećenja koristila se ljestvica Likertova tipa. Deskriptori Likertove ljestvice bili su: izuzetno lako, vrlo lako, lako, ni teško ni lako, teško, vrlo teško i izuzetno teško. Deskriptori su zatim brojčano kodirani od jedan do sedam, tako da deskriptoru „izuzetno lako" pristaje kod 1, „vrlo lako" kod 2, „lako" kod 3, „ni teško ni lako" kod 4, „teško" kod 5, „vrlo teško" kod 6 i deskriptoru „izuzetno teško" pristaje kod 7.

Autori su primijenili pretest i posttest garante kvalitete prema modelu opisanom u Segedinac i sur. (2011). U okviru pretest garanta kvalitete i ocjene validnosti autori su procjenjivali smislenost zahtjeva zadataka, raznolikost zadataka, upotrijebljenu terminologiju, duljine rečenica. Pretest garante kvalitete prije provedenog istraživanja procjenjivala su četiri eksperta – jedan sveučilišni profesor, dva istraživača u području kemijskog obrazovanja i jedan osnovnoškolski nastavnik kemije. Prema ocjenama evaluatora, zahtjevi zadataka definirani su jasno i precizno, raznovrsni su, a terminologija prilagođena dobi učenika. Rečenice u tekstu prikladne su duljine, što je od osobite važnosti za zadatke s umjerenim i bogatim kontekstom, jer bi duge rečenice u kombinaciji s dodatnim bitnim informacijama, koje čine kontekst u takvim zadatcima, mogle biti ometajući faktor. Posttest garanti kvalitete ocijenjeni su statističkom analizom rezultata testa. Osim osnovnih statističkih parametara testa izračunata je i reliabilnost kao Cronbach's alpha. Indeksi težine računati su kao postotak ispitanika koji su točno odgovorili na stavku, a indeksi diskiminativnosti stavki računati su primjenom ajtem analize između 27 % najuspješnijih i 27 % najmanje uspješnih učenika po modelu Ebel i Frisbie (1991).

Analiza podataka

Dobiveni podaci analizirani su softverskim paketom Statgraphics Centurion XVI i IBM SPSS Statistics 20. Analiza je uključivala Kruskal-Wallis jednosmjernu analizu varijance i post-hoc parne usporedbe nakon KW. Kruskal-Wallis postupkom odredit će se jesu li razlike između analiziranih varijabli (i-postignuća, ii-samopercipirana kognitivna opterećenja) statistički značajne, a post-hoc test utvrdit će koje se vrijednosti uzajamno razlikuju.

Rezultati istraživanja

Kao mjera unutarnje konzistencije izračunat je Cronbach's alpha koeficijent za svaki subtest. Dobivene vrijednosti za postignuća ($\alpha_{s1} = 0,84$; $\alpha_{s2} = 0,83$; $\alpha_{s3} = 0,81$) ukazuju na dobru relijabilnost, a vrijednosti dobivene za samopercipirana kognitivna opterećenja ($\alpha_{s1} = 0,92$; $\alpha_{s2} = 0,91$; $\alpha_{s3} = 0,90$) ukazuju na izvrsnu relijabilnost. Vrijednosti indeksa težina u rasponu su od 36 do 88%, a indeksi diskriminativnosti u rasponu su od 0,46 do 0,98.

U tablici 1 dana je deskriptivna statistika rezultata testa za mjerenje ukupnog postignuća (T_a) i ukupnog samopercipiranog kognitivnog opterećenja (T_{cl}), postignuća u subtestovima ($S1_a$ – subtest 1 postignuća, $S2_a$ – subtest 2 postignuća; $S3_a$ – subtest 3 postignuća) i samopercipiranog kognitivnog opterećenja u subtestovima ($S1_{cl}$ – subtest 1 samopercipirana kognitivna opterećenja, $S2_{cl}$ – subtest 2 samopercipirana kognitivna opterećenja, $S3_{cl}$ – subtest 3 samopercipirana kognitivna opterećenja).

Tablica 1.

Ako promatramo postignuća učenika, može se opaziti da ono opada sa složenošću konteksta. U zadatcima bez konteksta učenici su ostvarili prosječno postignuće 70,68%, u zadatcima s umjerenim kontekstom 59,17%, a najniže su postignuće ostvarili u kategoriji zadataka bogatih kontekstom (57,17%). Slični rezultati dobiveni su i za samopercipirana kognitivna opterećenja. Učenici su ocijenili subtest 1 ukupnim prosječnim opterećenjem 20,81 (3,47 po zadatku). Subtest 2 i 3 procijenjeni su sličnim kognitivnim opterećenjem 23,16 i 24,20, odnosno 3,86 i 4,03 po zadatku, respektivno. Da bi se odredilo potječu li dobiveni rezultati iz normalne distribucije, napravljeni su Saphiro-Wilk i Levene's test homogenosti varijance postignuća i samopercipiranog kognitivnog opterećenja za svaki test. Ti su testovi pokazali da rezultati ne potječu iz normalne distribucije. Stoga je s ciljem utvrđivanja značajnosti razlika za postignuća i samopercipirana kognitivna opterećenja za tri skupine zadataka napravljen odgovarajući neparametrijski test, Kruskal-Wallis jednosmjerna analiza varijance. *P*-vrijednosti dobivene tom analizom manje su od 0,05 (0,0003 za postignuća i 0,0008 za samopercipirana kognitivna opterećenja) i ukazuju na statistički značajne razlike kako u postignuću tako i u samopercipiranom kognitivnom opterećenju između različitih skupina zadataka (bez konteksta, s umjerenim i bogatim kontekstom).

U prlog tome, da bi se odredilo koje vrijednosti su međusobno različite, učinjene su post-hoc parne usporedbe nakon K-W. Rezultati su prikazani tablično (tablica 2).

Tablica 2.

Rezultati neparametrijskih post-hoc usporedbi pokazali su da postoji statistički značajna razlika u postignućima u zadatcima bez konteksta (S1) i zadatcima s umjerenim kontekstom (S2), kao i u postignućima u zadatcima bez konteksta i zadatcima bogatim kontekstom (S3), a između zadataka s umjerenim i bogatim kontekstom ne postoji statistički značajna razlika. Slično tome isti je test pokazao da je razlika u samopercipiranom kognitivnom opterećenju između zadataka bez konteksta (S1) i zadataka s umjerenim kontekstom (S2) kao i između zadataka bez konteksta i zadataka bogatim kontekstom (S3) statistički značajna, a razlika u kognitivnom opterećenju između zadataka s umjerenim i bogatim kontekstom nije statistički značajna. U daljnjem tekstu u tablici 3. dat ćemo primjer tri zadatka i ukratko ih komentirati. Ti zadatci prema složenosti konteksta pripadaju različitim kategorijama, ali imaju identičan postupak rješavanja.

Tablica 3.

Kao što je prethodno spomenuto sva tri prikazana zadatka imaju identičnu proceduru rješavanja, ali različit broj dodatnih informacija koje čine kontekst. Prvi zadatak sadrži samo one informacije koje su neophodne za rješavanje problema. Drugi zadatak uz neophodne informacije sadrži i tri dodatne informacije. Prva se odnosi na klasnu pripadnost, druga na svojstvo spomenute tvari – topljivost i treća na njezinu primjenu u medicini. Budući da taj zadatak sadrži tri dodatne informacije, on pripada kategoriji zadataka bogatih kontekstom. Sljedeći zadatak osim navedenih dodatnih informacija sadrži još jedan podatak, pronalaženje u prirodi. Stoga, kako taj zadatak sadrži četiri dodatne informacije, on pripada skupini zadataka s bogatim kontekstom.

U pogledu indeksa težine za dobivene zadatke, postignuti su slijedeći rezultati – 0,62 za zadatke bez konteksta i 0,52 za zadatke s umjerenim i zadatke s bogatim kontekstom, što ukazuje na to da su oba zadatka bez obzira na količinu konteksta bila jednako teška učenicima. Osim toga, sva tri zadatka imaju vrlo dobre indekse diskriminativnosti 0,82, 0,89 i 0,91 respektivno.

Rasprava

Ovim je istraživanjem pokazano da povećanje konteksta u zadatku vodi smanjenju učeničkog postignuća, a povećanju samopercipiranog kognitivnog opterećenja, osim u slučaju zadataka s umjerenim i bogatim kontekstom u kojima se pokazalo da razlike i u postignućima i u samopercipiranim kognitivnim opterećenjima nisu statistički značajne. Može se zaključiti da obimnost konteksta uzrokuje znatno niža učenička postignuća i istodobno znatno viša kognitivna opterećenja. Rezultati dobiveni za samopercipirana kognitivna opterećenja ukazuju na to da su učenici svjesni težine zadatka i kognitivnog opterećenja, koje nameće kontekst različite razine složenosti. Važno je spomenuti da većina učenika koja nije bila uspješna u rješavanju zadataka bogatih kontekstom također nije bila uspješna ni u rješavanju zadataka s umjerenim kontekstom. Shodno tome, učenici koji su bili uspješni u rješavanju zadataka s umjerenim kontekstom, bili su uspješni i u rješavanju zadataka bogatih kontekstom. Takvi zadatci obiluju informacijama i za njihovo uspješno rješavanje potrebno je razlučiti relevantne podatke i na njih usmjeriti pozornost, što zahtijeva ulaganje dodatnog mentalnog napora. Te zadatke učenici ocjenjuju kao teške i svrstavaju ih u kategoriju zadataka s visokim kognitivnim opterećenjem. Prema našim spoznajama provedeno je vrlo malo istraživanja u području ispitivanja utjecaja konteksta putem kontekstualiziranih pitanja iz znanosti. U radu Heller i Hollabaugh (1992) postignuća u zadatcima s kontekstom i bez njega nisu izravno mjerena, ali autori su došli do zaključka da su kontekstualizirani zadatci usmjeravali učenike principima i zakonima neophodnim za rješavanje problema, a tradicionalni su zadatci usmjeravali učenike na uporabu formula i jednadžbi. Nasuprot tome, Kotovsky i sur. (1985) kao i Mevarech i Stern (1997) došli su do spoznaje da učenici ostvaruju značajno viša postignuća u zadatcima bez konteksta nego u zadatcima bogatim kontekstom, što autori objašnjavaju odvraćanjem pažnje od zahtjeva, ali i time da konteksti iz realnog života prije vode

aktiviranju nekih jednostavnih modela, nego do apstraktnog mišljenja. Naša studija s tri razine složenosti konteksta dala je slične rezultate. Mogući razlog može se naći u nekoliko fizioloških procesa koji se prema Ahmed i Pollitt (2007) odvijaju dok učenici odgovaraju na pitanja. To su: čitanje, pretraživanje, podudaranje, rješavanje i pisanje odgovora. Prema navedenim autorima kontekst bi mogao imati značajan utjecaj na prvu fazu, jer se tijekom te faze oblikuju brojne mentalne reprezentacije, od kojih su mnoge irelevantne za proces rješavanja problema. To znači da se od učenika očekuje da razlikuju potrebne od nepotrebnih informacija, što uzrokuje značajno više kognitivno opterećenje. Naša studija, u kojoj je mjereno samopercipirano kognitivno opterećenje pri rješavanju zadataka različite razine složenosti konteksta, to je i potvrdila.

Još jedan fenomen u vezi s čitanjem, koji bi trebalo spomenuti, jest problem funkcionalnog čitanja kod učenika. Razumijevanje pročitanog predstavlja područje u kojoj se učenici iz Srbije ne snalaze dovoljno dobro. U prilog tim tvrdnjama govore i podaci PISA testiranja (OECD, 2010) koji će ovdje biti ukratko komentirani. Između PISA zadataka i kontekstualiziranih zadataka moguće je zapaziti izvjesne sličnosti. Naime PISA format za procjenjivanje čitalačke pismenosti učenika usredotočen je na vještine koje uključuju pronalaženje, odabir, interpretaciju i vrednovanje informacija iz širokog tekstualnog konteksta, koji je u vezi sa situacijama iz svakodnevnog života. Slično tome, kontekstualizirani zadatci uključuju dodatne informacije iz svakodnevnog života, i za njihovo uspješno rješavanje neophodno je da učenici posjeduju prethodno spomenute vještine. Rezultati PISA testiranja iz 2009. pokazuju da je čak 33,9 % učenika u Srbiji ispod razine 2, koja se smatra osnovnom razinom na kojoj učenici počinju demonstrirati vještine čitanja i kompetencije koje će im omogućiti da učinkovito i produktivno sudjeluju u životu, radu i socijalnim aktivnostima. Na ukupnoj ljestvici čitanja (OECD, 2010) s 442 boda naši su učenici ostvarili značajno niže postignuće od OECD prosjeka, koji iznosi 493 boda. Prema tome, uzrok nižih postignuća učenika u zadatcima s umjerenim i bogatim kontekstom može se prepoznati i u slaboj funkcionalnoj pismenosti ispitanika. Rezultat toga je da učenici mogu biti demotivirani i obeshrabreni pred zadatcima s dužim tekstom i unaprijed odustajati od takvih zadataka i proglašavati ih vrlo teškim.

Zaključak

Budući da su se prethodna istraživanja u području učinkovitosti kontekstualiziranih zadataka bavila općenito ispitivanjem učeničkih postignuća, ovim istraživanjem htjeli smo dati doprinos dosadašnjim spoznajama u ispitivanju napora koji učenici ulažu tijekom rješavanja zadataka bez konteksta, s umjerenim i bogatim kontekstom, kako bi se dobila informacija o kognitivnom opterećenju koje stvara kontekst.

Dobiveni rezultati koji ukazuju na to da su zadatci bogati kontekstom uzrok nižih postignuća i istodobno viših kognitivnih opterećenja imaju značajne teorijske implikacije. Naime, bilo bi važno dalje ispitati kako sposobnost funkcionalnog čitanja utječe na rješavanje kontekstualiziranih zadataka. Zatim, trebalo bi ispitati odnos

između učeničkih predznanja i uspješnosti u rješavanju zadataka bogatih kontekstom, kao i odnos između predznanja i mentalnog napora tijekom rješavanja takvih zadataka. Na kraju, vrlo važno bi bilo dublje ispitati motivacijske faktore uvjetovane kontekstom, odnosno ispitati u kojoj bi mjeri kemija trebala biti prisutna u kontekstu, a u kojoj u konceptu, kako bi se poboljšao proces učenja.

Ipak, ova studija ima i nekoliko nedostataka koje bi trebalo naglasiti. Prvo ograničenje tiče se same prirode zadataka. Naime, pri konstrukciji kontekstualiziranih zadataka najvjerojatnije će se javiti nedostatak uslijed stupnja bliskosti s konceptom, jer nekim učenicima kontekst može biti manje, a drugima više poznat. Ostala ograničenja ogledaju se u uzorku ispitanika i gradiva, budući da je ovim istraživanjem obuhvaćena samo jedna osnovna škola u Republici Srbiji i pokrivena samo jedna nastavna tema – Otopine i topljivost. Stoga je u daljnjim istraživanjima potrebno obuhvatiti još škola (nastavnika) i više tema.

Napomena

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