ONLINE NANOTECHNOLOGY COURSES FOR TEACHERS: LEARNING EVALUATION AND LEARNING PATTERNS

This study examined chemistry teachers' online learning in a nanotechnology course delivered through an information-rich environment Moodle website. The website consisted of several technological tools: video lectures, a discussion group, topic-related animations, and a collaborative Padlet board. Three cohorts that comprised 96 teachers participated in this course in 2016-2019. The main goals of the research were to evaluate the course and explore how different learners use the course materials. Evaluation tools included a) Pre-post questionnaires that examined teachers' knowledge of nanotechnology concepts. b) The "SOLO" taxonomy (Structure of the Observed Learning Outcome) that classified learning outcomes in terms of their complexity. c) Analysis of teachers' online activity reports. These reports included various data on learner activities in the course website, which reflected students' behavior and identified which activities drew the most attention. d) Interviews with teachers that revealed how they organize their learning activities. Our findings show that: a) The course was effective in improving teachers' knowledge of nanotechnology concepts. b) Teachers used learning materials in various ways and participated in higher rates in units relevant to the high-school curriculum. c) Several teachers returned to the course website after its completion when preparing their own classes. We can conclude that future online professional development courses should strive to maintain a strong link between their content and the existing curriculum, and remain available for teachers long after their completion, even with extracurricular topics such as nanotechnology. These findings contribute to designing the curriculum of future online nanotechnology courses in terms of the intended learning outcomes. They also highlight an important advantage of analyzing online activity reports for course design and evaluation.

Keywords: Data Logging, Web-Based Learning, Chemistry Education

INTRODUCTION

We present the integration of nanotechnology in science education, which in recent years has become an elective unit for the high-school chemistry curriculum (Authors, 2016; Delgado, Stevens, Shin, & Krajcik, 2015). This is reflected in the appearance of numerous new innovative courses for teachers and students (Dori, Dangur, Avargil & Peskin, 2014; Barak & Watted, 2017). Nanoscale materials have specific physical and chemical properties that depend on size. Understanding these properties is a challenge at the high-school level. Specially developed face-to-face and online courses in the field can be used to introduce teachers to the nano world (Authors, 2013). The online teaching method has a number of advantages. These include time flexibility, accessibility, and visibility (Bouhnik & Marcus, 2006). Yet it also has a few disadvantages such as a high dropout rate and lack of direct learning interactions (Dutton & Perry, 2002). Many online courses rely on a learning management system (LMS). The LMS enables the lecturer to create an information-intensive course that includes diverse learning resources such as presentations, quizzes, videos, and a students' discussion platform. The LMS can help overcome some of the disadvantages mentioned above by facilitating discussions, chats, and synchronic videos. Another advantage of online courses for educational researchers is the available data that can be analyzed and can present aspects of learner behavior, study patterns, and engagement (Baker & Inventado, 2014).

In this study, we examined one online professional development course: "Introduction to Materials and nanotechnology for Teachers". This course was designed to present contemporary scientific topics and to introduce nanoscale science and technology (NST) based on previous research (Authors, 2015). This online, semester-long course took place in 2016, 2017, 2018-2019 for 96 high-school chemistry teachers. Based on the Moodle environment, the course included video lectures, animations, a course forum, and a collaborative

Padlet board. Our aim is to evaluate the course and explore how different learners use the online course materials.

RESEARCH METHOD AND DESIGN

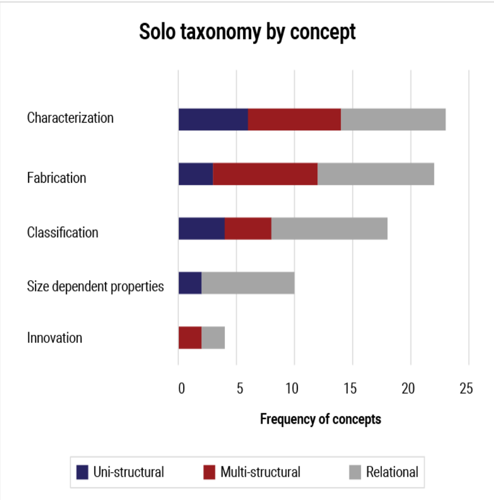
This study implements a mixed methods approach that combines qualitative and quantitative methods. We evaluate learning outcomes by implementing a pre-post questionnaire and the "SOLO" (Structure of the Observed Learning Outcome) taxonomy, which classifies learning outcomes in terms of their complexity. There are five levels to the taxonomy: Pre-structural - lowest level (1), Uni-structural (2), Multi-structural (3), Relational (4), and Extended Abstract - highest level (5) (Biggs, & Collis, 2014). In the final assignment, participants were asked to find examples of nanotechnology in the internet and describe the application with three concepts that they learned in the course. We analyzed their answers according to the five levels of the SOLO taxonomy. We used educational data mining methods to analyze Moodle's course activity reports and learn about usage levels of the learning materials. In addition, we conducted 13 semi-structured interviews to hear from teachers about learning patterns in the online course. We used this data to triangulate with the learning patterns data received from the Moodle log files. We followed ethical guidelines and coded the learner's identification details before the analysis.

FINDINGS AND DISCUSSION

a) Pre-post questionnaire: we applied the Wilcoxon signed rank test to the overall difference between the average pre- and post-test answers ($p < 0.05$). We found a significant improvement in understanding 8 of 9 NST concepts. b) Solo Taxonomy presents the NST concepts that teachers choose to use in the final assignment. We can see that the complexity of understanding in each concept is between Uni-Structural (2) and Relational (3), as shown in Figure 1. The understanding is not in the lowest or highest level Pre-Structural (1) or Extended Abstract (5). c) The Moodle reports included various data on learner activities that reflected students' behavior and identified which activities drew the most attention. From analyzing the video usage, we found that the group participation stabilized after the middle of the course. We also found that the teachers' rate of participation was higher in units related to the high-school curriculum. Figure 2 presents the access level of learning materials for teachers who completed the course and those who did not complete the course. In addition, when we checked the relationship between learners' achievement according to the SOLO taxonomy and the usage of learning materials, we found that learners that had a "relational" complex understanding of all concepts used in all videos and quizzes but were not necessarily active in the course discussions. d) Semi-structured interviews - we found different online learning patterns: single access to each video, parallel access to a video and a related quiz for technical convenience, repeated access to videos for a specific interest or for better understanding. We also found that teachers return to the course website a few months and even a year after completing the course. They do so in order to prepare classroom materials, lessons, or to train fellow teachers in nanotechnology.

CONCLUSION

Online professional development courses should strive to maintain a strong link between content and the existing curriculum, and remain available for teachers long after their completion. Our findings highlight the importance of analyzing online activity reports in order to identify the frequency and timing of material usage and their relevance to the curriculum. The analysis from this research identified students' dropout tendency and their level of complexity of understanding (SOLO taxonomy). The research is an example of usage of educational technology by learning through examples. These findings may contribute to the curriculum of future online nanotechnology courses in terms of the intended learning outcomes.



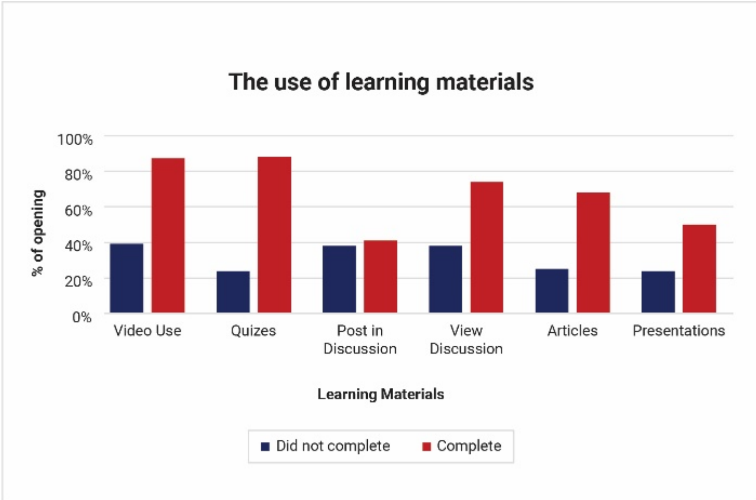


Figure 1: *NST concepts in the final* assignment

Figure 2: Usage levels of learning materials. Blue: teachers who completed the course. Red: teachers who did not complete the course.

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