# E-LEARNING IN CHEMISTRY EDUCATION: SELF-REGULATED LEARNING IN A VIRTUAL CLASSROOM

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## ABSTRACT

The virtual Chemistry classroom is a learning environment for students that are willing to study Chemistry, but have no opportunity to do so at school. The program launched in 2015, and currently, there are 22 students in the 11th grade and 80 students in the 10th grade.

This study investigates and characterizes the virtual learning environment, students' learning profiles and self-regulated learning processes, and tries to establish a connection between these variables.

Self-regulated learning skills (SRL) help cope with learning and learning progression. Comparing students' SRL skills and strategies whilst studying Chemistry in two different learning environments (face to face and virtual classrooms), may result in answering the questions: what are the needed skills and strategies in order to be successful in the virtual Chemistry environment, and can one predict which student will do well studying in a virtual learning environment, based on their SRL profile? Can these skills be developed in a virtual environment using aids, and what aids can contribute to acquisition of SRL skills?

Initial results indicate that there are small differences in some SRL categories between control and intervention groups. Significant differences were found in intervention students chat activity over time, and in their ability to answer different level questions (categorized by Bloom's Taxonomy). These findings were used to build a student profile and advance understanding of the correlation between course characteristics and the SRL of students in the program. The students will be followed over a period of 3 years, and the link between SRL and their ability to answer higher level questions in Chemistry will be further investigated.

## 1. INTRODUCTION

E-learning is becoming a major tool in the educational world, and therefore holds great importance. This study deals with the construction and implementation of a virtual Chemistry class for high school students. The virtual Chemistry classroom is a solution for those students that are willing to expand their knowledge of Chemistry, but have no opportunity to do so in their school.

Tallent-Runnels, et al. (2006), summarize 76 research papers regarding students encountering E-learning and conclude that students preferred flexibility, convenience and autonomy of individual pacing, although it required self-management. It was found that E-learners had the same level of both comprehension and higher thinking skills as their peers who studied in a face-to-face classroom environment.

Self-regulated learners (SRL) are defined as those who proactively seek out information, and take the necessary steps to master it (Zimmerman, 1990). Self-regulated learners are conceptualized as metacognitive, since they plan, set goals, organize, self-monitor, self-evaluate during the learning process. They are motivated and hold high self-efficacy, engage in self-attributions and have intrinsic task interest, and are behaviorally active participants in their learning processes (Zimmerman, 1989; 1990; 2008; Pintrich & De Groot, 1990). Self-regulated learning skills are important in all learning environments, especially in a virtual learning environment, since it lacks the immediate ability to seek help from teachers (Cho, 2004; O'Neill, Singh & O'Donoghue, 2004; Tsai, 2011). It is equally important to challenge high achievers, to help them gain deep understanding of the material, and to support low achievers in monitoring and regulating their

learning (Kramarski & Michalsky, 2013). In order to self-assess SRL skills, a Likert type questionnaire, containing 80 items attributed to ten different categories was developed by Weinstein, Palmer & Shulte, (2002): Learning and Study Strategies Inventory (LASSI). In this research, a modified and translated form of the LASSI questionnaire was used, with 48 items related to six categories out of the original ten categories: attitude and interest; concentration and attention to academic tasks; motivation, diligence, self-discipline, and willingness to work hard; use of support; time management principles for academic tasks; test strategies and preparing for tests.

The main purposes of this research are to follow the development of student's SRL skills studying Chemistry in a virtual environment, to portray the characteristics of a student suitable for studying in such an environment and to determine the efficiency and necessity of virtual learning of Chemistry.

## 2. COURSE DESCRIPTION

A three year virtual Chemistry course was designed, in which each student attending, had weekly synchronic and a-synchronic lessons, tutoring online lessons, home-labs and science camps (containing inquiry labs and lectures). All assignments for the virtual Chemistry course were designed with consideration for the development and progress of SRL and thinking skills according to Bloom's Taxonomy (Collins et al 1992; Churches, 2008).

## 3. THE RESEARCH

### 3.1 Research Questions

1. What are the characterizations of the virtual Chemistry course (teaching, student profile and development and course changes)?
2. What are the characterizations and differences between SRL of the research participants (9th grade science students, 10th grade face-to-face Chemistry classroom students and 10th grade virtual classroom Chemistry students).
3. Is there a correlation between the intervention students' (the 10th grade students' in the virtual Chemistry class who chose to major in Chemistry) SRL and the level of success in the virtual Chemistry course?

### 3.2 Method

#### 3.2.1 Participants

Table 1. Research groups

| Phase | | 1 | 2 |
|---|---|---|---|
| Group | Pre | Control | Intervention |
| N | 109 | 17 | 24 |
| Grade | 9 | 10+11 | 10+11 |
| Purpose | baseline scores | comparison | Research |
| LASSI questionnaire | end of 9th grade | -End of 9th grade ; -After experiencing a computerized unit; -After the first semester of the 11th grade | -Beginning of the 10th grade; -End of the 10th grade; -After the first semester of 11th grade |

#### 3.2.2 Instruments and Analysis

Tests, graded assignments and questionnaires, paired comparison tests for each student, t-test comparisons between the research groups, and a-parametric tests within the intervention group were used as the quantitative means of analysis. Analyzing chat conversations and in-depth interviews are the qualitative means of analysis (Beyth-Marom, & Ellis, 1986; Chi, 1997; Shkedi, 2011).

# 4. RESULTS AND DISSCUSION

No significant differences were found between the t-test analyses and a-parametric tests performed for the two groups in order to track individual differences per student, and between the intervention and control group after answering the first unit a-synchronic assignments. This result indicates that the starting point for all students is the same at the beginning of the research.

Overtime, significant differences in the ability of the intervention students' to answer different types of questions, of different thinking skill levels according to Bloom's Taxonomy were found as shown in Table 2.

Table 2. Means and significance of development of thinking skills (full $10^{th}$ grade; one semester $11^{th}$ grade)

| grade | Means and significance of question category | | | | | |
|---|---|---|---|---|---|---|
| | Knowledge | Comprehension | Application | Analysis | Synthesis | Evaluation |
| 10 | 83.427*** | 72.549*** | 77.001** | 70.027*** | 42.906* | 44.679** |
| 11 | 78.003 | 79.222** | 71.677*** | n.r.[1] | 86.271* | 90.973*** |

*p<.05. **p<.0005. ***p=.0001. p (significance)
[1] Since there was only one question in this category no repeated measure calculations were possible.

## 4.1 Student Profile

Students were divided in three groups (high, medium and low achievers) according to their $10^{th}$ grade annual scores. A weak but significant positive correlation between effort mark (calculated with consideration to all non-mandatory tasks, in order to establish effort hierarchy amongst students) and final grade of $10^{th}$ grade was found (Pearson Correlation Coefficients 0.40232, $p < 0.0305$). There was no correlation between LASSI category grades and effort mark, or between LASSI category grades and final $10^{th}$ grade score.

## 4.2 Chat and Forum Messages

Student's messages from the chat area during the synchronic lesson were counted and analyzed. Results shown in figure 1a are significant (Pearson coefficient = 0.65, $p < 0.0118$). Students who were more active in the chat achieved a higher final grade at the end of the first year ($10^{th}$ grade). Figure 1b shows significant correlation between the number of votes cast by students in the synchronic lesson and the number of messages posted in the chat area during these lessons (votes in the synchronic lesson are students' answers to a multiple choice question (arranged as a poll question). Students cast their vote; the teacher reveals the results and explains the answer) (Pearson coefficient = 0.70, $p < 0.00000172$). These results indicate that the more students' are involved during the synchronic lesson (by messaging and voting) their grades improve.
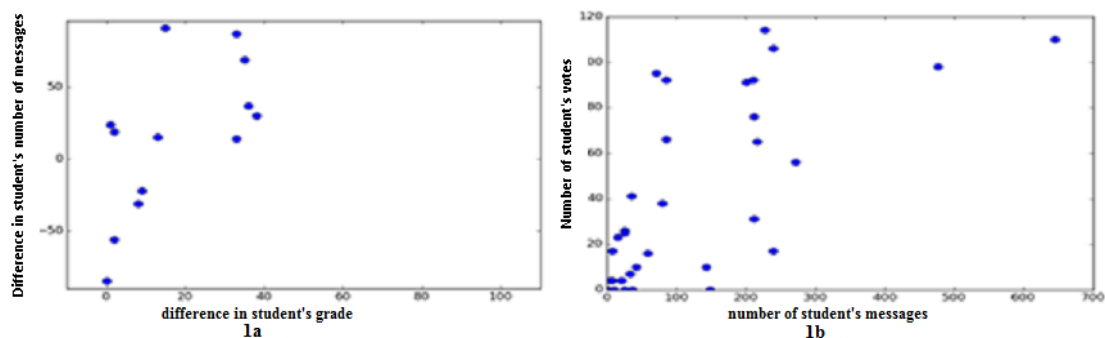


Figure 1. a. Correlation in students' number of messages vs. difference in students' final grades; b. Number of students' votes vs. number of students' messages in synchronic lessons

All students' chat messages during the first year (10th grade) were counted and sorted into five categories according to their content (1. Chemical content messages  2. Technical content messages  3. Social content messages  4. Administrative content messages  5. Other; see figure 2a).

Differences were found between students' messages throughout the year, indicating that changes in their messaging habits and terminology took place. There has been a continuous rise in Chemistry content related messages in the chat area during the synchronic lessons in the first year (10th grade) as seen in figure 2b, as well as a general reduction in technical content-related messages during the first term of the first year (10th grade) (see figure 2c). A continuous rise in social content-related messages during the first year (10th grade) occurred (see figure 2d). This finding indicated formation of a social network between the students.
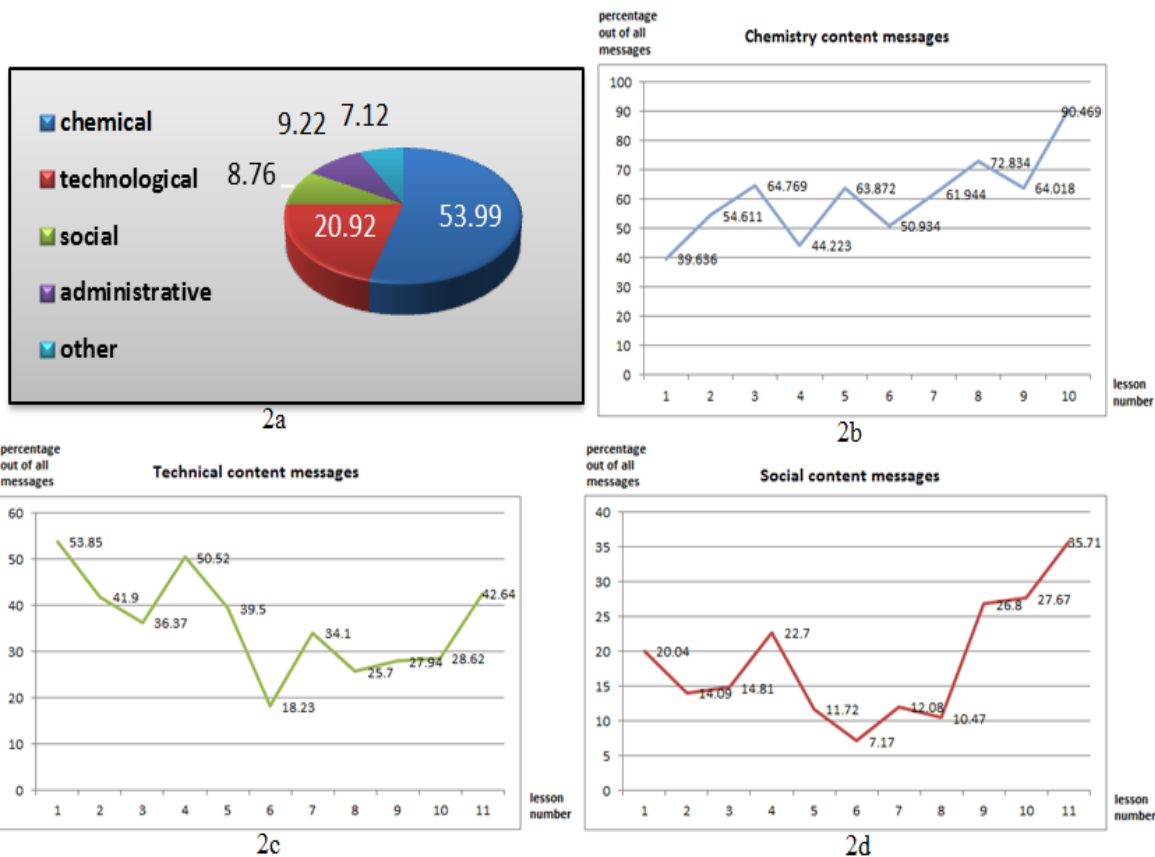


Figures 2a-2d.  a. Relative percentages of chat messages per category (10th grade) in synchronic lessons;
b. Percentage of Chemistry content messages;  c. Percentage of Technical content messages;  d. Percentage of Social content messages

## 4.3 LASSI Questionnaires

The average score of the pre-group students (N=109) of the modified LASSI questionnaire in each of its categories was used to set a baseline and track SRL differences (per group) and SRL skill development (per student). Distribution of the LASSI questionnaires took place as indicated in table 1.  A Wilcoxon a-parametric test was performed for each student in the intervention and control groups in order to track changes that have occurred in the period of 1.5 years.  No significant differences between students in the three research groups at the beginning of 10th grade (PRE-LASSI questionnaire) were found.  All students, in all groups, seem to possess the same level of SRL according to the six categories of the modified questionnaire. In table 3, the significant mean score differences for the LASSI questionnaires for each research group are presented (Wilcoxon a-parametric test).

Table 3. Differences between means of LASSI questionnaires: control and intervention-group

| | (PPOST)-PRE mean difference | (PPOST)-POST mean difference |
|---|---|---|
| **Control group** | N = 15 | N = 14 |
| concentration and attention to academic tasks | 0.450** | |
| motivation, diligence, self-discipline, and willingness to work hard | -0.350* | |
| **Intervention group** | N = 7 | N = 8 |
| motivation, diligence, self-discipline, and willingness to work hard | -0.339* | |
| use of support techniques and materials | | 0.250* |

*S<.05. **S<.003   Wilcoxon signed rank S (significance)

In the control group, significant differences were found between the end of first semester of 11th grade, PPOST-LASSI questionnaire, and the beginning of the 10th grade (PRE-LASSI questionnaire): A positive significant change in concentration and attention to academic tasks: $p < 0.003$; a negative significant change in motivation: $p < 0.0310$. In the intervention group, there are significant differences over the same period, in one category: A negative significant change in motivation: $p < 0.05$. In addition, a positive significant change in use of support techniques and materials was observed between the PPOST LASSI questionnaire and the POST-LASSI questionnaire: $p < 0.05$.

# 5. CONCLUSION

The virtual Chemistry class enables students to study Chemistry while developing SRL during their studies and although the students were from all over the country, social networking took place. According to Piller, (2014), one of the biggest challenges in on-line environments is not only to initially engage students but also to sustain the motivation throughout the course. In both groups (control and intervention), motivation declined (more so for the control group). Several factors may explain this: students may have chosen poorly, resulting in disappointment; novelty decreased over time; difficulties in coping with subject matter (increasing level of difficulty and time issues). For the intervention group, one may add: bad synchronization with school schedule, need for more interaction in the learning process (teacher and peers), and technological problems. In the control-group alone, the positively significant change in concentration and attention to academic tasks can be a result of the fact that the groups' preparation for their matriculation exams at the end of this year (as opposed to the intervention group that are to be tested at the end of the 12th grade). In the intervention group alone, the positively significant change in use of support techniques and materials can possibly be explained by understanding the nature of learning processes in the program: students are more resourceful and use external resources (such as, internet links and searches) in order to find relevant material to support their studies in any topic, and use the internal course resources more than other students. Students possessing higher SRL skills seem to do better than students with lower SRL skills. These students who are more involved use the provided course materials and summarize the lessons, all of which have a positive effect on the students' scores.

Future research will supply more sufficient results and it is hoped to support evidence collected until now regarding the connection between the students' SRL and the level of success in the virtual Chemistry course.

# ACKNOWLEDGEMENT

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