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Organizing learning and teaching in online information-rich environment: Higher education chemistry courses for teachers and students

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שבט תשפ"ב

Abstract

This dissertation examines chemistry teachers' and undergraduate university students' learning patterns in online chemistry courses. Online learning is not new; however, it has gained momentum in the Internet age, which accelerated in the wake of the Covid-19 pandemic. On the one hand, the advantage of online courses is that students can learn from anywhere, at any time. On the other hand, studies indicate that students' completion rate is lower in online courses than in face-to-face learning. The main goals of this study are to identify learning patterns that can predict students' successful completion of online chemistry courses and develop tools for evaluating online courses using the theoretical frameworks of engagement and self-regulated learning. Self-regulated learning can be defined as the learners' ability to act independently, be active, and manage their learning process. Self-regulated learning is essential in all forms of learning, but it is of even greater importance in online learning, given its flexibility.

The study was conducted in two stages: The first stage is descriptive; its purpose is to characterize the learners according to their learning patterns in the online learning environment. This stage relied on qualitative and quantitative research methods. The second stage of the study, the prediction stage, relied mainly on quantitative methods. Key study findings include two models developed to determine whether learners will complete the course.

The study was based on data collected from chemistry courses at two academic institutions: the Open University and the Weizmann Institute of Science. The Open University data spanned seven cycles of online chemistry courses over three academic years (2017-2020), in which 954 students were enrolled. The Weizmann Institute data spanned three online course semester-long cycles over three academic years (2016-2019), in which 95 teachers were enrolled for professional development. The descriptive stage, in which the learning patterns were characterized, was based on interviews with participants registered in any of those courses. In addition to the interviews, the teachers' learning patterns were analyzed based on the reflective summary and final course assignments.

The analysis was underpinned by several characteristics of self-regulated learning theory: goal setting, the learning environment, learning strategies, time management, help-seeking, and self-evaluation. From the Weizmann Institute course analysis, we

learned about new learning patterns that we presented through five case studies. These patterns include, for example, continuous learning from week to week, completing the course in intervals, or completing the course all at once: “binge-watching” the course.

Next, the qualitative analysis of learning patterns in several chemistry courses was analyzed using log files extracted from the Moodle learning management system. These log files are reports detailing learners’ various actions on the course website without compromising their privacy. The data in these reports include (but are not limited to) dates on which each learner was active, their number of visits to the website, and whether, when, and how many times they accessed the course activities. In addition, the research dataset includes demographic information and data on the learners’ achievements, which, together with their online activity data, provide a holistic picture of the learners’ characteristics.

Quantitative data analysis using EDM methods is a complex process. When we began to receive the log files and combine them with the demographic and academic achievement data, we found that the raw data were unsuitable for direct analysis. Rather, they required preliminary processing and testing. The methodology chapter describes the method we developed to manage and undertake the initial processing of the data collected. This method includes four main stages: data gathering, data interpretation, database creation, and data organization – where each stage consists of several sub-stages. The development and use of this method revealed that early pre-processing of the data could prevent considerable inaccuracies in the research findings and significantly strengthen the reliability of the resulting conclusions.

The descriptive (first) stage laid the foundation for the analysis stage, in which we identified various parameters that contribute to the successful completion or non-completion of the course. In the second stage of the research, by analyzing the Open University courses’ log files, we constructed two logistic regression models to identify unique variables that can predict whether the course will be successfully completed. The models indicate that two factors are strong predictors for completing the course: (i) the submission status of the first optional assignment in week 5 of the course and (ii) the student’s cumulative video opening pattern (SCOP) by week 7. The logistic regression model we applied in the analysis of the Weizmann Institute’s courses indicates that students’ cumulative video opening pattern by week five strongly predicts course completion.

We also evaluated the learning outcomes and difficulties at the Weizmann Institute, where we studied the “Introduction to Materials and Nanotechnology” online course for teachers PD. These factors facilitated meeting another goal of the research: developing evaluation tools for online courses for teachers’ professional development. To this end, we developed a framework that combines educational data mining methods with traditional evaluation tools. This grouping leads to a multi-dimensional evaluation framework that considers 1) knowledge, 2) the complexity of learners’ understanding, and 3) identifying learners’ struggles. The first facet was evaluated using the pre-post knowledge questionnaires, the second using the structure of observed learning outcomes (SOLO) taxonomy to analyze the course assignments, and the third by analyzing the online Moodle log files and semi-structured interviews. This multi-dimension evaluation tool allowed us to assess how teachers have expanded their knowledge and skills in subjects that are not part of the high-school science curriculum. Examining the teachers’ learning patterns in the online video lessons, we identified the more challenging topics resulting in course non-completion.

This study has potential applications for researchers, lecturers, and learners. Our qualitative analysis can be used to develop and update existing SRL questionnaires to make them more relevant for evaluating learning in online settings. Our quantitative analysis, particularly the models we developed, can improve learning evaluation already in the middle of the course rather than only at the end. These models also make it possible to design future intervention research strategies. As for learners, we wish to emphasize the importance of developing their self-regulated learning and to show how their learning process choices affect their potential to complete the course.