

Visualization of students' cognitive knowledge in digital concept mapping

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ABSTRACT

Meaningful learning through the creation a digital concept map is the easiest way to gain cognitive knowledge, new information, and possibility how to expand among learners. Only a few empirical studies have been conducted in the field of nursing regarding learning through concept mapping to achieve higher levels of knowledge and digital skills. The study evaluated the student's ability to visualize cognitive knowledge by creating a digital concept map. The objectives were to identify the perception using digital technologies and conceptual mapping, differences and relationships between gender, age, years of study, and branches. We used the ContextMinds program map creation. There were 92 Slovak students of nursing, public health and physiotherapy participated in the study. Data were collected and analyzed using IBM SPSS version 25.0. Perception of learning using digital concept mapping strategy was assessed using descriptive statistics, where paired t-test, analysis of variance (ANOVA) and Chi-square were used. The study found a positive perception of creating the digital concept map, but a low level of digital skills. First-year students took one or more weeks to submit the final version of the concept map in comparison to third-year students who took one or more hours. For second-year students, a creation of a concept map was less problematic than for first-year students. Students prefer standard teaching and learning methods. Healthcare absolvents are required to be proficient in digital literacy. Applying cognitive knowledge to create a digital concept map is a challenging strategy procedure.

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1. INTRODUCTION

Online learning has become an important part of modern education, the importance of which was confirmed during the COVID-19 pandemic [1], [2]. Digital technologies came to the fore and were the driving force in choosing an appropriate teaching method. The educational process was interactive and more focused on digital literacy, which was influenced by the skills of teachers and students [3]. Innovative methods focusing on computer work were used in the distance education. The creation of a digital concept map was one of the methods whose digital skills, critical thinking, and cognitive level were motivating factors for students to use this method [4], [5]. The concept map, derived by Novak and Gowin [6] on the basis of Ausubel's assimilation theory [7] aiming to increase students' opportunities of meaningful learning, contains both cognitive and meaningful components of learning based on the active linking of new knowledge with previous knowledge that is critically connected and stored in long-term memory [8].

Emphasis is placed on the structure of the map and the correct naming of the relationships between the concepts found in the map, which form the content of the student's knowledge. Previous studies [9], [10] have suggested that creating a concept map at the metacognitive level provides students with a "larger format" of knowledge that is meaningful and memorable. Using concept mapping, the teacher tracks knowledge which becomes visible on the map through subsumption, progressive differentiation, and integrative reconciliation. A teacher finds gaps in knowledge that are graphically represented by incorrect or correct connections [11]. A student in the process of creating a digital concept map is active and receptive to new knowledge with critical judgement and independent decision-making [12]. The development of critical thinking in students depends on appropriate teaching method, which is the responsibility of the teacher [13].

In the education of nurses, concept mapping is one of the innovative pedagogical approaches, of which positive results for critical thinking and the support of meaningful learning are confirmed by many authors [14], [15]. By concept mapping, students can remember a larger amount of information, which will be reflected in the pre-clinical assessment as well as in the clinical setting in patient care and determination of nursing interventions in a logical way [8], [16]. Only a few empirical studies have been conducted in the field of nursing regarding learning through concept mapping to achieve higher levels of knowledge and digital skills. The aim of this article is to evaluate the strategy of creating a digital concept map using a software application and its importance in the acquisition of meaningful learning and digital skills in healthcare students including nurses, and to find the differences between chosen variables. We hypothesized that there will be a difference in perception of digital concept mapping and use of software application among health care branches, and year of study.

2. RESEARCH METHOD

2.1. Study design

A quantitative exploratory design was used in this study due to the aim and objectives focusing on digital concept map creation visualizing the cognitive level of students based on Bloom's taxonomy. Learning using terms is the most difficult because it requires a certain mental level of the learner. The creation of a digital concept map began with a focused question that clearly specified a goal that visualized the content of the student's knowledge. The student was able to reach all levels from the cognitive domain. This process was performed at the course of internal medicine and a set topic with all participants.

2.2. Study sample

A purposive sample of nursing, physiotherapy and public health students was selected within the internal medicine course in each branch of the academic year 2021/2022. There were 92 students from the first and third year of nursing, the second year of physiotherapy and public health from a university in Slovakia participated in this study. Students worked in groups on assigned topics. Each group consisted of four to five by-themselves randomly selected students. Students worked in groups on assigned topics. Students did not form groups based on academic output, but preferred friendship within the group.

2.3. Data collection method

An anonymous online survey (LimeSurvey form) approved by the research ethics committee and the university management was used. A link to the questionnaire was emailed via university website to students one week before the end of the semester. The purpose of the questionnaire was to evaluate the concept mapping method in the context of the level of digital skills and meaningful learning among selected university students. The questionnaire contained two major parts: the first part included basic demographic information (age, education, field of study, and year of study). The second part contained questions focused on digital skills and meaningful learning. Currently, there are several developed online concept mapping software such as Minmondo, FreeMind, XMind, WiseMapping, GitMind, and Mindly. The inclusion criteria for the software application selection was its suitability of language mutation (the software had to have a Slovak version), and its user-friendly operation. The skill to use the selected software was supported by available instructional videos from the YouTube channel, where students had the opportunity to work in their own pace and mode. The final set of questions evaluated the creation of a concept map [17], and students' perception of the concept mapping method via software application ContextMinds [18].

This part of the final instrument was formulated based on previous research [19] and modified by the researchers. On a five-point Likert scale, students expressed their perception choosing one of the options: strong disagreement, disagreement, not sure, agreement, or strong agreement. Each question was scored from one to five. A score >4 indicated a positive perception, a score of 3 indicated a neutral perception, and a score <3 indicated a negative perception. In addition, an open-ended question was included in order to assess students' feelings about creating and using concept maps. IBM SPSS version 25.0 was used for statistics and data analysis. The data collection had a good internal consistency of 0.90 Cronbach's alpha. The results are

presented in means and standard deviations. Paired t-test, analysis of variance (ANOVA) and Pearson's correlation coefficient were used to detect statistically significant differences between the selected variables.

2.4. Organization of the study

The creation of the digital concept map took place in an academic environment, in the winter and summer semesters of 2021/2022. Learning objectives, activities and assessment in the context of concept mapping were aligned with the curriculum and the responsible course teacher. Pedagogical activities and concept map outcomes were compulsory for students.

At the beginning of the semester, the software owner and responsible person provided online basic training on concept mapping using ContextMinds [18] to the teachers and students involved in the study. The online training via Microsoft Teams lasted about 2 hours. It included an introduction to the software and the creation of a sample concept map. At the beginning of the semester, after managing the work with the software, the teacher assigned the students a topic with relevant instructions for processing concept map. Students in groups worked on the concept map at home during a period of six weeks of the academic course within the particular semester. At the end of semester, the teacher evaluated the final version of the concept map including cognitive knowledge of students with each group in person within the conditions for successful completion of the course. Finally, the concept map as an innovative teaching method implemented within students undertaking healthcare programs was evaluated using the research instrument described in the chapter 2.3 of the methods section.

3. RESULTS AND DISCUSSION

Nursing students are required to learn and achieve a deeper understanding of complex information through the development of cognitive skills focused on analysis and synthesis. The cognitive component consists relevant ideas of which new material can be acquired through appropriate strategic learning methods [2] and the application of critical thinking [20]. Teaching digital concept mapping is well suited to forming a new generation of health professionals who are critical, active and communicative. The advantage of learning with available digital mapping software is that result can be monitored during the teaching process.

3.1. Sample demographics

The total of 93.5% were 1st degree students, 5.4% were 2nd degree students. The larger number of students were women (92.4%), in comparison to the group of men (7.6%). The average age was 21.3 (SD±2.1) years. The highest number were nursing students (60.9%), followed by physiotherapy students (23.9%), and the lowest number were public health students (14.1%). The highest number were first-year students (35.9%), followed by second-year students (33.7%), and third-year students (29.3%).

3.2. Evaluating students' perception of using digital concept mapping focused on the cognitive knowledge

Ongoing research in nursing education emphasizes the promotion of concept maps to enable the development of critical thinking skills in the first years of study in order to write better nursing care plans [4], [21] and clinical reasoning [22]. Table 1 shows the students' perception of the creation of conceptual mapping and meaningful learning. The highly positive perception was found in dimensions of understanding, analysis, and evaluation. From these results, we can assume that this digital concept mapping method is in accordance with the context of Bloom's taxonomy. The average score of the answers shows that students were more able to combine different types of information (3.08 ± 1.023), increase the level of memorization (2.96 ± 1.02), and summarize previous knowledge and acquire new from different subject (2.78 ± 1.06) than other activities listed in the Table 1.

Analyzing students' perception of conceptual mapping, our results indicate that students the most positively perceive combining different types of information, increasing the level of memorization, and summarizing previous knowledge and acquiring new across different subjects. Concept mapping provided an interactive approach for students to communicate their ideas in collaborative group activities, which facilitated the cognitive process in the learning environment. The advantage of a concept map is that it creates connections between sets of knowledge that can be linked to practice [23]. According to the results of higher-order thinking skills (HOTS), we agree that cognitive development is achieved by acquiring knowledge through collaborative skills in online learning [24]. In contrast, in our results of evaluating the concept mapping method and the cognitive dimension of understanding, students were unable to connect the visualized theoretical level of knowledge with clinical practice (2.32 ± 1.25) regardless of age or gender.

Table 1. Students' perception of the creation of conceptual mapping with an emphasis on the cognitive knowledge (N=96)

Content		M±SD score
1.	The map helps me to increase the level of memorization	2.96±1.02
2.	The map helps me develop analytical skills	2.67±1.05
3.	The map helps me to clearly and systematically link different types of information	3.08±1.02
4.	The map helps me to understand new information in clear comprehensive way	2.60±1.22
5.	The map helps me to link theoretical knowledge with clinical teaching	2.32±1.25
6.	The map helps me to learn in a meaningful way	2.44±1.20
7.	The map helps me to facilitate learning	2.59±1.13
8.	The map helps me to summarize previous knowledge and gain new knowledge across different subjects	2.78±1.06
9.	The map helps me to think analytically and then think critically and solve problems	2.55±1.14
10.	The map helps me to define basic concepts within the new curriculum	2.59±1.07
Total score		26.64±8.43

3.3. Students creating a digital concept map in relation to time

The creation of a digital concept map in relation to the time spent was analyzed after testing of dependencies using ANOVA at the level of significance $p < 0.05$. The distribution of the sample did not show a significant correlation between gender and age. Significant demographic variables in this paper were divided into two categories analyses of variance: year and field of study.

In our research, the time spent to create the final version of the concept map had a significant impact on its completion. Year and degree of study were significantly correlated with the time needed to create a closing concept map. We asked how long it took students to create the concept map through a question with the following options: one or more hours, one or more weeks, and one or more months. In the context of the cognitive evaluation displayed in a final digital concept map, first-year students significantly longer (one or more weeks: $M=2.36$; $SD\pm 0.74$) in comparison to third-year students (one or more hours: $M=1.85$, $SD\pm 0.81$). The higher the grade, the less time students needed to create a concept map ($p=0.031$). Nursing students had significantly more time to develop a concept map ($p=0.001$) in comparison to physiotherapy students. As shown in Table 2, first-year students (testing differences within the year of study), as well as nursing students (testing differences within the branch of study), took longer to complete the concept map than other students. The focus of concept mapping still remains the length of time needed to create a map [25], the application of critical thinking [26], low digital skills or lack of communication [27].

Alsuraihi [2] argued that students may not initially like this method, especially if they have little information and motivation about using concept maps for meaningful learning. Another risk factor that directly or indirectly affects the teaching process is the level of knowledge and information collection during the lessons, which the learner must master in order to form the information in a graphic form using the concept map. One of the conditions of meaningful learning is that new information must complement and be presented alongside that which the student acquired during learning. The ability to visualize the knowledge that the student acquired and supplemented during the lesson by creating a concept map is a meaningful understanding of learning as a whole [16]. Creating a concept map in a digital format did not provide students with everything they needed to achieve the new learning material. According to our results, we can agree that concept maps are effective in increasing critical thinking [8], [28], and digital skills [29].

Table 2. Creating a digital concept map in relation to spent time

Variable		n	ANOVA	p	M	SD
Year of study	First	33	3.606	0.031*	2.36	0.74
	Second	31			2.03	0.71
	Third	27			1.85	0.81
Study branch	Nursing	56	7.082	0.001*	2.27	0.73
	Public health	13			2.23	0.83
	Physiotherapy	22			1.59	0.67

*Significance $p \leq 0.05$; M=median; SD=standard deviation

3.4. Evaluating students' perceptions of digital concept mapping using software

All students were able to create an online concept map with the essential instructions they were given at the beginning of the semester. Finally, students could generate a final version from the software in a format such as pdf and share the material online. Students' perception of creating a digital concept map using software were analyzed by Chi-square (χ^2/p) at a significance level of $p \leq 0.05$. The descriptive statistics are presented in Table 3. More than half of the students (52.2%) found the software easy to use and 1/5 of the students did not need additional information to start the program. The user environment was significantly

more challenging for first-year nursing students compared to higher-year public health and physiotherapy students. First-year students did not like to learn using digital technologies in their further studies.

Creating a digital concept map using a software application was a challenging learning method for students. The low level of digital skills among students in the first year of study and the time spent creating a conceptual map were the reasons for not using this method during the study. The study found that digital skills are absent among students of nursing and the first year of study, which was also reflected in the significantly negative decision to continue this method of learning in higher grades. On the contrary, other study [7] confirmed that the future of education using mobile applications will have a positive effect on student performance as well as interaction in the teaching process [30]. The results indicate the importance of using a digital technology as an educational strategy in the preclinical education of healthcare students, especially in nursing. It is been confirmed that digital technologies have a huge potential to advance learning strategies in healthcare education [3].

The traditional provision of health care and education, where the beginnings of healthcare professional preparation for practice were complicated [31], is gradually being replaced by applications based on artificial intelligence, which work with information and data many times greater than the capacity of the human brain. The advantage of digital technologies is that they are not subject to fatigue failure under excessive load of student. Therefore, it is necessary to develop digital skills and critical thinking already during education using appropriate teaching methods [30].

The educational methods aimed at developing digital skills and competences increase the demands on teachers, whose task is to prepare students for life and work in a digital society. The information technology laboratory (ITL) research showed that the teaching method in the educational environment has a significant impact on developing skills for the 21st century [32]. However, the results of digital economy and society index (DESI) found a low level of digital skills of the citizens of the European Union at 44%. Therefore, the most important factor in the educational use of digital technologies is their mastery by the students and teachers themselves [33]. According to the results, we can agree that concept maps are effective in increasing critical thinking and digital skills. However, this type of learning is significantly absent in our healthcare education system.

Table 3. Students' perception of working with the software to create a digital concept map

Questions	Software evaluation			Study program			Year of study			χ^2/p	
	Answer	Frequencies	%	Nursing	Public health	Physiotherapy	χ^2/p	First	Second		Third
Is easy to use	No	43	46.7	31	5	6	11.259/	20	10	12	6.713/
	Yes	48	52.2	25	7	16	0.024*	13	20	15	0.15216
I had no problem with it	No	31	33.7	21	5	5	1.665/	13	6	12	4.699/
	Yes	61	66.3	35	8	17	0.435	20	25	15	0.950
It provides everything necessary to learn the content of the curriculum	No	54	58.7	35	10	9	7.369/	26	14	14	10.579/
	Yes	37	40.2	21	3	12	0.118	7	17	12	0.032*
I will definitely use it in my study	No	76	82.6	47	12	16	2.391/	32	23	20	7.566/
	Yes	16	17.4	9	1	6	0.303	1	8	7	0.023*
Learning through software is time consuming	No	63	69.6	39	7	17	2.117/	15	26	22	13.779/
	Yes	28	30.4	17	6	5	0.347	18	5	5	0.001*
I need additional information to learn the software	No	78	84.8	50	10	18	1.677/	30	26	22	1.208/
	Yes	14	15.2	6	3	4	0.432	3	5	5	0.547
I don't like learning using digital technology	No	67	72.8	40	10	17	0.363/	29	18	20	7.321/
	Yes	25	27.2	16	3	5	0.834	4	13	7	0.026*
Student statement	"It was not possible to open this page via Wi-fi on campus"										
	"I don't need it"										
	"As I have eye problems, I try to limit my use of technology"										

*Significance $p \leq 0.05$

4. CONCLUSION

Creating digital concept maps in an online environment is an innovative teaching and learning method that brings a new perspective to the education of nurses and the next generation of health professionals. Digital literacy is rightly becoming popular in nursing education. The results of the study showed that current digital technologies and good educational software increase the effectiveness and attractiveness of the educational process in the relationship to meaningful learning and critical thinking. Students better analyze, argue and evaluate visualized curriculum content. However, the results showed that the low level of digital literacy among students is the reason why this method is difficult to implement in comparison to standard learning methods. The digital concept map method is the way to prepare future healthcare professionals to effectively use health information technologies and tools for analyzing,

processing and communication in the context of quality and patient safety. The digital future is changing the way healthcare is delivered and it is vital that all healthcare staff are able to accept this change. It is assumed that digital technology will contribute to the effective education of healthcare students.

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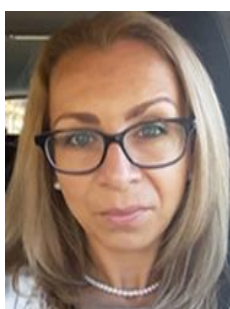
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