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Research Article

The Effect of Mind Mapping on Teaching and Learning: A Meta-Analysis

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Abstract

To improve teaching and learning, it has become increasingly popular to use visualized tools for study. We try to find out the effect of mind mapping on teaching and learning considering the advantage of mind mapping. Although numerous research studies have shown the advantage, there aren't conclusive results yielding. To conform the effect, we adopt the method of meta-analysis by reviewing experimental and quasi-experimental studies. The meta-analysis shows that mind mapping has positive effect on teaching and learning and country, usage, subject and achievement can influence the results.

Keywords: mind mapping, meta-analysis, teaching, learning

INTRODUCTION

One of the most important problem in education is to achieve a greater degree of utilization of mental abilities. One approach to this problem is the use of so – called mind maps, whose founder is Tony Buzan (Nebojsa et al., 2011) .Although numerous studies are devoted to testifying the advantages of mind mapping in education, there are lack of conclusive results representing the effect of mind mapping on teaching and learning. In order to shed light on a more definitive conclusion on the potential effect, we hope that we can achieve it by using the technique of meta-analysis, which is "a procedure for integrating the results of empirical research studies" (McGaw and Glass,1980, Pp.1)

Mind map was defined by Buzan (1993, Pp.59) as "an expression of Radiant Thinking and is therefore a function of the human mind," and "a powerful graphic technique which provides a universal key to unlocking the potential of the brain". The mind mapping has four essential characteristics: The subject attention is crystallized in a central image, the main themes of the subject radiate from the central image as branches, branches comprise a key image or key word printed on an associated line, and the braches form a connected nodal structure (Ibrahim, 2013).Similar to concept map, mind map is also a kind of graphic organizer, which is described as two-dimensional visual knowledge representations, including flowcharts, timelines, and tables. They show relationships among concepts or processes by means of spatial position, connecting lines and intersecting figures(John and Olusola,2006).

Different from mind map, mind mapping means the technique for visualizing these relationships among different concepts has distinctive features over concept mapping in terms of its colors and free form. By using such pictorial and graphical design flourishes, mind mapping can make learning and teaching more vivid and thus can promote memory retention as well as enhance the motivation of the learners. When it comes to free-form and unconstrained structure of mind mapping, Martin Davies (2011) believe that if so, there are no limits on the ideas and links that can be made, and there is no necessity to retain an ideal structure or format. Mind mapping thus promotes creative thinking, and encourages ''brainstorming''.

According to Akinoglu and Yasar (2007), learning is accompanied by cognitive strategies for knowledge retention, cooperative and collaborative learning, problem-solving, critical thinking and transformative learning. Many teachers have faced difficulties in teaching their course effectively while many students have faced difficulties in learning the course taught. Chin et al. (2011) also mention that mind mapping have been widely used in education in brainstorming ideas, training and development, organizing ideas and problem solving. Based on these, we conceive that mind mapping has positive effect on teaching and learning. Moreover, Mind Mappings (MM) (Buzan, 1974) are already frequently used in educational practice. Therefore, it is necessary to study the mind mapping's effect on teaching and learning.

LITERATURE INTERVIEW

Constructivist theory

Different approach to account for the beneficial effects of mind mapping can be found in theoretical sources. Some explanations focus on unique, intrinsic properties of mind mapping, for example, Nebojsa et al. (2011), based on the work of human brain, hold that mind mapping is a brilliant expression of thought and therefore a natural function of the human mind and it is a powerful graphical tool that provides a universal key to unlocking the potential of the human brain. Others point to the properties that mind mapping share with other visual tools, such as concept mappings and flow mappings.

Constructivist theory is rooted in the subjectivist worldview, which emphasizes the role of the learner within the context of his environment (Burrell and Morgan, 1979). According to the theory, when a learner is committed to the interaction between him and his environment, he can better understand them, resulting in meaningful learning. In education, according to Harkirat et al. (2011), it involves reconciliation of disparate prior conceptions with more scientifically accepted new information through active student involvement in resolving inconsistencies, thus improving the organization and scientific accuracy of conceptual representations during learning, often leading to improved students' science learning outcomes. Teaching for active construction of new knowledge, is a process of helping students mobilize their prior understanding and reorganize them in light of current experience.

Visual tools, as their proponents argue, are deeply rooted in constructivist theory. (Eastman, 1977; Jones, 1977; Novak and Gowin, 1984). Mind mapping is one kind of the visual tools and is also building on the theory. Mind mapping emphasize the active engagement of the learner who can utilize the existing knowledge to construct new knowledge in his mind resulting in the conceptual change. The changed concept can not only enrich the existing information, but also enhance the application due to the richness of information retrieval.

Cognitive loading theory

Cognitive loading theory assumes that a limited capacity working memory as well as an effectively unlimited long-term memory, holding schema that vary in their degree of automation. It also insists that working memory load should be reduced and schema construction encouraged. Working memory is capable of holding only about seven items or elements of information at a time (Miller, 1956). Thus, it is necessary to reduce the so-called working load. Standing as a distinctive part of the theory, schema theory postulates that schema provide a mechanism for knowledge organization and storage when knowledge is stored in long-term memory in the form of schema, resulting in the reduced working memory load. Knowledge can be held and processed in working memory effortlessly because our restaurant schema acts as a single element. The sub elements or lower-level schemas that are incorporated in the higher-level schemas no longer require working memory capacity. Often, this acquisition of schemas is an active, constructive process (John et al., 1998). That sounds like what the constructivist theory support.

Mind mapping is a technique of representing knowledge by organizing it as a network or other non-linear diagram incorporating verbal and symbolic elements which are assumed as the schema. Students can condense their knowledge by using mind mapping, thus reducing the working memory load and remembering the knowledge easier and clearer. Furthermore, students' involvement in the mind mapping can encourage the students' active practice which in turn consolidates their knowledge. Some students have problem in learning well in class because they cannot find good ways like mind mapping to suit their learning style. By using mind mapping, they can personalize their notes so as to benefit for their memory. According to Chin Sok Fun, compared to words, the human brain remembers images better than words; mind mappings that show smooth flowing curves and variety of color can assist students to understand and remember the subject matter. A study conducted by Christine, Donald and Thomas on students from business and other courses shows that even students with different learning styles (verbal, logical, spatial or interpersonal) can make use of mind mappings to explore learning opportunities.

Instrument differences

In the past, mind mapping was done using by paper and pencil, but until the advancement of information technology, mind mapping nowadays can be easily constructed, processed, disseminated and presented by using computer hardware and software. Nebojsa et al. (2011) find that mind mappings are nowadays created almost exclusively by computer. There are several excellent softwares for creating mind mappings such as Mindmanager (www.mindmanager.com) and Mindomo (www.mindomo.com).They allow students to create simple presentation of ideas, knowledge and information and more efficient learning. These versatile products are designed to make education more productive and improve the learning condition.

It is easier to edit by using the software instead of using the pen and pencil. Obviously, operation in the computer will save more time thus will be more effective.

Subjects differences

Researches show that mind mapping is effective in several subjects. Buzan and Buzan (2003) reported that use of a mind mapping technique improved students' achievement in science. Orhan (2007) showed significant positive outcomes in students' concept learning, overcoming misconceptions, academic achievement and attitudes towards science courses when students take notes using the mind mapping method. Science education emphasizes the engagement of students in searching, implementing, experimentation or observation while mind mapping encourage the students' involvement in learning.

Pehkonen (1997) stated that mind mapping benefits students taking mathematics education. Brinkmann (2003) described that mind mapping can be used in mathematics education to organize information, act as memory aids, work for repetition and summary, summarize the ideas of several students, meaningfully connect new information with given knowledge, introduce new concept, let cognitive structure of students become visible and foster creativity.

Chei-Chang Chiou (2008) wrote that mind mapping help students in advance accounting courses. The mind mapping can help the students to interact their accounting knowledge with their formal information as well as to raise the students' interest of accounting through color and free form.

Meta-analysis of concept mapping

Until now, there are no meta-analysis of mind mapping. Therefore, in order to analyze mind mapping, we need to review meta-analysis of concept mapping which was once analyzed. Horton et al. (1993) conducted a meta-analysis of 18 classroom-based concept map studies. They reported (over 14 studies) that concept mapping helped students raise posttest achievement scores with 0.42 standard deviations.

John C. Nesbit and Olusola O. Adesope (2006) extracted fifty five (55) studies from sixty seven (67) standardized mean difference effect sizes and got five thousand eight hundred and eighteen (5,818) participants. It proved that concept mapping studies split by educational level (the mean effect size of grades 4 to 8 is 0.905,the highest among all levels), class setting(the mean effect size of not entirely in class is 1.039), subject(the mean effect size of humanities, law and social studies is 1.265,the highest among all subjects), duration(less than 5 weeks reporting the mean effect size of 0.701,the highest among all duration) and the way of learning(the mean effect size of maps constructed is higher mean effect size with 0.819 than that of maps studied).

Research questions

By reviewing all experimental and quasi-experimental studies on the teaching and learning effects of mind mapping that met specific criterion in meta-analysis, we try to approach to the potential benefits of mind mappings in learning and teaching and find out what are the key factors in the benefits so as to achieve the goal of improving teaching and learning. Hence, the primary research questions of this meta-analysis are as follows;

Do mind mappings have positive effect on teaching and learning in comparison with other, non mapping teaching and learning activities just like concept mapping?

What are the moderating variables that will affect the mind mappings' effect on teaching and learning?

How can we improve teaching and learning by using mind mappings?

METHOD

Locating the Studies

The literature search was conducted with the key words *mind mapping or mind mapping* and *experiment*, with the studies published between 1999 and 2013.The database we searched included Web of Science, Eric, Proquest , PsycINFO, Wiley Online, Google Scholar, Science Direct and CNKI. In terms of the select of the papers, we set up several criteria. First, the study must be related to teaching and learning. Second, the study had to have treatment and control groups, that is, the effect of mind mapping and other activities had to be compared. Third, the study must randomly assigned participants to groups. Forth, the study had to report sufficient data to allow an estimate of standardized mean difference effect size.

To ensure that the criteria of the including studies were reliable, one researcher read the abstract of each study in the search and select the appropriate studies, then a second researcher randomly select from a sample of twenty (20) of the one hundred and sixty three (163) studies. The decisions to include or discard showed 100% agreement, resulting in a list of one hundred and sixty three (163) studies were obtained.

When it comes to the coding, we also assign two researchers to work. The first one code the studies in the current meta-analysis, including twenty (20) menu items like the year of the study, source(journal or dissertation) ,educational level, gender, country , subject, usage(paper and pencil or software),duration of the study and treatment, comparison treatment and so on. Then the second one recode one third of the studies in the same way. The estimated interrater reliability was 90%.The discrepancies were discussed between the authors and could be modified whenever necessary.

Statistical analysis

Computing the Effect Sizes

After finishing the selection above, we get fifty eight (58) studies that compared mind mapping and other activities without any statistical control. So we need to calculate their effect sizes with Cohen's *d*, which was estimated by dividing the differences in the means of the experimental group and control group with the pooled standard deviation ($d = \frac{x_1 - x_2}{s}$,x_1 and x_2 respectively mean the experimental group and the control group using mind map while s means the pooled standard deviation）.

To get the unbiased estimate of the standardized mean difference effect size, we calculate Hedge's g($g = (1 - \frac{3}{4n - 9})\ d$,n means the total number of participants in the experimental and control groups)(Lipsey and Wilson, 2001).

During the process, 18 studies of the original fifty eight (58) studies were discarded because there was insufficient information for estimation of effect size.

To avoid loss of information, we decided to include all the effect sizes first.

Combining Effect Sizes

Each effect size was first multiplied by the inverse of its variance to yield the weighted effect size w($w = \frac{n_1 n_2 (n_1 + n_2)}{(n_1 + n_2)^2 + n_1 n_2 g^2}$,n_1 is the sample size of experimental group and n_2 is the sample size of control group). Then the sum of all the weighted effect sizes was divided by the sum of the inverse variances to generate the overall mean effect size $\overline{ES}$ ($\overline{ES} = \frac{\sum (w_i ES_i)}{\sum w_i}$,) .To determine statistical significance, we need to calculate 95% confidence interval ($\overline{ES_L} = ES - 1.96SE$, $\overline{ES_U} = \overline{ES} + 1.96SE$,SE= $\sqrt{\frac{1}{\sum w_i}}$, $\overline{ES_L}$ is the lower limit and $\overline{ES_U}$ is the upper limit, SE is the standard error of the mean effect size) .

To avoid the sampling error resulting from the random sampling of participants from the population, we need to test the homogeneity of variance statistic by calculating Q($Q = \sum w_i (ES_i - \overline{ES})^2$),When Q exceeded the critical value of the chi-square distribution (p<.05), the mean effect size was judged to be significantly heterogeneous.(Lipsey and Wilson,2001).

During the process, we need to deal with the effect sizes which are statistically dependent that is one important principle of meta-analysis to avoid according to Lipsey and Wilson (2001).For instance, if a study has one control group and two treatment groups and it is inappropriate to divide them into two effect sizes considering that they share the same control group.

Faced with such situation, we decided to calculate average effect sizes to get statistically independent effect sizes. Also, if one study was compared on students' imagination and creativity, we average the two effect sizes so that one sample contributed only one effect size which is therefore statistically independent.

Testing for Publication Bias

According to Lipsey and Wilson(2001),we should pay attention to the selection bias which is also the weakness of meta-analysis, so it is necessary for us to consider the publication bias. Therefore, we generated some funnel plots. Our impression was that there was little publication bias, since most studies were distributed symmetrically about the mean effect size.

RESULTS

After dedicated selecting, we've got forty (40) studies involving five thousand two hundred and thirteen (5,213) participants, which is presented in Appendix1.The positive mean effect size reveal that mind mapping do good to improve teaching and learning.

Differences in students' countries

Table 1. Standardized weighted mean effect sizes of the differences in students' countries

Category	N of studies	Effect size	95%CI		homogeneity of effect size	
Country		SE ESs	Lower	Upper	Q	df
China	41	0.74	0.49	0.99	590.12	40
Ex-China	8	0.22	-0.17	0.60	45.95	7
Turkey	1	0.71	0.41	1.00	0	
UK	2	-0.09	-0.50	0.66	0.20	1
mixed	4	0.05	-0.57	0.67	23.06	3
unknown	1	1.2	0.59	1.82	0	

Note. SE ESs= the standardized weighted mean effect sizes; CI=confidence interval.

Students from different countries may score distinctively by using mind mappings. From the table, we can find that the mean effect size for mind mapping studies conducted in China was much higher than for other locations. Additionally, we can find a large quantity of studies that meet the specific criteria in China. However, the results are to some degree limited by the small sample of the countries abroad so that the certainty of the interpretation is also limited. After all, homogeneity was rejected for all the mean effect sizes in Table1,indicating that varying individual effect sizes exist widely. Heterogeneity was remarkably higher across studies in China.

Differences in the usage of mind mapping

Table 2. Standardized weighted mean effect sizes of the differences in usage

Category	N of studies	Effect size	95%CI		homogeneity of effect size	
usage		SE ESs	Lower	Upper	Q	df
Paper&pencil	37	0.66	0.39	0.62	595.78	36
software	12	0.71	0.41	1.00	46.98	11
unknown	3	-0.02	-0.24	0.621	12.55	2

Note. SE ESs= the standardized weighted mean effect sizes; CI=confidence interval

This section addresses the second research questions: Are there any differences between the way of paper-pencil and software in the use of mind mapping? The homogeneity tests of software and paper and pencil show that these effect sizes varied significantly across studies since Q exceeded the critical value of the chi-square distribution, which means that the mean effect size was judged to be significantly heterogeneous. Hence we adopt the random effects models to calculate the effect sizes of software and paper and pencil (Lipsey and Wilson, 2001). On the contrary, the unknown usage adopts the fixed effects models to deal with the results. Thus, the final standardized weighted mean effect sizes of the fifty two (52) studies that measured students' achievement are presented in Table1.Generally speaking, students using software had the highest overall achievement according to the result of SE ESs.

Differences in subjects

Table 3. Standardized weighted mean effect sizes of the differences in subjects

Category	N of studies	Effect size	95%CI		homogeneity of effect size	
Subject		SE ESs	Lower	Upper	Q	df
Social science						
Arts	4	0.95	0.72	1.19	7.36	3
English	15	1.34	0.89	1.78	188.79	14
Natural science						
Biology	14	0.35	0.16	0.55	43.95	13
Chemistry	2	0.38	0.09	0.66	3.20	1
Geography	4	0.00	-0.41	0.42	14.06	3
Medicine	3	-0.59	-1.47	0.30	36.91	2
Others	5	0.32	-0.31	0.94	46.42	4

Note. SE ESs= the standardized weighted mean effect sizes; CI=confidence interval.

Table 3 shows that geography and medicine didn't have positive effect on teaching and learning by using mind mapping and the mean effect size of English was much higher than other subjects. What's more, the social science seems to be more effective in learning and teaching than natural science by using mind mapping.

Differences in the effect of mind mappings under various conditions

Table 4. Standardized weighted mean effect sizes of the differences in conditions

Category	N of studies	Effect size	95%CI		homogeneity of effect size	
Educational level		SE ESs	Lower	Upper	Q	df
College	8	0.48	-0.01	1.08	71.31	7
Middle school	18	0.41	0.24	0.58	52.48	17
Primary school	7	1.52	0.66	2.38	3.2	6
Senior high school	11	0.97	0.56	1.37	106.10	10
Others	2	-0.34	-2.10	1.43	57.94	1
Duration						
1-2months	13	0.39	0.14	0.64	56.31	12
3-6months	26	0.79	0.50	1.08	288.41	25
7months or more	7	0.39	-0.34	1.12	161.32	6
Document type						
Dissertation	38	0.72	0.52	0.91	295.33	37
journal	14	0.42	-0.05	0.89	263.90	13

Note. SE ESs= the standardized weighted mean effect sizes; CI=confidence interval

The mean effect sizes for mind mapping were split by educational level, study duration and the way of publication. There were no laboratory studies in which participants constructed mind mappings and students performed the learning activity entirely in a classroom under the instruction of the teachers. From the table, we can find that the 3-6months of the training of mind mapping made the teaching and learning most effective compared with other kinds of duration. Also, students in primary school can be affected more than students in other schools by mind mapping. Here, others refer to some unconventional schools like the vocational schools and its mean effect size was negative. In China, these schools are always ignored since the majority regards them as the worst schools. Then, in terms of the form of studies, we can detect that dissertation has more positive effect.

Differences in academic and affective achievement

Table 5. Standardized weighted mean effect sizes of the differences in conditions

Category	N of studies	Effect size	95%CI		homogeneity of effect size	
Achievement		SE ESs	Lower	Upper	Q	df
Academic achievement	26	0.75	0.344	1.07	5384.96	25
Affective achievement	12	0.68	0.41	0.94	41.76	11

Note. SE ESs= the standardized weighted mean effect sizes; CI=confidence interval

From Table5, we detect that studies performing academic achievement are more effective than that of affective achievement. Heterogeneity of academic achievement was noticeably higher compared with the affective achievement, perhaps reflecting the greater diversity of treatments and lower experimental control in mind mapping research.

As to testing for publication bias, it is in Appendix2 and it shows that there is little publication bias, thus to some degree, our statistics can be convinced.

DISCUSSION

This meta-analysis systematically combines the fifty two (52) studies investigating the effect of mind mapping on teaching and learning. We acknowledge that a majority of the studies included were cross-sectional and cross-cultural and thus we cannot make any strong causal claims. In the following sections, we discuss some potential implications of the findings.

Effect of usage and condition

Unlike concept mapping, mind mapping attach much importance to the process of conducting since nearly all studies we found focus on students' drawing by their own instead of studying mind maps.

Then we can find that the usage of mind mapping has positive effect on students' learning and teachers' teaching. Specifically, by introducing software, mind mapping achieve more effect on teaching and learning. By means of software, it will save more time and be more vivid in both teaching and learning. Therefore, when we put mind mapping into use, we should underlie the software and spare no efforts to improve the teaching facilities. However, according to the studies analyzed, we discovered that most studies used paper and pencil, especially in China. Obviously, it's necessary to rise the educators' attention to improve the education environment in the hope of progressing in teaching and learning.

As to the duration, we find that 3-6months would be the most effective. It gives us an important clue that it is best for students to grasp the skill of mind mapping well after 3-6 months. Then teachers can have a good command of time to guide students to learn mind maps well.

Effect of subjects and achievement

In Table3, it is obvious that the effect of social science(art and English) is greater than natural science(biology, medicine, chemistry, biology) and geography as well as medicine don't represent positive effect. Mind mapping seems to be more effective as to its memorizing and visualizing characteristics. This may be related to Buzan's starting point when he tried to study mind mapping. He carefully studied human's brain and found that color and other vivid things can be helpful to the working of left and right brain. Moreover, we can find that concept map and mind map are best applied in different areas.

As to the achievement, we can find that mind mapping is more helpful to improve students' academic achievement rather than affective achievement. There may be two reasons for explaining it. First, mind map is a kind of visualized tool and it helps a lot in terms of information retention which is helpful to learning well in English. Second, most studies come from China and China pay more attention to students' academic achievement and will try their best to improve it while ignoring the ability, creativity or something.

Limitations

This meta-analysis is not without limitations. First of all, there exists considerable heterogeneity in the effect sizes across sizes. Such heterogeneity may also reflect the variance in the quality of the studies selected.

Second, the sample of the studies was also limited, especially, most studies came from China, thereby raising concerns about the internal validity of some studies.

Third, even though this meta-analysis attempted to examine the effectiveness of mind mapping on teaching and learning, there are still some variables that can hardly be captured or controlled in the studies.

RECOMMENDATIONS AND CONCLUSION

From the insights of this meta-analysis, we have generated some recommendations for future research on the effectiveness of mind mapping on teaching and learning.

Research from other countries except China is needed more and then we can compare and analyze the impact of all kinds of factors. That is to say, broader study is required. High-quality research is needed on the use of mind mapping in primary school and make the comparison across countries.

This meta-analysis, therefore, helps provide evidence about mind mapping's positive effect on teaching and learning and we also try to find out the factors that affect the influence.

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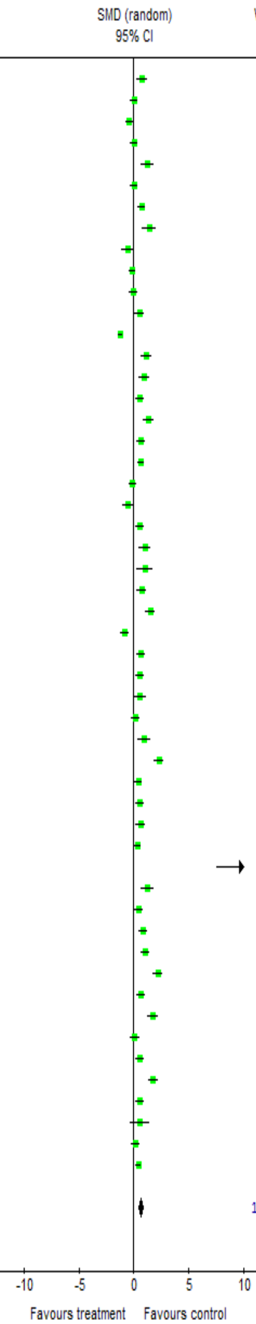
Appendix1

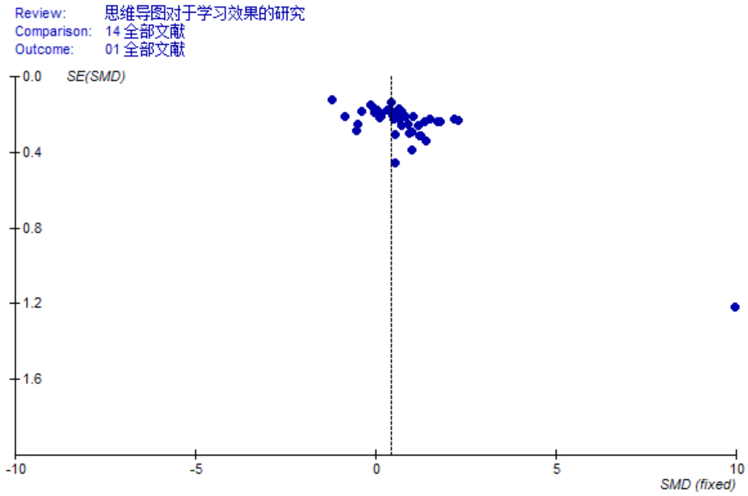
Review: 思维导图对于学习效果的研究
Comparison: 14 全部文献
Outcome: 01 全部文献

Study or sub-category	实验组 N	实验组 Mean (SD)	对照组 N	对照组 Mean (SD)	Weight %	SMD (random) 95% CI
Ali G" unay Balim	32	33.31(6.02)	32	28.90(6.21)	1.91	0.71 [0.21, 1.22]
Anthony V D' Antoni	66	5.92(1.20)	65	5.87(1.33)	2.03	0.04 [-0.30, 0.38]
CYNTHIA TREVINO	61	18.62(9.33)	63	22.38(9.14)	2.02	-0.40 [-0.76, -0.05]
CYNTHIA TREVIN（2）	61	18.62(9.33)	59	18.56(8.27)	2.02	0.01 [-0.35, 0.36]
Chin Sok Fun	21	54.54(15.92)	29	35.52(15.26)	1.81	1.20 [0.59, 1.82]
Harkirat S. Dhind（2	66	5.92(1.20)	65	5.87(1.33)	2.03	0.04 [-0.30, 0.38]
Harkirat S.Dhindsa	63	2.72(0.58)	61	2.31(0.57)	2.01	0.71 [0.35, 1.07]
Ibrahim. M. A. Jbeil	22	17.90(0.97)	22	16.09(1.53)	1.77	1.39 [0.72, 2.05]
Paul Farrand	25	2.80(0.67)	25	3.20(0.78)	1.86	-0.54 [-1.11, 0.02]
Stuart J. Ritchie（2	100	52.16(23.84)	86	55.31(24.03)	2.06	-0.13 [-0.42, 0.16]
Stuart J.Ritchie	52	70.30(25.69)	56	70.87(26.24)	2.00	-0.02 [-0.40, 0.36]
陈霞	40	40.70(6.90)	40	37.00(7.71)	1.96	0.50 [0.06, 0.95]
段海琪 黄松	167	74.93(7.54)	167	84.43(7.85)	2.09	-1.23 [-1.47, -1.00]
方爱翠	35	20.55(6.67)	35	13.90(4.38)	1.90	1.17 [0.66, 1.67]
方爱翠（初一年级1组	35	19.08(5.89)	35	14.20(4.80)	1.92	0.90 [0.41, 1.39]
方爱翠（四年级1组）	45	13.05(5.59)	46	10.21(4.97)	1.98	0.53 [0.11, 0.95]
方爱翠（四年级2组）	44	12.60(4.74)	42	7.53(2.17)	1.94	1.35 [0.88, 1.82]
房梅	48	83.67(9.57)	62	77.44(10.41)	2.00	0.62 [0.23, 1.00]
冯白炼	73	35.83(8.60)	70	30.64(7.22)	2.03	0.65 [0.31, 0.99]
冯百炼（重点班）	86	32.96(6.93)	83	33.65(6.47)	2.05	-0.10 [-0.40, 0.20]
傅声晔	34	34.75(3.26)	31	36.32(2.86)	1.92	-0.50 [-1.00, -0.01]
何方平	53	85.89(10.07)	52	80.13(11.32)	2.00	0.53 [0.14, 0.92]
李海杰	27	17.59(1.67)	26	16.08(1.29)	1.85	0.99 [0.42, 1.57]
李海杰2组	13	17.00(1.35)	18	15.39(1.69)	1.68	1.01 [0.24, 1.77]
吕露	46	56.98(5.68)	50	52.69(6.54)	1.98	0.69 [0.28, 1.11]
苗晓红	50	64.96(12.43)	50	45.66(13.26)	1.96	1.49 [1.05, 1.94]
聂思成	49	5.70(5.20)	49	14.77(14.04)	1.98	-0.85 [-1.26, -0.44]
彭娟英	50	75.36(28.03)	50	58.78(20.83)	1.99	0.67 [0.26, 1.07]
沈华梅	50	15.79(3.42)	52	14.20(2.68)	1.99	0.51 [0.12, 0.91]
石茵	20	32.56(5.16)	25	29.51(5.61)	1.83	0.55 [-0.05, 1.15]
王道磊	52	71.31(10.35)	50	69.77(10.49)	2.00	0.15 [-0.24, 0.54]
王宏	25	32.00(5.57)	25	26.80(5.32)	1.84	0.94 [0.35, 1.53]
王丽新	63	73.58(7.49)	64	54.95(8.63)	1.95	2.29 [1.84, 2.74]
王秀平	64	34.95(8.19)	67	31.53(8.43)	2.02	0.41 [0.06, 0.76]
王秀平（北京普通）	46	38.87(7.41)	44	35.11(6.63)	1.97	0.53 [0.11, 0.95]
王秀平（北京重点）	42	43.04(6.69)	43	37.60(10.03)	1.96	0.63 [0.19, 1.07]
王秀平（太原重点）	64	40.38(7.25)	69	37.93(8.23)	2.03	0.31 [-0.03, 0.66]
王婷婷	20	93.50(1.55)	20	77.75(1.55)	0.58	9.96 [7.58, 12.34]
王琛	25	32.00(2.27)	25	26.80(5.32)	1.82	1.25 [0.64, 1.86]
王璐	48	80.63(10.57)	48	75.56(10.57)	1.98	0.48 [0.07, 0.88]
王璐2	48	69.59(10.87)	48	60.63(10.87)	1.98	0.82 [0.40, 1.23]
魏丹	52	72.50(10.44)	52	63.19(7.31)	1.98	1.03 [0.62, 1.44]
魏红霞	63	67.88(4.46)	64	57.86(4.65)	1.96	2.19 [1.74, 2.63]
夏恩伟	48	85.40(5.60)	48	81.80(5.60)	1.98	0.64 [0.23, 1.05]
曾燕燕	50	86.79(3.67)	48	79.95(4.24)	1.94	1.71 [1.25, 2.18]
张丽	43	48.49(22.70)	43	43.48(71.86)	1.97	0.09 [-0.33, 0.52]
张琳	50	83.05(5.04)	50	79.94(5.78)	1.99	0.57 [0.17, 0.97]
张巧妹	50	80.27(6.50)	48	67.56(7.70)	1.94	1.77 [1.30, 2.24]
张峭林	49	132.91(6.26)	51	128.80(8.66)	1.99	0.54 [0.14, 0.94]
张茹	10	8.88(1.07)	10	8.30(1.00)	1.55	0.54 [-0.36, 1.43]
周丹	44	17.88(3.72)	44	17.31(4.08)	1.98	0.14 [-0.27, 0.56]
周凤敏	109	94.84(11.28)	107	89.73(13.25)	2.07	0.41 [0.14, 0.68]
Total (95% CI)	2599		2614		100.00	0.63 [0.42, 0.84]

Test for heterogeneity: Chi?= 680.33, df = 51 (P < 0.00001), I?= 92.5%
Test for overall effect: Z = 5.83 (P < 0.00001)



Appendix 2


Review: 思维导图对于学习效果的研究
Comparison: 14 全部文献
Outcome: 01 全部文献
0.0
SE(SMD)
0.4
0.8
1.2
1.6
-10
-5
0
5
10
SMD (fixed)