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Hülya Yıldızlı[1], **İrfan Şimşek**[1]
[1]İstanbul University- Cerrahpaşa

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The Effects of Software-Aided Mind and Argument Mapping on Learning in Higher Education

Hülya Yıldızlı[1*], İrfan Şimşek[1]
[1]İstanbul University-Cerrahpaşa

Abstract

By carrying out software-aided mind/argument mapping applications in the "Theories of Learning and Teaching" course offered to post-graduate students completing a master's degree in education, the present research aimed to examine the effects of the applications on academic achievement, as well as explore students' opinions on these applications. The research followed a mixed-method design integrating quantitative and qualitative research methods. Participants consisted of post-graduate students (six students) who were taking the course titled "Theories of Learning and Teaching". The experimental process lasted for 12 weeks. The experimental part of the research has been realized in two stages: In the first stage, the students were given the opportunity to learn about and practice preparing software-aided mind and argument mapping applications on computers and tablets for two weeks. In the second stage, participants were instructed about the theoretical dimension of teaching and learning processes and of the software-aided mind and argument mapping. Theories of Learning and Teaching Course Achievement Test, Reflective Diaries, Student Self-Assessment Forms and Semi-Structured Interview Schedules were utilized as data collection tools. The results suggested that the use of software-aided maps in learning and teaching processes has a considerably positive effect on students' academic achievement. Besides, it has been observed that the students acquired various skills with regards to the use of such tools.

Key words: Academic achievement, higher education, software-aided argument mapping and mind mapping

Introduction

The efficiency of learning and increasing productivity of students in an educational environment are considered as high priority goals in today's paradigms concerning learning and teaching. The significance of these paradigms is on the rise at higher education level. It is a significant question as to how the learning experiences of individuals should be, in order for them to develop knowledge in meaningful structures in mind and to be specialized in their own fields. Because of this importance, the paradigms that prioritize the active participation of students in the learning process emphasize the diversity of learning experiences at higher education level. The increasing enrichment in the variety of instruments in parallel with the rise of computer technology provided a fertile ground to nurture new experiences in learning environments. As a result, new software-aided tools came into prominence in learning environments. In the last 15-20 years, software-aided packages that facilitate the visual presentation of linkages (concept mapping, mind mapping or argument mapping), relations and information among different ideas were produced (Davies, 2010). The increase in information and speed gave rise to the need for using those tools with brain-friendly technologies (Buzan, 2016). Then what are these maps? What are their advantages in learning environments?

What is mind mapping?

Mind mapping, developed by Tony Buzan in 1970's, is a technique that enhances learning skills of individuals, their creativity as well as productivity (Mento et al, 1999). Activating certain parts of the human memory, a mind map is a graphic and network-oriented technique that utilizes keywords, images which promote new associations and ideas in order to store and organize a set of information. Each element of memory is activated

* Corresponding Author: *Hülya Yıldızlı, hulyayildizli@istanbul.edu.tr*

by this mind-mapping technique. This is a key aspect to unlock facts, ideas and knowledge as well as to unleash the spectacular potential of human mind (Buzan, 2006). Obviously, mind-mapping is not a simple note taking method. These maps are the non-linear visual representations of the ideas and interrelations of them (Biktimirov & Nilson, 2006) and a network of interrelated concepts. These free-forms are at the same time a means for finding out the creative relations among the ideas (Davies, 2010).

Since there are certain criteria as to how each technique, method and strategy is used, there are also certain rules to be followed in the case of the efficiency and productivity of mind-mapping. According to Buzan (2006; s.144-145), *the mind map has four essential characteristics:*
(1) The subject of attention is crystallized in a central image.
(2) The main themes of the subject radiate from the central image as branches.
(3) Branches comprise a key image or key word printed on an associated line. Topics of lesser importance are also represented as branches attached to higher level branches.
(4) The branches form a connected nodal structure.

Figure 1: Mind map, source: Buzan (2006)

As can be seen in Figure 1, mind maps can be enriched by images, colours and words in the process of mapping. This dynamic structure also presents a kind of individual-specific learning map.

Mind maps can be utilized in almost any sort of activity that contains ideas, planning, or creativity (Buzan, 1989). These maps facilitate the formation of visual images to enhance the learning potential of the students and function as a reflective tool for creating wide associations among the learning materials (Budd, 2004); they also enable learners to evaluate their knowledge (Wandersee, 1987) and provide a better approach for the teachers in order to build up more efficient dynamics with those students who adopt varying ways of learning (Nesbit & Adesope, 2006). Having been utilized in all stages of a course (preparation, introduction, progression, evaluation), mind-mapping can also be useful in processes such as note-taking, problem solving, brainstorming, studying, planning, research, collection of data acquired by various sources, systematic presentation and forming opinions about complicated subjects and so on (Adodo, 2013).

The widespread use of technology in learning environments has enabled these maps to be created using a variety of phones, tablets, PCs or smart boards (see for example, *Elvedere*: Suthers et al.2001; *Digalo*: Schwarzand Glassner 2007; *Reason!Able*: van Gelder 2002, Miro, Mindmeister, Milanote, mind mapping; Figure 2: e-mind mapping). Such software provides a range of features that stimulate mental processes and creativity. Most web-based applications and software:

- Automatically create regular or coloured mind maps: It is easy to create e-mind maps using modern software. There is no space limitation in electronic maps as in handmade maps.
- These maps can be edited and developed at any time: Even after the mind maps have been created, they can easily be adjusted and re-shaped by new ideas.
- They allow for a more convenient analysis and management of data, as they facilitate the use of a range of tools: These maps render interaction with a large quantity of information much easier. As they become a visual and structured interface for accessing information sources, they prevent confusion and provide quicker and easy access to these sources.
- They enable sharing: They offer a wide range of ways to quickly share mind maps with other people (edition, images, web pages, graphics, and pdf).
- They can be transformed into various communication and report formats: it is an effective tool for presenting ideas which are difficult to express on free-hand maps. The software allows for the presentation of maps in several ways, setting up new branches one by one, making interactive presentations or focusing on the specific subjects (Buzan & Buzan, 2016).

Figure 2. E-mind mapping sample (Source: https://www.toolshero.com/effectiveness/mind-mapping-buzan)

What is argument mapping?

As for the argument-mapping, it has a different format from the mind maps. These maps are important tools in revealing the inferential structure of the arguments. Inter propositional inferences are the main characteristics of argument-mapping (Davies, 2010). Argument mapping is the presentation of an argument in which the inferential structure is usually made clear by graphical techniques and these maps are "box" and "arrow" diagrams where the intersecting points correspond to the claims and highlight the evidentiary relationships of these connections (van Gelder, 2002). In an argument map, the argument is visually represented using a visual flowchart in "box-arrow" form; the boxes are for highlighting propositions whereas the arrows are used to highlight inferential relationships that combine the propositions (Dwyer, Hogan, & Stewart, 2012; van Gelder, 2003). On these maps, "boxes-arrows" in different colours can be used to support or object to (because, thus, but, however etc.) a certain argument.

The use of argument-mapping has increased in learning-teaching environments thanks to its ability to provision supportive settings for critical thinking of students (van Gelder et al, 2004; van Gelder, 2015). Enabling students to consider the informational content more critically, argument-mapping also allows students to control their own information structures and increase their meta-cognitive awareness towards learning (Dwyer, Hogan, & Stewart, 2012). By argument-mapping, students (1) develop a better critical attitude towards arguments (2) evaluate any structure of knowledge better (3) become more open-minded in their thinking processes (4) and get considerably better in argumentative writing (Rider & Thomason, 2014).

The use of software-supported argument-mapping in learning environments, similar to mind mapping, has recently become more widespread. The use of diagrams on ready-made software applications makes the learning process more efficient (Davies, 2012; Davies, Barnett, & van Gelder, 2019; van Gelder et al. 2004; van Gelder, 2007; van Gelder, 2015), functional (van Gelder, 2002) and saves on time by providing ready to use templates at hand (see Figure 3). These software applications enable students to quickly represent the reasoning by using box and line diagrams. These maps make the learning process fun, and allow students to unravel how different arguments function, provide them with opportunity to compare with different logical structures, and enable them to acquire a deeper and practical understanding of the structure of the arguments. Software-aided argument maps do not analyse or check the validity of arguments, but they help students to practically analyse and evaluate the arguments in a better way, as they encourage them to construct arguments openly and meticulously (Davies, 2010; Davies et al, 2019).

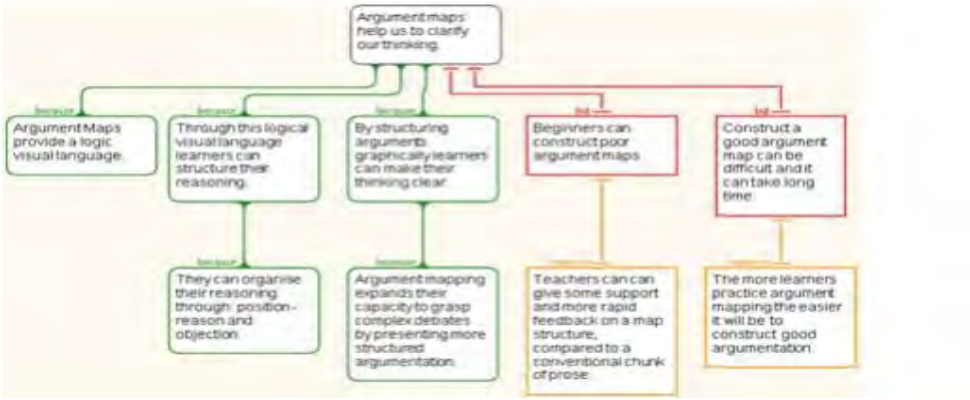

Figure 3: Argument mapping, (Source: Jasem, 2014, books.kmi.open.ac.uk)

The Purpose and Significance of the Research

Mind and argument maps, as mentioned above, are not limited to pen and paper. They are rather popular as software (Tergan, 2006; Zumbach, 2009). Considering the literature; there is a certain amount of research available on these maps and software-aided maps. These studies have focused on the teaching process of different disciplines at different grade levels (including higher education level; Fu, Lin, Hwang, & Zhang, 2019; Israel, Zipp, D'Abundo & Deluca, 2020; Kunsch, Schnarr, & van Tyle, 2014; Lin, Shadiev, Hwang, & Shen, 2020; Luo, 2019, Wu & Wu, 2020). A number of studies also focused on developing higher-order thinking skills (reflective thinking, questioning, reasoning, critical thinking, problem solving etc.) as well as academic achievement (Aljaser, 2017; Butchart et al. 2009; Bütüner & Gür, 2008; Carrington, Chen, Davies, Kaur, & Neville, 2011; Davies, Barnett, & van Gelder, 2019; Eftekhari, Sotoudehnama & Marandi, 2016; Evrekli & Balım, 2010; Jeong, 2020; Mento et al, 1999; Rider & Thomason, 2014; van Gelder & Rizzo 2001; van Gelder et al. 2004; van Gelder, 2007).

The present research attempted to find out whether such software-aided maps have any influence on the academic achievement of graduate students studying in faculties of education. The graduate programs in these faculties have very important goals. In the context of National Qualifications Framework for Higher Education in Turkey (NQF-HETR, 2019), the students at this level are obliged to develop and deepen their knowledge in their area to an expertise level; be able to utilize their theoretical and practical knowledge at an expertise level; be able to integrate and interpret the interdisciplinary knowledge and develop new knowledge by doing so; they are also expected to critically evaluate their expertise level knowledge of their own area and regulate their own learning processes, have advanced level skills on information/communication technologies and software in proportion to the requirements in their field; have ability to make use of their acquired knowledge in problem solving and use their practical skills in interdisciplinary areas. It is clear that post-graduate students are expected to gain meaningful in-depth knowledge of their field, as well as other skills, attitudes and habits. Therefore, it is necessary to provide them with rich learning experiences that support meaningful learning at the graduate level. The assessment of the preliminary knowledge of students, the use of materials which clearly reflect the content of students' basic knowledge, the active participation of students in order for the meaningful development of knowledge and determining as to how the process of learning takes place (or not) for them are all quite important elements (Hay, Kinchin & Lygo-Baker, 2008). This situation also leads to the need for applied studies in the graduate education. This research, thus, originated out of this significance and need. The teachers or prospective teachers who have graduated from the faculties of education are expected to learn various methods and techniques in their teaching practices and how they should be used. These knowledge and skills can only be built in the environments that support learning by practice and experience.

This research has been carried out within "Theories of Learning-Teaching" course that is offered at the faculties of education. The course is very significant in those faculties. By virtue of the knowledge and skills that are obtained in the course, the teacher or prospective teacher can make a plan of teaching in an easier way, he/she can have a better judgement about the educational applications that emerge from certain theories, and he/she can better analyse how/where these theories should be used in the process of learning-teaching (Gredler, 1987). Because of the significance of the course, it is necessary for graduate students to have enriched learning experiences about this course. In addition, students in higher education deal with arguments all the time. Indeed, a major purpose of a higher education is to teach students how to read, understand and respond to complex arguments. The ability to do this makes for highly employable, adaptable and reflectively critical individuals (Davies, 2011). Based on this idea, in this research, certain software-aided mind mapping and argument

mapping techniques were utilized in order to provide the students with the appropriate way of meaningful learning and it was intended to answer the following questions concerning the research:

1) Is there any significant difference between the pre-test and post-test mean scores of the experimental group using software-aided mind mapping and argument mapping?
2) What are the opinions of the students who participated in the experimental research about the application process?

Method

Having focused on the mind and argument mapping techniques and their influence on the process of learning, the research has been designed following a mixed methods research strategy synthesizing quantitative and qualitative methods. Qualitative and quantitative methods were administered simultaneously and given equal priority; however, data collection and analysis were carried out separately and the results were combined while making general interpretation of the data. The quantitative part of the research has been carried out by the experimental research model (one group pre-test post-test design). The qualitative part, on the other hand, was undertaken as a case study. The experimental design of the research is displayed on Table 1. As it is seen on Table 1, the research was carried out with an experimental group. The reason for carrying out the research with a single experimental group is that the number of graduate students and groups was not high enough. This research was completed within the scope of a scientific branch (more specifically Primary Education Master Program) of a state university. The students from the faculties of education apply to study at various scientific branches with their varying points, knowledge and skills. Therefore, it was not possible to find any group that would be the equivalent of the existing one. However, there might be some other groups from other universities who study at the same departments and conduct research in similar areas, which might qualify as the equivalent groups. But in that case, the course would have needed to be taught by different professors. In the literature, many research studies were carried out with one-group experimental design (Öksüz & Coşkun, 2012; Siah, 2019; Yamak, Bulut & Dündar, 2014). In line with the literature, the present research was carried out with one group. In addition, the study emphasized the following: the study was conducted in a single group, but more than one qualitative data collection tool was used to analyse the effects on the students in depth.

The measurement tools within the scope of the research were administered to the experimental group as a pre-test. The experimental process lasted for 12 weeks. The students in the experimental group passed through certain processes such as learning about the ways in which mind and argument maps are created, performing certain tasks related with software-aided mind and argument maps, and making evaluations about the process of learning. In addition, the experimental group was given achievement tests and interview forms at the end of the tasks.

Table 1. The Experimental Design of the Research

Groups	Pre-Test	Experimental Process	Post-Test
Experiment	TOLTCAT 1	The applications aiming at the technology-oriented preparation of mind/argument maps The teaching processes supported by mind/argument maps; the teaching evaluation processes	TOLTCAT 2

TOLTCAT: Theories of Learning-Teaching Course Achievement Test

The qualitative part of the research was conducted using a case study design. The study also attempted to illuminate how the students get through the experimental application process and how they are affected by the process. For this reason, the interviews and document analysis techniques were used so as to collect qualitative data. Three types of qualitative data were collected:

a) First, at the beginning of the experiment, focus group interviews were held with the experimental group to collect information regarding the extent to which they used software-aided mind and argumentation maps during/outside the course as well as their perceived awareness and importance of using these techniques. The reasons for the increase in their awareness: Pointing out to the practices to be done, inspiring their interest, providing motivation for the endurance of learning and the use of these tools in learning.

b) Secondly, the reflective diaries and self-assessment forms written by the students during the experiment were continuously reviewed by the researchers. These forms were collected regularly.

With these data collection tools, the students were provided with feedback about their learning processes.

c) Finally, at the end of the experiment, one-to-one interviews were conducted with the students about the study.

Study Group

The study group of the research is composed of the graduate students at the Department of Elementary Education. The work group consisted of 6 students in total: 2 men, 4 women.

Data Collection Tools

For the research, the following data collection tools have been used:

The Theories of Learning-Teaching Course Achievement Test

Certain achievement tests that consist of open-ended questions regarding the content of the course were created in the study. Open-ended questions were composed of the questions that measured such skills of the students as thinking, reasoning, comparison, generalization, application, analysis, evaluation and so on. Following the preparation of the questions, experts were consulted, and revisions to the questions were made in the measurement tool in line with the feedback received from experts. There were 25 questions in the final test. Because of the high number of questions, the exam took place over three sessions both before and after the experimental procedure. It is quite difficult to grade the answers to the open-ended questions. Therefore, the following principles were taken into consideration in order to ensure the reliability in grading the student answers: (1) It was made clear in the answer key, which outlines the students should mention. (2) Holistic grading method was preferred. (3) While the students' answers were being graded, it was endeavoured to grade the certain answers of all students simultaneously and all at once. (4) In the process of answer grading, the confidentiality of the student names was ensured.

Student Self-Assessment Form

The Student Self-Assessment Form was utilized to evaluate the mind and argumentation maps that the students prepared after the course**.** In these assessment forms, it has been endeavoured to evaluate whether the students had sufficient factual, conceptual and operational knowledge that they acquired in the course about the teaching-learning theories. (1) *Do I know the significant concepts in …. Theory? What are they?* (2) *Do I know the basic assumptions of …Theory? What are they?* (3) *Could I explain the basic theoretical differences between ... and ... Theories?* Besides, the maps that were prepared by the students were re-evaluated in the form of feedbacks offered to students by the teachers. In accordance with the feedbacks given by the teacher, students were asked to evaluate themselves in these self-assessment forms. For example: (1) *Are the maps that I drew theoretically reliable?* (2) *Have I accurately reflected the details of the theory on my mind maps?* (3) *Have I formed the connections between concepts in my map in accordance with the theoretical framework*?

Reflective Diaries

The reflective diaries are the ones that students had written at the end of each lesson. These were the diaries that covered the feelings and views of students about what they learned in the course, what they found interesting, what they should examine, and how they generally evaluated the maps that they prepared. The researchers had an informative meeting about the writing of the diaries with the students prior to the experimental process. The diaries were collected from the students regularly (each week) and a general evaluation was made.

Semi-Structured Interview Forms (One-to-one Interviews and Focus Group Interviews)

At the beginning of the experimental process, the focus group interviews were conducted with the experimental group about the extent to which the students make use of the software-oriented mind and argumentation maps and the significance of using these techniques and raising their self-awareness of such tools. All participants were present in this meeting. This interview process lasted two hours.
At the end of the research, semi-structured interview forms were utilized to make interviews with the students

about the experimental study. The questions of this interview schedule were re-evaluated in accordance with the expert views. One-to-one interviews with the students lasted on average for 45 minutes. To provide examples of the questions in the interview form: (1) *What do you think about the use of mind and argument maps in learning?* (2) *What do you think about the theories being discussed and learned on the map?* (3) *What do you think about mind and argument maps?* (4) *Do you find it enjoyable to use these maps during and after class? And why?*

Procedures

The experimental phase of the research took place in the following order:

1) The imindmap software was utilized for mind mapping, and Rationale^{TM} program for argument mapping in the present study.
2) The experimental process was 12 weeks long.
   In the first phase of the experiment, informative lessons were held with the students over two weeks about what these maps are and how they are used. During this period, they were also informed about the use of the above software applications. Software-based mind and argument mapping practices were carried out with the students. Sample titles related to the content of the two-week process include: conceptual framework of maps, their usage purposes, advantages, types of software related to maps, software's that were used in the research, how they were used, making applications on maps, and so on.
3) The application process in the research after the two-week introduction lessons of mapping is as follows: Mind mapping activities took place in two ways. First of all, prior to the relevant subject and before the beginning of lessons, the students were asked to create maps that indicated their prior knowledge about the subject. Secondly, following the end of the course, the students were asked to re-create mind maps on the basis of the relevant sources in the course and course notes outside the class. These re-created mind maps were evaluated together with teacher and the students. In this evaluation process, the students introduced their maps and made comparisons between the maps they created before/after the classes. Thus the students were ensured to make a self-assessment by comparing the two mind maps. At the same time, with the mind-mapping software, the students were provided with the opportunity to uncover the conceptual structure of the theory via the mind-mapping software.
4) On the other hand, the students integrated argument mapping into their learning processes as follows: By taking into account the assumptions and principles of the learned theory, they clarified their reflections on the learning-teaching process through in-class discussions and demonstrated these points with argument maps. For example: They were provided with opportunities to enrich the maps using questions such as: How do we structure the learning-teaching process when we consider the basic assumptions and principles of behavioural theory?
5) Students were asked to share the maps they created with one another. The aim here was to enable students to see how information can be organized in different minds, and enrich the learning activity by asking questions to one other.
6) During the experiment, students were given the opportunity to write their reflective diaries and self-assessment forms. It was assumed that these data collection tools would contribute to students' learning processes.

Data Analysis

Both quantitative and qualitative data analysis techniques were employed in the study. The data of the achievement test was analysed by using a statistics program. The data in the scope of the student self-assessment form, reflective diaries and semi-structured interviews, on the other hand, were analysed descriptively.

And also, in order to ensure validity in the study, (a) Expert opinions were obtained in the arrangement of the data collection tools used, (b) Necessary participant confirmation (consent) was obtained after the interviews, (c) The research process was explained in detail, (d) The researchers engaged in a long-term interaction with the study group (prolonged engagement). Different data collection techniques were used together (triangulation) in order to increase the reliability of the research. The methodological process of the research has been expressed in depth. The necessary expert opinions were obtained for the analysis results of the research data.

Results

Within this section, quantitative and qualitative results will be evaluated separately. The data is presented under the categories; (1) the data from achievement tests, (2) the data from self-assessment forms – reflective diaries, and (3) the data from semi-structured interviews.

The Results Obtained from Achievement Tests

The data presented in Table 2 and 2 show meaningful differences between the pre-test and post-test average points of the students who were in the experimental group. As expected, this meaningful difference was in favour of the post-test points. (z=2,05, p<.05). The results indicate the positive effect of the software-aided maps on the students' academic achievement.

Table 2. The results of pre-experimental and post-experimental administration of achievement tests

Post-test-pre-test	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	0	,00	,00	-2,214*	,027
Positive Ranks	6	3,50	21,00		

*Based on negative ranks

Table 3. Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Pre-test	6	28,83	1,941	26	31
Post-test	6	105,00	3,347	101	110

The Results Obtained from Self-Assessment Forms – Reflective Diaries

The results obtained from self-assessment forms and reflective diaries are presented in Table 4.

Table 4. The Results Obtained from Self-Assessment Forms

Reflective Diaries	f
A deeper comprehension of the subject	6
Enabling self-assessment	6
Providing a more enjoyable way for in-class/out-class learning	6
Learning to ask questions to the self	6
Providing individual feedbacks effectively	5
Enabling the evaluation of one's prior knowledge	5
Enabling the self to discover learning strategies	6
Enabling the self to form stronger associations among the sets of information	6
Enabling the self to be more cautious in out-class studies	5
Making the remembering easier in the exams	5
Providing internalized hints related to the subject	4
Enabling the self to be more effective in in-class discussions	5
Enabling the self to make more effective presentations of one's ideas in the class	5
Using them effectively in one's professional development	3
It is easier to draw such maps with pen and paper	1
Developing higher-order thinking skills	5
Increasing the interest in/ motivation for learning	4
Increasing academic self-efficacy in the course	3
The philosophical and historical backgrounds are quite important in the formation of argument maps. Otherwise, it leads to the formation of weaker argument maps.	3

Table 4 suggests that self-assessment forms and reflective diaries were used to increase students' activity in the learning process. The majority of the students stated that the use of mind mapping and argument mapping enabled them to learn the subject in-depth, make self-evaluation, render the in/out-class learning environments more enjoyable, and evaluate the prior knowledge about the subject. In relation to this, for example, S2

explained: *At the end of the lesson, I created maps at home again. I searched different sources about how to enrich the map. Then I noticed the increase in my interest in learning and research*. Besides, S6 claimed: *"While evaluating myself with these maps, I also realized that I was actually questioning how to get the right information"*. S3 reported: *"Comparing my first map with the last one, I was quite happy to see how much progress I made*".

In addition, the students stated that learning with these maps increases attention in extra-curricular activities, facilitate easier recollection of knowledge in exams, can be used as an effective tool in class discussions, enable them to develop high-level thinking skills, and increase interest, motivation and self-efficacy in learning. To illustrate, S5 commented: "*Questioning these theories thoroughly in classroom discussions allowed me to ask myself ,how can one ask different (/genuine) questions?".* And S2 noted: "*The discussions in the classroom and the examples that came forward during these discussions made it easier for me to recall the information I learned*".

Moreover, some of the students stated that the effective utilization of these maps in the learning processes had positive contributions to their professional development. For example, S1 put forward the following argument: "*Having studied and mapped the relevant subjects, I wrote questions to myself and answered them all. This is the way I administered them to my own students… They and I have realized that we concentrated our attention on the important and cornerstone elements of the subject in this way*". In addition, S4 reported that: "*Learning how to learn also teaches one how to teach. For this reason, it led me into questioning my own teaching process*".

It is an important finding that one of the participant students claimed that it was in fact easier to draw such maps with paper and pencil. Some students also claimed that it was necessary to know the philosophical and historical backgrounds of theories in creating argument maps; otherwise these maps cannot be effective as a learning method. To provide an example, S3 noted: "*While analysing the theories, we also realized that these theories were also affected by the results of a variety of disciplines. Therefore, we need more philosophical and historical background readings*".

The Results Obtained from the Semi-Structured Interviews

The results obtained from the semi-structured interviews and focus group interview with the students are presented in Table 5.

Table 5. The Findings Obtained from the Semi-Structured Interviews

(a) The results that were obtained from the focus group interview prior to the experiment	f
Not having used software-aided mind maps at all	6
Having heard about what mind maps are during undergraduate classes	5
Not having heard about/not having used argument maps in learning process at all	6
Having a limited knowledge about the purposes and benefits of these maps	6
(b) The results that were obtained from one-to-one interviews after the experiment	
1) The Usage Purposes of Mind and Argument Maps	
Personal planning	4
Note-taking and summarizing whilst studying	6
Searching for alternative solutions to the problems	3
Summarizing books/articles (searching new sources of information)	4
Producing new ideas	5
Making self-assessment	6
Providing permanence (of knowledge) in learning	6
Making learning processes enjoyable	6
Providing associations of the acquired knowledge with the other dimensions of life	6
Discovering the personal ways of learning	6
Providing an easier means to remember information	6
For teachers, learning how to use them in the processes of teaching	5
Discovering alternative ways of thinking (Critical, reflective thinking etc.)	6
Saving time for ourselves	5
In-class assessment and evaluation activities	6
Providing students with alternative perspectives on their current knowledge	6
Making it easier to notice the connections among the factual, conceptual and operational knowledge	6
2) The students"perspectives on the mind and argument-mapping	

Concrete schematization of the current associations, likening's and connections	
Summarizing a subject	6
Providing a holistic view on a subject	6
A sensible way of note-taking and noting ideas as map forms	5
Organized, colourful, mnemonic schematization of any long and/or monotonous set of information lists in parallel with the natural stream of consciousness	3
A note-taking method	3
Putting an internalized learning method on paper/computer	2
Visualization of a subject	5
A practical technique that is used to associate different subjects and encapsulate subjects	2
A method that is utilized to make an effective use of knowledge via facilitating a better flow of knowledge in the brain	2
Transformation of a list consisting of monotonous information into a mnemonic, colourful, organized schema that is compatible with the natural processes of the brain	5
Like a city map	1
A mirror of your own natural thinking	3
Being able to compile ideas	
3) The advantages of using the mind and argument-mapping	
It makes learning enjoyable by pictures and shaped note-taking methods.	6
It provides a better assimilation of information and ideas in the process of creating maps.	6
Increases attention in the learning process.	3
Unlike classical and long notes, it facilitates the repetition and recall of acquired knowledge.	6
It provides an effective and efficient use of time in learning.	6
It supports creative thinking.	
It allows seeing the main points and sub-headings related to the acquired knowledge.	5
It enables the visuals, forms and concepts of the subject to be associated and integrated in all aspects.	5
Strengthening the neural connections in the brain, it ensures the long-term storage of the acquired knowledge.	3
It helps to discover one's own learning methods.	6
Mapping of the subject results via more mental associations.	4
It increases the level of comprehension in developing connections with real life through increasing mental associations.	4
It provides a quick command of the subject.	5
It provides an opportunity to evaluate and compare theoretical aspects from a holistic point of view.	6
It is effective in comparing different theories in terms of their own characteristics and noticing the differences between them on a single map.	6
It allows spotting the occurrences of the deficiencies in our leaning process.	6
It raises the effectiveness in the assessment of learning.	6
It helps to overcome the presupposed limitations in learning.	3
It improves argumentative reading, writing, questioning.	5

Analysis of Table 5 in relation to the focus group interview with the students in the experimental group prior to the experiment indicates: none of the students had ever used software-aided mind maps, heard of argument maps before, or used them in learning processes. Students also noted that the first time they heard about mind maps was during their undergraduate studies and added that they had limited knowledge about the purposes and benefits of using these maps.

One-to-one semi-structured interviews were conducted with the students after the experiment. These interviews were conducted to illuminate the effects of using mind-mapping and argument mapping on learning processes on the students. Student views were categorized as the *usage purposes of these maps*, *their subjective perspective*s that are formed in the process of using them and the *advantages of using these maps*. As seen above, the students in the experimental group stated that they used software-based mapping tools in their personal planning, seeking alternative solutions for problems, producing new ideas, making learning enjoyable, and developing different ways of thinking. Considering the students' views on the meaning of these mapping tools; the majority of the students found the maps quite functional in summarizing the subject, grasping the subject from a holistic view, effective note-taking, visualizing the subject, and transformed it into a colourful mnemonic organized scheme. And regarding the advantages of using mind mapping and argument mapping, the majority of students considered that they make learning more enjoyable, they are easy to integrate a set of

information, and they facilitate the efficient and effective use of time in the learning process. They also help to discover personal methods of learning and were quite useful in the comparison of various theories of learning. In addition, the students stated that using these maps was effective in the assessment of learning, in developing different mental connotations, the mastery of the subject in a short time, and overcoming any limitations to the learning.

To provide few examples of direct quotations from the students.

S1: *In my opinion, it provides an enjoyable learning process by making a difference with regard to the narratives in the books where the theoretical knowledge is very intensive; and promoting creative thinking. The interesting and fun part is that our brain makes interesting associations with the objects and events we encounter in our own lives and improves the permanence in mind… I think it is pleasant enough for our own personal learning process.*

S3*: In the mind and argument maps I have created; I think that it is quite supportive for the creative thinking to utilize the connections and connotations I have formed on the subject that I work on. Besides, upon mapping some visuals and connotations, I realized that I could expand the subject further and that the subject becomes more persistent (in the memory). When I mapped the topics separately, I realized that I could make more extensive associations.*

Discussion and Conclusion

In this study, it is clear that the use of software-aided mind-mapping and argument-mapping had a positive effect on the academic achievement of the post-graduate students who studied at the faculties of education. Comparing the academic achievement pre-test and post-test scores, a significant difference was found in favour of the post-test scores of the experimental group. As one can see, the instructional use of these maps helps the development of students' knowledge and skills. National and international literature found that that the academic achievement of the student's increased after the use of such software-aided mapping tools (Adodo, 2013; Akınoğlu & Başar, 2007; Balım, 2013; Bessick, 2008; Bütüner & Gür, 2008; Eftekhari, Sotoudehnama, & Marandi, 2016; Evrekli & Balım, 2010; Israel, Zipp, D'Abundo, & Deluca, 2020; Wu & Wu, 2020; Zumbach, 2008). The results of studies in the related literature are compatible with the results of the present study. Knowledge mapping applications contribute to the effective management of information and lead to increased success (Buzan, 2006, Buzan & Buzan, 2016). Therefore, the mind and argument maps which provide meaningful and permanent learning could be used frequently in learning environments.

In this study, the opinions and reflections of the students who participated in the experimental group were analysed in depth and it was found that quantitative and qualitative research results support each other. The qualitative findings obtained from the self-evaluation forms, reflective diaries and semi-structured interviews (one-to-one interviews and focus group interview) were utilized for in-depth illustration of post-graduate students' views participating in the study. Considering the results obtained from the self-assessment forms and reflective diaries, it can be argued that the use of software-aided mapping tools in the learning process enables graduate students to learn the subject in depth, make self-assessment and evaluate the prior knowledge about the subject. Based on the students' views, the following advantages of these tools were reported in enriching the learning process: (1) more attention and care in extra-curricular studies, (2) studying becomes more enjoyable, (3) it becomes easier to repeat and recall the information, 4) in-class discussions become more effective, (5) high-level cognitive skills are developed, (6) increased interest, motivation and self-efficacy in learning. It is also important to note that these applications have a positive impact on the professional development of the students. The direct quotations from students also support these results. There was also one student who had a negative opinion about the use of these maps in learning processes. The student claimed that it was, in fact, easier to draw such maps with pen and paper. Actually, there are advantages in using these software-aided maps. Because the students can make any adjustments in these maps based on preference, they can add any visual that they want, and expand the information structure as much as possible (Buzan, 2006). This (student opinion) can be interpreted as follows: Affective factors such as attitudes and beliefs about technology should be taken into account in technology supported learning and teaching practices since such factors can influence an individual's actions in teaching-learning processes. Therefore, these technology-related variables may also lead to the formation of certain judgments in the learning process. In the literature, it has been indicated that the individual attitudes and beliefs towards technology can affect the usefulness or ease of technology (Shroff, Deneen & Ng, 2011; Teo, 2009; Wixom & Todd, 2005).

The results obtained from the semi-structured interviews conducted with the students at the end of the experimental application process were in line with the above-mentioned results obtained from the self-assessment forms and reflective diaries. The findings from semi-structured interviews were categorized as "the usage purposes of maps", "the meanings of maps for the students", and "the advantages of using these maps". Participant s views on the intended purposes and advantages of the maps suggested that they can be used for personal planning, studying, seeking for different solutions to problems, searching new sources, producing new ideas, providing permanence in learning, discovering personal ways of learning, forming connection of the acquired knowledge with the other areas of life, developing different thinking ways, in-class measurement and assessment activities, making a better analysis of the types of information related to the subject area, considering the subject in a holistic way, evaluating the theoretical knowledge in various aspects, making comparison of the theories easier, developing argumentative reading, writing and questioning skills and so on. It was clear from student comments that the maps that they had been making use of became very useful and effective tools in their learning processes and other domains of their lives. The results obtained from the focus group interview following the experimental procedure also indicated such a development. According to the findings in the focus group interview, it turned out that the students had never made use of these software-aided maps, they heard about them in the classes for the first time and had very limited prior knowledge concerning the purpose and benefits of the maps. The changes in student views have been remarkable. Therefore, one can argue that these maps, which allow enriched learning experiences, are effective in developing students' cognitive and affective skills. Especially the graduate-level studies aiming at the development of high-level skills should support such enriched learning experiences. The findings obtained from the literature concerning the use of argument and mind maps in learning processes are also compatible with the results of the study. For instance, Zumbach (2008) and Jones et al (2012) found positive effects of the mapping techniques on the motivation of students. Moreover, Butchart (2009), Davies (2009), and Dwyer et al (2011; 2012) concluded that the argument-mapping practices promote the critical thinking of students as well as making the learning interesting and more creative (Koznov & Pliskin, 2008). Similarly, Rider and Thomson (2014) argued that these maps contribute to students' argumentative reading, writing and their progression in the questioning skills. Meta-analysis studies also show that argument-mapping-supported learning environments are highly effective in developing students' critical thinking skills (van Gelder, 2015). Adodo (2013) attempted to show that the use of mind-mapping tools raises students' creative thinking and creative problem-solving skills, facilitates memory recall, and strengthens connections with other disciplines. Similar to these findings, Evrekli et al. (2009), in their study with prospective teachers, came to the conclusion that their use of mind mapping can have certain advantages in the purposes of effective note-taking, in-class assessments/evaluations, promoting the permanence of acquired knowledge, and discovering the effective methods in learning. In addition, in this experimental process, the persistent use of these maps before, during and after the learning procedure enabled students to assess their own learning. It was found out that the student who checked his/her prior knowledge was able to structure the learning process more easily. This leads one to expect that their certain attitude toward learning shows up in such a way that renders it more complex and sophisticated. In order to improve the quality of learning at higher education level, it is recommended that such maps be used as the prime strategy in the assessment/evaluation processes (Hay, 2007). Likewise, the findings of this study support such suggestions. The present research also studied as to what sort of meaning structures the participant students developed with regard to these maps. On the consideration of the student views on the mind and argument maps, it is seen that they have given them the following set of meanings: a note-taking method, a concrete schematization of acquired information in mind, mapping the ideas, visualization of the subject, a practical technique to encapsulate the relevant subjects, (something) like a city map, a natural mirror of one's ideas, being able to compile the ideas and so on. The set of meanings that is given by those students is also compatible with the findings from the quantitative and qualitative data collection tools. It was found that the meanings of the maps the students developed in their minds match up with the definitions of these maps in the literature. It is important for this research to consider the meanings formed by the students. Because it is important to practice through them and to direct the learning process through these structured meanings in educational environments. The formation of these meanings by the students shows that the experimental application process has achieved its prime goal. These maps that were used in the scope of the research are at the same time an active note-taking method. Because the standard note-taking methods lack the kind of elements such as visual rhythm, patterns, colours, images, dimensions, spatial awareness, integrity, connections and so on. Those missing elements, however, are crucial in all brain functions, especially in the process of learning. The standard notes conceal the keywords, cloud the recollection of information, and cause a waste of time (reading and reading over the insignificant notes), and they are unable to activate the creative functions of the brain (Buzan & Buzan, 2016). Therefore, it has been argued that utilizing mind-mapping techniques are quite advantageous in learning processes by virtue of activating the higher-order learning potential of the brain. As it has been clarified throughout this article, this research supported the idea that the use of software-aided mapping tools is quite effective in post-graduate students' learning processes and their development of knowledge, skills, and behaviours (as mentioned above). These can be very convenient

techniques that can be used in different stages of the course. These mapping techniques can also be quite useful for creating modern learning environments which are convenient for today's world. Such stages of learning in which theoretical knowledge must be internalized should support the students' development in different ways of thinking. In particular, undertaking the study with post-graduate students in higher education was very important for the students in the sense of experiencing how the learning processes can be enriched in practice. The data obtained from the students support this interpretation.

Recommendations

It is also a necessity to conduct this research in various courses at undergraduate and graduate levels. Those software-aided applications may provide favourable learning environments for courses such as critical and analytical thinking, philosophy of education, and sociology of education. Future studies can investigate the effectiveness of these software-supported maps in such courses. And those can be used for further studies on solving any problem in the classroom, developing the out-class learning environments of students, solving social problems, raising their awareness about the variables that may affect their learning processes and finding out personal solutions in such situations. In fact, these maps can become useful tools for teachers when distance education and digital education tools are important during the Covid-19 pandemic, For example, these tools can be used effectively by teachers before, during and after the courses. In the limited time period of distance education, these maps will facilitate teachers' evaluation processes to reveal the conceptual structures of students in more depth and how the students analyse the arguments. At the same time, using these learning tools as tools that enable students to assess themselves also ensures meaningful learning experiences. These maps can help students organize their notes outside of the classroom and more easily absorb important information with additional reading. This provides them with the opportunity to develop an in-depth understanding of the subject area (Dwyer, Hogan & Stewart, 2012). The limitation of this study was that it was conducted with one group and within one department. Furthermore, the research was carried out within the scope of only one course. These maps can be used as a tool for the integration of disciplines in a study conducted in the teaching of many disciplines. It is also possible to conduct further studies that will also take various affective variables into the account.

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