Digital Educational Mind Maps: A Computer Supported Collaborative Learning Practice on Marketing Master Program

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Abstract. Mind mapping approach is acknowledged as a fruitful collaborative educational technique. However, there is a lack of researches on students' experience during learning with mind maps. Nowadays, information technologies are developed and wide spread impetuously. Thus digital mind maps become more and more popular. The process of their creation is strongly supported by different software, but little is known about this software application to educational needs. This paper aims to fill this gap. The comprehension of mind mapping approach adoption is implemented in a form of pedagogical reflection. The data for the pedagogical reflection were gained from the research, which was designed in a mixed methodology. The combination of a survey and a participant observation aimed to get collaborative data on students' perception and estimations of mind mapping. The survey's questionnaire was developed based on the technique's functions and results of participant observation. The analysis highlighted that the Coggle may be confidently use as an educational software in case of supporting in-class and home collaborative activities on mind mapping. As a result, the set of recommendations for teaching with mind maps was developed. The directions for a further work are discussed.

Keywords: Collaborative learning · Computer-supported collaborative learning · Mind mapping · Digital mind maps · Mind mapping software

1 Introduction

Mind mapping has become a widely established learning technique [1]. It solves a wide range of educational tasks, e.g., critical thinking development, assistance to memory, rising of students' involvement [1–6].

Furthermore, mind mapping approach is acknowledged as a fruitful collaborative educational technique. However, there is a lack of research on students' experience during collaborative learning with mind maps. Below, we will use abbreviation *MM* for a *mind map*.

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Last two decades rapidly developed information technologies have started a new era of MMs, and brought into life *digital mind maps* (to address one digital mind map we will use *DMM* abbreviation). Evidently, educators, who share an idea of computer-supported learning, have begun to include DMMs into educational routines. As far as the mind mapping approach is quite popular in different areas [2, 4], the processes of DMMs creation are strongly supported by a variety of software.

Collaborative software dissemination made it possible to support educational collaborative processes at the very beginning of 21th century. Moreover, a number of collaborative mind mapping tools were introduced (e.g., *MindMup*[1], *Coggle*[2]). In spite of mind mapping approach and mind mapping software are popular to in-classes routines, little is known about the practice of such tools selection and adoption to educational needs.

Furthermore, any mind mapping tool is a representative of an interactive visualization software, and, consequently, inherits its features. It is known, that researchers highlight potentially ambivalent impact of a visualization software in teaching. This point of view represents the following general weaknesses relevant to a mind mapping tool [7]:

1. it may not meet a student's needs;
2. it may be too time consuming in usage for students and teachers;
3. it may switch the focus from content to visual effects.

Summarizing, the poor documentation of an educational process supported by collaborative mind mapping tools and a huge amount of available software raise several questions on selection and adoption such software to a particular instructional process. The paper contributes into amount of knowledge on the mind mapping approach in learning process. It integrates students' experience, instructional design and learning software perspectives. The research focuses on learning experience both positive and negative, weak and strong points of the mind mapping approach and software, the ways to deal with them.

The paper pursues the following goals:

1. to describe students' experience in learning with DMMs;
2. to introduce the Coggle web-service adoption to support collaborative learning through mind mapping;
3. to discuss DMMs from teaching, learning and educational collaboration points of view.

The empirical base of the research is an observation and a survey during series of seminars for "Consumer Behavior in Global Environment" course with the first year master students of Marketing Program in National Research University Higher School of Economics (HSE). During the course MMs act as a powerful collaborative technique. In order to consider on students' experience and interpret their feedback the pedagogical reflection is used.

[1] http://mindmup.com.

[2] http://coggle.it.

2 The Core of Mind Mapping Approach

The world of visual educational forms is rather rich. We are going to define basic concepts and to overview the core of mind mapping approach in this section.

Tony Buzan has registered a MM as a trademark and defined it as a diagrammatic method of representing ideas, with related concepts arranged around a core concept [8] (Fig. 1[3]). Unfortunately, in our context this definition is a bit confusing, because concept maps [9] in education are as popular as MMs [10]. Despite there is a close relation of these two models, there are number of meaningful differences between them. This difference is studied and discussed in [11].

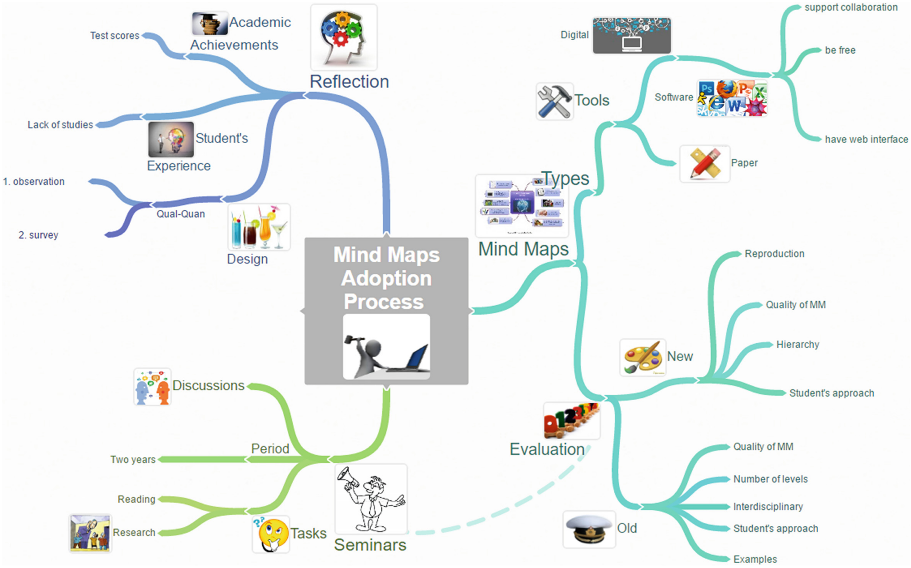

Fig. 1. The mind map of this paper

A MM is a hierarchic graph organized around the central image. An entire subject is divided into a set of categories diverging from the central image. Each notion creates a branch including subcategories and examples logically drawn from the notions. Furthermore, a MM packs information in a logically sustainable way. It also uses colors, figures, fonts, and images. Taken together these features facilitate memorization. Due to analytical work while developing a set of categories and subcategories mind mapping supports understanding, critical thinking, and comparison [4], structuring of a problem to be solved [6]. As a thinking method, mind mapping is a favorable environment for collaborative learning and creative problem solving [18, 21].

[3] The full version of this mind map may be accessed at Google Drive (https://goo.gl/BeHSzT).

From a technological point of view, a MM is represented by a rooted tree of concepts, but this tree has extra features:

1. an additional layer of associations between concepts;
2. a set of concept's visual properties, such as color, figures, images, etc.;
3. an explicit circular layout of MM elements.

In this work we will use the term MM to address a thinking method and its main visual artifact.

The efficiency of MMs application in terms of academic achievements is thoroughly investigated [12–14]. Mind mapping has no discipline boundaries, for a review see [2, 4]. Moreover, this technique rises students' involvement [7], bridges old and new knowledge [7, 8], and even improves learning outcomes [2, 3, 8]. MMs serve as a facilitators and assessment tools [4, 5] and as an approach to design of self-instructional modules [3]. Dhindsa, Makarimi-Kasim, and Anderson [14] found that MMs are perceived as more enjoyable compared to traditional teaching approach, but not significantly different in personal relevance. The current research of mind mapping implementation focuses on academic results or functions executed by this technique, but except rare exclusion [13] there is a lack of attention to students' experience during usage of MM.

3 CSCL Through the Mind Mapping

DMMs have become widely used and investigated teaching technique. Willis and Miertschin [15] study visual educational forms as active learning approaches and concern on MMs and mind mapping approach as powerful learning tools developing critical thinking and problem-solving skills. Jbeili [13] has found a positive impact of DMMs on individual students' science achievements and recommended usage of DMMs for teaching. Circumstantial investigation on visual thinking and visual forms in education is given in by McLoughlin and Krakowski [15]. They have presented methodical recommendations on educational materials and the way of their changing and improving. Furthermore, they have explored the role of information technologies in conducting visual forms of education such as MM.

Collaborative facet of a MM is also a subject of researchers' interest. Koznov and Pliskin in [16] explore the role of MMs in CSCL. They also introduce Comapping[4]. The main disadvantage of Comapping in our case is the absence of a free plan for education. They avoid the discussion of different programs referring to commercial overview of these tools. Wu, Hwang, Kuo, and Huang consider different computer platforms for collaborative mind mapping, mobile gadgets and PC [17]. Vaida, Plotz and Fink focus on machine reading or hand-drawn MMs obtained as a result of a brainstorm session [18]. Liu, Zhang, Tao, Ren, Li, and Du present an online mind mapping tool for integrating and sharing personalized learning resources [19]. Although authors claim the superiority of their product compared to E-learning

[4] http://comapping.com.

systems, they do not analyze existing E-learning systems or mind mapping tools in terms of integrating and sharing needs.

4 CSCL Mind Mapping in “Marketing” Master Program

4.1 Instructional Design

The mind mapping approach was implemented as a part of seminars during the master’s “Consumer Behavior in Global Environment” course at the first time in 2014/2015 and repeated in 2015/2016 academic year with the first year students of the same program. We found mind mapping relevant, because this learning technique meets some important requirements of a curriculum:

- bridging courses inside the master program;
- development of student’s creativity;
- shaping of critical analysis skill.

The course is a mandatory part of the program studied since 2012/2013 academic year. The course includes lectures and seminars. Formative assessment consists of a mind mapping and an essay. Summative assessment is cumulative and contains a MM and an essay.

The major part of seminars’ tasks includes a collaborative component. Students work in pairs and prepare MMs of an outclass reading or results of research tasks. The other important collaborative components are a discussion and an evaluation of MMs in class.

4.2 Course Software Environment

The majority of master students are busy at work and it seems to be reasonable to automatize their learning activities as much as possible. That is why we preferred using DMM and CSCL during the instruction. In this section we speak about software, which was used to support mind mapping in our case.

Criteria of a mind mapping tool selection are developed according to several educational requirements and infrastructure limitations. At first, a desired mind mapping tool is expected to be easily accessible in order to provide remote educational activities of students and a teacher. Thus, we decide to search a tool with web-interface. At second, we need a collaborative tool to support collaborative learning processes. This means that a suitable mind mapping tool has to support group working on a MM, document sharing, commenting, etc. And at last, the *learning management system* (*LMS*) of Higher School of Economics has no plugins or extensions to support learning through mind mapping. So, we can only reckon on free software. Summarizing these three requirements, our ideal mind mapping tool should:

1. support all the significant constructive blocks of MMs;
2. be free;
3. have a web interface;
4. be collaborative.

Following our criteria, we selected a mind mapping collaborative web-service called Coggle. It has several useful to CSCL features:

1. It is possible to collaborate while constructing a MM and to share it, or its parts.
2. A MM can be saved on Google Drive.
3. A MM can be exported to PDF, PNG, TXT and MM file.
4. A MM layout supports an automatic rearrangement and a full branch drag-and-drop.
5. A MM nodes allows to use Markdown markup language and MathJAX.
6. Embedded MMs are permitted and several MMs can be connected by links.

Some of these features and extra technical information are summarized in Table 1.

Table 1. Coggle technical specification.

Feature	Details
Supported browsers	Google Chrome, Opera, Mozilla Firefox, Internet Explorer 11, Microsoft Edge
Export formats	MM, PDF, PNG, TXT
Import formats	MM, TXT
Real-time collaboration	supported
Free plan[a]	supported
Free plan limitations	Maximum image size is 150 × 150px

[a]For the other plans and details visit (https://coggle.it/me)

4.3 Mind Mapping Approach Implementation

In "Consumer Behavior in Global Environment" course mind mapping approach serves as a framework for seminars. Students are asked to represent their homework as MMs weekly. One week there is a reading task, next week a research task takes place.

In terms of content there are two types of tasks: reading and research. Reading tasks are targeted to memorizing and understanding of important categories of the course and critical thinking on these categories. Research tasks concern on implementation of the categories for understanding consumer behavior in the field and developing marketing decisions. In the academic year 2014/2015 the proportion between an individual task and a collaborative task was approximately equal, but in the academic year 2015/2016 in accordance to formative assessment results all the tasks were done in pairs. Pairs were formed by students themselves.

An example of a reading task for a pair: *Choose any article from the list provided for the seminar, read it, discuss and construct based on the article mind map. An example of article: Jillian C. Sweeney, Geoffrey N. Soutar (2001) Consumer perceived value: the development of a multiple item scale. Journal of Retailing. 77. P. 203–220. (doi:*10.1016/S0022-4359(01)00041-0*).*

An example of a research task: *Using participant observation and in-depth interview analyze a consumer's lifestyle and identify its structure. Present results of the task as a MM. Based on the results propose marketing tools.*

4.4 Evaluation

Table 2. Rubrics.

Criteria	Weight, %	Explanation
Number of levels in a MM	20	Each level after a central concept costs 3 points
Interdisciplinarity (reasonable using concepts and theories from the other disciplines)	15	Each category from an external field brings 2 points. Limitations of correctly used categories: not less than 2, but not more than 9
Student's approach	10	Originality, individual approach
Examples	10	1 point for each suitable example
Quality of a MM	30	A student uses adequate images, different colors, and fonts in a MM. If these visualization is missed a student yearns 0 points

5 The Monitoring of Mind Mapping Approach Adoption

The "Consumer Behavior in Global Environment" course has adopted mind mapping for two years as a pilot project. So, each assessment plays a great formative role and is accompanied with a full feedback. This section reveals analysis tool, methods and data collection mechanisms, which were combined in this work.

5.1 Toos and Methods

The comprehension of mind mapping adoption is implemented in a form of pedagogical reflection. Here and after under the pedagogical reflection we will understand a critical reflection, which means that teachers and students play an active role in evaluating and instruction improvement. The impact of critical reflection on learning process and outcomes is concomitantly discussed in [20].

The data for the pedagogical reflection are gained from the research, which is designed in a mixed methodology [21]. This methodology relies on the idea of combining strengths of different methods. The mixture of a survey and a participant observation aims to get collaborative data on students' perception and estimations of mind mapping. According to Preliminary Qualitative Input Design [21] the survey's questionnaire is developed based on learning functions of MMs and results of participant observation. Evaluation of how mind mapping approach performs its learning functions is measured by questionnaire. The participatory observation allows detecting emotions, troubles or some unexpected reactions during the process of the adoptions.

According to Buzen [8] learning functions are helpful in:

1. understanding and remembering learning material;
2. connecting learning material with personal experience;
3. making unexpected suggestions;
4. connecting with other disciplines;
5. in making up something on your own.

Both basic learning outcomes, like understanding and remembering, and complex learning outcomes, like a new knowledge construction, follow from this list of functions.

The participant observation is conducted while presentations of MMs and a discussion on them were going. The participant observation detects student's emotions, questions and discussions on the method. All observed phenomena are documented in a research dairy. The observation results verify Buzen's learning functions and indicate significance of the problem raised in the questionnaire.

Data analysis in mixed methodology inheritably owns triangulation or cross-validation [21]. Quantitative perspective allows formalizing execution of learning functions from student's point of view, whereas qualitative perspective clarifies possible sources of problems and discourage experience.

5.2 Data Collection

General population consisted of the first year “Marketing” master program students of Higher School of Economics (Perm') of 2014/2015 and 2015/2016 academic year. The volume of a research sample was 23 observations. Furthermore, a participate observation was conducted during seminars with students in 2014/2015 academic year. The topic about the implementation of mind mapping in learning process was a part of seminars. During both academic years the survey was conducted at the end of the course. Students were provided with a self-reported pen-and-paper questionnaire at the last class. All indicators were measured in an ordinal scale. The sample differed from the population, because some students were absent, others left the program by the end of the fall semester.

6 Results and Discussion

This research differs from mainstream papers on MM and DMM by focusing on a process of adoption and its unfolding into a set of learning functions and perceived usefulness. The results of the survey show complex perception of the mind mapping approach. The participant observation shows that adoption of the mind mapping approach is strongly associated with a student's motivation. During the adoption of MMs switching costs are an important factor. As MM is a rarely used teaching method in Russian Federation, students are more likely to write an essay or make an oral presentation of some problem solution tasks. For a master program students switching costs are relatively high, what is why during the 2014/2015 academic year a high level of resistance to the method was observed. The participant observation also reveals the importance of a teacher's presentation of the mind mapping approach and instructions on the process of MMs creation. Students cannot see benefits of the mind mapping without credible evidences and success stories.

The participant observation also reveals weak points of assessment of MMs. Highly standardized approach to the assessment was used in 2014/2015. The criteria and their weight coefficients are available in Sect. 4.4, Table 2. The observation shows, that students pursue to meet these requirements, but not to design the best MMs. As a result, MMs often were overloaded, difficult to read and to understand. The next (2015/2016) academic year the assessment system is not that formalized. The new scheme of assessment is represented in the Table 3. The drawback of this approach is a less evident content of criteria. The usage of different weight coefficients confuses students.

Table 3. New Edition of Rubrics.

Criteria	Weights for reading tasks, %	Weights for research tasks, %	Explanation
Hierarchy	20	15	Meeting the requirements of hierarchy structure and volumes of categories
Reproduction	35	15	Meeting the requirement of correct usage of categories, adequate reproduction of learning material
Student's Approach	10	40	Originality, individual approach, categories from external fields
Quality of a MM	30	30	A student uses relevant images, different colors, and fonts. If such visualization is missed, a student yearns 0 points.

The results of the survey demonstrate considerable variance between estimations of execution of different functions. The entire usefulness of the mind mapping is estimated lower, than memorizing and understanding functions. Two waves of the survey demonstrate that students acknowledge usefulness of MMs for understanding and memorizing learning material whereas creative potential of the technic is perceived controversially from year to year.

In evaluation of usefulness of MMs for learning (measured as 0 – absolutely usefulness, 10 – very useful) median is 5.7. Medians for understanding, memorizing are 6.57 and 7 respectively, whereas making up something on your own, connect learning material with personal experience, connect with other disciplines, make unexpected suggestions are 6,43, 5.96, 5.35 and 5. The median of complexity of usage (measured as 0 – very simple, 10 – very difficult) is 6.83.

The learning function "help to make unexpected suggestions" has evaluated with the lowest score. The function "help to connect with the other course materials" is also estimated relatively low (Table 4). The dimensions of a personal relevance and making up something on their own are estimated relatively high.

Another important finding of 2014/2015 academic year is a great role of software in the process of the mind mapping approach adoption. We may consider that Coggle supports all the significant constructive blocks of MMs (e.g. colors, relations, pictures),

Table 4. Overall scores 2014/2015 and 2015/2016.

N	MMs help in learning	MMs help understanding	MMs help in remembering	MMs help to connect with personal experience	MMs help to connect with personal experience	MMs help to make unexpected suggestions	MMs help to connect with the other courses material	MMs help to make up something on your own	How difficult to use MMs	Public presentations usefulness	Year
1	6	6	8	8	5	6	8	5	9	8	2014
2	5	7	7	6	5	5	5	8	8	8	2014
3	8	8	10	7	7	7	8	10	8	9	2014
4	9	7	8	7	6	6	9	9	8	7	2014
5	5	7	9	3	3	5	8	9	10	5	2014
6	7	6	5	5	8	6	5	6	9	6	2014
7	6	8	6	3	3	3	3	6	6	6	2014
8	3	8	6	2	1	1	3	8	8	8	2014
9	7	7	6	7	8	5	7	5	7	4	2014
10	0	6	8	7	5	7	6	0	8	9	2014
11	4	3	7	4	7	2	2	10	7	10	2014
12	6	7	6	7	5	5	7	2	5	9	2014
13	7	8	7	5	3	7	4	3	7	8	2014
14	9	10	10	10	8	8	9	8	8	10	2015
15	8	8	8	7	7	8	9	8	10	8	2015
16	9	9	10	10	10	10	10	7	10	10	2015
17	4	6	5	4	2	3	3	8	6	8	2015
18	0	0	1	1	0	2	2	8	5	9	2015
19	5	7	5	5	6	5	10	7	8	10	2015
20	3	4	4	4	0	6	6	8	7	10	2015
21	6	5	8	7	5	5	5	9	9	9	2015
22	7	8	9	9	7	7	10	7	7	10	2015
23	7	6	8	9	4	4	9	6	8	9	2015
Median	5,70	6,57	7,00	5,96	5,00	5,35	6,43	6,83	7,74	8,26	
Mode	7,00	7,00	8,00	7,00	5,00	5,00	9,00	8,00	8,00	8,00	
MIN	0	0	1	1	0	1	2	0	5	4	
MAX	9	10	10	10	10	10	10	10	10	10	

presents easy GUI for the construction of MMs, supports collaboration, and is accessible through the Internet. Moreover, we suggest the criteria to select mind mapping software for collaborative learning purposes. The short-list of them follows:

1. globally accessed web-service;
2. collaboration (e.g. sharing, group-working) while MM's creation;
3. the most of the constructive blocks of MMs are supported.

In 2015/2016 feedback form is expanded with questions about student's experience in Coggle.

Thus, Coggle is used in learning process in 2015/2016 academic year. The results are tabulated in Tables 5 and 6 contains aggregated data from Table 5.

Table 5. Responses on Coggle usage, 2015/2016.

Question	Responses												
Coggle usability in individual activities	7	6	8	10	1	6	8	1	6	10	2	4	7
Coggle usability in collaborative work	9	6	10	8	3	9	8	7	5	10	4	8	9
Complexity of learning Coggle	6	6	10	10	2	10	8	1	8	8	8	6	7

Table 6. Statistics of responses on Coggle application to learning practice, 2015/2016.

	Median	MAX	%	MIN	%
Coggle usability in mind mapping	5.85	10	15	1	15
Coggle usability in collaborative work	7.38	10	15	3	8
Complexity of learning Coggle	6.92	10	23	1	15

Coggle usability for the mind mapping and collaborative work is measured as 0 – very inconvenient, 10 – very convenient. The median for usability in mind mapping is lower than for usability in collaborative work. It may mean that making MMs students face some problems with the software. The mostly mentioned drawbacks of the software are downloading of images, building of horizontal connection and management of branches. Some students report about problems with zooming, simultaneous access, and accessibility by means of mobile clients. There is criticism of low level of customization, inconvenience for presentation and poor choice of colors and fonts. It should be mentioned, however, that the only trouble with images in Coggle's free plan is a size limitation, and there is no need to download pictures as far as they may be embedded in a MM using a link.

Complexity of learning Coggle is measured as 0 – high complexity, 10 – low complexity. Median for complexity of learning, 6.92 witnesses about low complexity for a half of the sample and high complexity for another half. As median score for usability in collaborative work is 7.38 the conclusion about high usability for collaborative work is proved.

Students consider a practice of presentation and a discussion of MMs as a highly useful activity. The median of this index is 8.26. The benefits of a presentation and a discussion are mainly related to development of oratorical gifts and a structure of thinking. MMs is one more topic for organization discussion into class. The results show that MM suffers from general weakness of an interactive visualization technique [7]. Students cannot recognize DMM as a useful approach. Students find DMM time consuming and difficult to use. Students do focus on a form of a MM instead of content and process of its creation.

7 Recommendations

Summarizing our experience and the results of the investigation we can confidently recommend integrating DMMs into daily educational practices. Of course, this integration should be controlled at both technological and methodological level.

In case of supporting in-class and at home collaborative activities on MMs we may suggest using a collaborative mind mapping web-service Coggle. Among the other functionality, free plan of this service supports all significant features of MMs, has no limitations on quantity of public diagrams, allows to chat and comment.

We also recommend to identify as clear as possible the goal of usage of MMs in learning. Memorizing and understanding is relatively straightforward to manage, whereas solving of creative tasks requires more profound preparation. This preparation lies out of the method as such. It includes break of stereotypes of reasoning and training on generation of new ideas. Particular attention should also be paid to multidisciplinary function of mind mapping. The task should include instructions emphasizing this aspect.

Before a course begins we recommend to estimate students' motivation and their switching costs. This estimation is useful in development of a strategy of presentation and instruction on MMs. The evidence and success stories are helpful for presentation of MMs as a learning tool.

Undoubtedly, MMs cannot be the only learning tool during a course. In order to avoid routinization of mind mapping it is necessary to combine it with other learnings technics. Assessment approach is still an open question. Both more or less standardized approaches to assessment have their disadvantages.

8 Future Work and Conclusion

This work touched two aspects of application mind mapping technique to modern education. At first, we discussed the role of software selection and adoption to educational processes. At second, we explored the methodological features of collaborative digital mind mapping within a particular master course.

The future work on technologies grows from the selected software limitations. Unfortunately, Coggle is a general purposed mind mapping software and it does not support any specific educational activities such as evaluation. Moreover, for today it does not allow to export a MM in a format without information loss, which can be easily parsed by another program. But, this problem may be solved by an extra software, which communicates with Coggle through its powerful API.

The students' experience of collaborative learning with DMM on the marketing master program is described and generalized. Through the results of the mixed research we may conclude:

1. An implementation of DMMs demands attention not only to mind mapping approach, but to supportive software, its introduction and adoption.
2. In spite of Coggle has rich functionality in MMs' creation and collaboration, it is not a fully educational software. So, there is no possibility in using it to evaluate MMs or to support any kind of assessment.

It turned out that perception of usefulness of the mind mapping is differentiated according to its functions. Simpler functions get more positive perception, whereas more complicated ones get less positive. MMs, as well as traditional techniques, may become routine. In terms of instruction and encouraging, usage of MMs is sometimes more complicated than habitual techniques, because its results may not be as visible as habitual techniques' result. MMs are especially demanding to assessment, because of the complex procedure of construction and management goals. The given results show that focus on students' experience opens the dimensions significant for MMs implementation for learning process.

Of course, the results may be a consequence of Russian cultural particularities where more attention is paid to result of problem solution, but not to the process which is underpinned to it. Due to this MMs emphasizing the process are perceived as overwhelming and creating high switching costs.

This research has certain limitations. Firstly, all the estimations are subjective. It raises the question of development objective criteria of estimation of MMs adoption process. Secondly, the sample is quite limited that makes impossible applications results out of it. The results need to be tested on the other samples. Thirdly, the paper considers the evaluation issue of mind mapping not so deep as it deserves. Further search of optimal design for evaluation is also the important direction for future research.

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