The aim of the present study was to determine the effect of previous learning experiences in using expert concept maps (ECM) on understanding cell division processes. The study included 219 elementary school students aged 13, whose task was to create their own concept maps (CM) following the same set of guidelines and 30 key-terms. 4 groups of students were distinguished, based on differences in CM application within the learning process. Based on our results, we could conclude that learning based only on ECM demonstration does not contribute to a better students’ understanding when compared to quality teaching without the CM application.

Keywords: concept construction, biological concepts understanding, previous learning experiences

INTRODUCTION

The use of concept maps (CM) for instructional purposes has grown significantly over the last three decades, as they “provide a useful and visually appealing way of illustrating students’ conceptual knowledge” (Jones et al. 2012). They are often used as media for constructive learning activities and as communication aids in lectures, study materials, and collaborative learning (Cañas et al. 2003). Using an ECM as an advanced organizer improves knowledge organization and integration, and enhances deeper understanding (Cutrer et al. 2011). The aim of the present study was to determine the effect of previous learning experiences in using ECM on understanding cell division processes, which have been recognized as a very challenging teaching topic. We hypothesized that the application of ECM during teaching process could help students in continuous learning using the CM, which could then further enhance shaping and organizing of CM by students.

METHOD

The present study encompassed 219 elementary school students (7th graders) aged 13 taught by 4 teachers, which all follow the same curriculum and use the same biology textbooks and ECM. Subsequent to learning on cell divisions, all students were asked to create their own CM following the same set of guidelines and 30 key-terms (Fig. 1). Four student groups were observed: 1) students continuously taught with application ECM and construction of the CM during the learning process (E1, 14%), 2) students who were offered to usage ECM as a support for individual learning (E2, 34%) 3) students who have occasionally experienced a demonstration of ECM during the teaching process (E3, 26%), and 4) students without an experience in teaching with ECM and actively using the CM, but having a basic exercise for their usage (E4, 26%). Based on the guidelines proposed by Novak & Cañas (2008) and following a criterion map, the hierarchical structure, key-concepts and propositions, linking words and cross-links as well as the practical conceptual understanding within each student CM were analyzed and scored (Fig. 1). To enable a simpler verification of the concept acquisition, the key-concepts used within the students’ CM were sorted into the higher-leveled concepts: Inheritance, Reproduction, Mitosis and Meiosis. Because of the low and unequal sample
sizes non-parametric statistical tests were used (Statistica 12). Given that there was only one CM evaluator, the degree of reliability was not specifically determined.

RESULTS

Taking into consideration the basic CM features important for facilitating the conceptual understanding (Novak & Cañas 2008), Kruskal-Wallis test ($H = 19.45; \text{d.f.} = 3, p < .01$) as well as paired between-group comparisons performed by Mann-Whitney test (Figure 1) confirmed the conceptual understanding differences between the four tested student groups, and significantly weaker conceptual understanding of the students belonging to group E3, when compared to the other groups.

![Figure 1](image-url)  
**Figure 1.** Differences in the mean student performance considering the basic CM features important for facilitating the conceptual understanding between the 4 tested student groups supported by paired between-group comparisons performed by Mann-Whitney test.

When compared to other groups, only E1 students showed significantly higher levels of creative thinking and conceptual understanding, which was evident through the diversified CM patterns, i.e., modulated usage of the given key-terms and addition of new relevant terms (i.e., linking words and cross-links) used to explain concepts and to depict connections between the key-concepts, evidencing the level of the student conceptual understanding (Figure 1). Regarding the mean number of the understood concepts ($3.7 \pm 9.6$) (Figure 1), students demonstrated rather weak conceptual understanding, although it significantly differed between the groups ($Kolmogorov-Smirnov$ test, $Z = 3.049; p < .0001$). Considering the higher-leveled concepts, students generally clustered most concepts around Inheritance (44%), whereas at least around Reproduction and Meiosis (18%). Demonstrating understanding up to three concepts more than other groups, E1 students are most successful. (Figure 1). E2 students evidenced to understand in average only 1-2 key-concepts within each higher-leveled concept, except within Inheritance, where they showed slightly better results. These students also depicted the lowest number of linking words and cross-links, but not significantly lower compared to E3 and E4.

DISCUSSION AND CONCLUSIONS

The present study evidences that only students who were continuously taught by means of ECM and systematization of knowledge by creating their own CM have successfully adopted cell-division concepts
foreseen by the curriculum. Schwendimann (2016) suggested that experts often use the same linking words as beginners in constructing CM, but they create more complex CM-patterns. It might also be the case with students in creating CM, because those students with more intense experience in ECM and CM usually exhibit greater success in demonstrating their knowledge within CM. Our results correspond to many previous observations suggesting that implementation of student-created CM greatly enhances students’ identification of internal connections among concepts, and supports the thesis that “the way in which knowledge is structured by an individual determines how it is used” (Mintzes et al. 2005 and references therein). Based on our results, we could conclude that learning based on ECM and/or only their demonstration, does not contribute to a better students’ understanding when compared to quality teaching without the CM application. E2-students showed minimum understanding and linking concepts, because they likely relied on the presented ECM when creating their own CM. As well, they tried to “make a perfect copy” of the ECM, paying more attention to technical details than to their own understanding, which resulted in many mistakes. In learning by means of ECM, a reflection interview as a knowledge integration activity (Tripti et al. 2016), and an expert reference map as an aggregate of several expert-generated maps (Schwendimann 2016) could be included, as it might encourage students in the proper use of ECM. We should definitely further investigate how teachers’ experience in the application and interpretation of the ECM could enhance students’ understanding within the teaching and learning processes.

REFERENCES


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