THE EFFECTIVENESS OF PROBLEM BASED LEARNING MODEL WITH MIND MAPPING IN HEALTH LAW AND ETHICS LECTURES

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ABSTRACT

The challenges of the world of work in the Industrial Revolution Era 4.0 accelerated by the COVID-19 pandemic, require education graduates who have 4C competencies (Critical, Creativity thinking, Collaboration, and Communication) and HOTS (High Ordinary Thinking Skill) thinking skills. The lecture process in Health Ethics and Law at the Community Health Sciences study program FKM Unand has not been able to accommodate the needs for learning achievement (CPL) 4 C and the ability to think HOTS well. The results of interviews with 10 informants of Bachelor of Public Health revealed that the characteristics of public health ethics with the problem have not been mastered. The use of mind mapping in learning shows an increase in students’ abilities by 75%, and without mind mapping only 35% (Buzan T 2009). This study aims to determine the level of student learning effectiveness using the Problem Based Learning Model By Using Mind Mapping. This type of research is Research and Development using the ADDIE development method (Analysis, Design, Development, Implementation, and Evaluation). The effectiveness test of the model was carried out on students with a pretest-treatment-posttest research design on the experimental class and the control class by dividing the experimental class and the control class. In drawing conclusions, statistical analysis of T-test was used on the posttest scores of the experimental class and the control class, and the gain score between the posttest and pretest scores of the experimental class. To ensure the equality of the experimental class with the control class, a pretest and t-test analysis were carried out and the results found that there was no difference in initial ability between the two classes. From the posttest results, it was known that the average value of the experimental class = 82.73 while the control class = 69.51, and after the T-test there was a significant difference at the 95% confidence level, which means that the use of the model is effective in increasing student competence. The second analysis was carried out by looking at the gain-score between the pretest and posttest values of the experimental class, where the average value was 60.54 and 82.73. After the T-test was conducted, it was also known that there was a significant difference at 95% confidence, which means that the use of the model has been able to increase the posttest score effectively and significantly with the pretest value. So that the overall implementation of Problem Based Learning by Using Mind-mapping models is effective in improving learning outcomes.

Keywords—Problem Based Learning, Mind Mapping, 4C, HOTS, ADIIE, T-test

I. INTRODUCTION

The World Economic Forum recommends that there are 10 main competencies needed in the 4.0 Industrial Revolution era, namely competence in (1) problem solving, (2) creative thinking, (3) critical thinking, (4) coordination with various partners, (5) making right decisions, (6) emotional intelligence, (7) service oriented, (8) negotiation skills, (9) flexible in knowledge, (10) radian thinking skills from various disciplines. The challenges ahead require a learning model that is able to develop student competencies as expected, so that graduates can exist in the era of RI 4.0 which is developing very quickly, including health workers (Simarmata et al., 2020).

According to Eggem and Kauchak, (nd), Ausubel and Robinson (1969) cited by Sukmadinata (1987) the learning process can be divided into 2 dimensions, namely the dimension of how to master the knowledge itself, and the dimension of how to connect new knowledge with the structure of existing ideas. In the first dimension, it can also be distinguished into the learning process of discovery learning (seeking), and reception learning (receiving).
In the second dimension, it is distinguished between rote learning, namely learning that is memorizing and meaningful learning, namely learning meaningfully.

What is important in meaningful learning is the relationship between cognitive structures and new knowledge material. Cognitive structure is all the knowledge and experience that students have from previous learning outcomes. In the process of meaningful learning, new knowledge must have a relationship with its cognitive structure, because that relationship will occur by the existence of similarity in content (substantiveness) and regularity. Thus, these two properties will show the logical meaning of the material to be studied.

Learning problem solving is a psychological process that is more complex than learning propositions or learning from prior knowledge. Kadir (2013) said Contextual Teaching and Learning (CTL) is a holistic or comprehensive learning approach. (Johson, 2002) concluded that in contextual learning there are at least three main principles, namely interdependence, differentiation, and self-organization.

Johson (2002) recommends several main components in contextual learning, namely carrying out meaningful relationships, carrying out meaningful activities, managing independent learning, developing collaboration, developing creative and critical thinking, maintaining student personality, achieving high standards, and using an authentic assessment system, Problem-based learning model, using real problems that occur as a context for students to learn to think critically, creatively, and problem-solving skills and to acquire pure knowledge and concepts from lecture material.

The description of the educational challenges of the XXI century and the Revolution 4.0 era where the competencies to be achieved and the direction of character-based education development contained in the Public Health Research Master Plan are also in accordance with the Andalas University Development Master Plan (RIP), requiring the development of an effective learning model to improve competence the 4C. Currently, Andalas University is also conducting trials of the Case Based Method and Project Based Learning models in several courses to be applied, if the results are positive, it will certainly be used as a general policy in the learning process later.

Problem Based Learning (PBL) model is a learning model whose process requires critical and creative thinking to find the best solution in the real problem solving process in the field. Creative thinking requires higher order thinking skills (HOTS) in addition to still paying attention to abilities basic. The goal to be achieved by Problem Based Learning is the ability of students to think critically, analytically and logically to find alternative problem solving through empirical data exploration in order to foster a scientific attitude (WinaSanjaya, 2011). Problem Based Learning is not merely a procedure, but it is part of learning to manage oneself as a life skill. Another opinion regarding the definition of Problem Based Learning (PBL) according to Kunandar, is a learning approach using real world problems as a context for students to learn about critical thinking and problem solving skills, as well as to acquire essential knowledge and concepts from learning materials.

As with a model characterized by syntax, currently many PBL models have been developed, including those known as the 5 syntax, 6 syntax and 7 syntax models or known as the seven jumps step. Lakono's research (2013) explains that often in carrying out the Problem Based Learning learning process students are not disciplined in carrying out the steps well, so the results are not good and boring. These steps include: (1) clarify concepts, (2) define problems, (3) discuss/analyze problems, (4) identify possible solutions, (5) set-task/learning objectives, (6) research solutions, (7) Synthesis results/solution.

In realizing character education which is proclaimed to produce graduates according to the competencies of the XXI century as described above, it is manifested in the existence of an ability program to discuss regulations or the field of ethics and law to be known, felt and implemented. One of these programs is specifically given in education through courses in Health Ethics and Law. Public health challenges are faced nationally and globally, so public health workers need to have SKM competencies with a composition of 40% science, 30% skills and 30% ethics. Ethical problems can occur in public health activities through activities: (1) health promotion and disease prevention, (2) risk reduction, (3) epidemiological research and other public health, and (4) structural and socioeconomic disparities.

The concept of Mind Mapping developed by Toni Buzan (2009.) is a technique or tool that can be used as part of a model in achieving more effective learning objectives. Learning with Mind Maps also leads to the development of creativity, critical thinking, communication and collaboration. The subject matter of Health Ethics and Law

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includes Public Health Ethics, Health Research Ethics, Professional Ethics, and Clinical Ethics, as well as ethics in accordance with specialization sciences with their respective characteristics. The Health Laws studied are Public Health Law and Medical Law, where Public Health Law is a relatively new science that is very developed. In the implementation of learning, it is described to answer challenges through the development of a Problem Based Learning model.

Public health ethical challenges include prioritizing issues to be addressed in the context of limited resources, which requires compromise in weighing the costs and benefits (Carter et al. 2012). Some problems in public health do not recognize an ethical perspective. Public health is multi-professional, interdisciplinary and context sensitive. Ethics education is arguably the cornerstone of training, practice, as well as research. Training in Public Health Ethics tailored to their particular profession or research focuses on (1) providing a summary of the literature on Public Health Ethics education such as in the United States, Europe, Canada and in developing countries (India), (2) exploring attitudes and approaches to include ethics in public health curricula, and (3) discuss reported barriers to effective Public Health Ethics education. Therefore, Problem Based Learning (PBL) or problem-based learning is expected to train and develop students’ abilities.

From in-depth interviews with 10 alumni of Bachelor of Public Health, eight people stated that they had received ethics lessons, but only in general. All informants need special knowledge of Public Health Ethics, Research Ethics, and Public Health Law. During college, most said they did not understand public health ethics and public health law. Examples of existing cases are more directed to clinical ethics and medical law. The results of interviews with alumni are also in line with several quantitative studies obtained.

James W. Tysinger, et al (1997) said his research entitled Teaching Ethics using small group problems, said that problem-based learning introduces students to critical thinking in the case of patients in small groups (Kipnis Kenneth, Gerhard Anita, 1995). Furthermore, in a study entitled Medical Ethics Education in Problem Based Learning Curriculum and (Xiaojie Ding, et al 2014) in his research Assessing the Effectiveness of Problem Based Learning of Preventive Medicine Education in China showed Problem Based Learning is the best interactive learning. IP AdiWibowo (2013) in the research title Effect of Problem Based Learning, learning motivation and Intelligence Quotient resulted in high learning motivation as much as 66.67% and 1.867 higher than conventional learning. NyetMoi Siew (2017) with his research on The Effects of Thinking Map Aided Problem Based Learning resulted in Mind Mapping research showing an increase in the application of the Problem Based Learning model that showed a very maximum. Because Mind Maps change the way of thinking that is usually linear to lateral and even radiant. In the future the era faced by the world of education is increasingly unclear or Volatility, Uncertainty Society 5.0, namely living alone with the help of the internet of things, robotics and big data. The core of 21st century skills is creativity, namely thinking new things. Innovation is doing new thing, iteration doing some thing.

Several similar studies reported on the use of mind-mapping learning and succeeded in increasing creativity, critical thinking and collaboration skills well (WahyuRikhaRovikhatul Ula, 2019), (Rikha, 2018), (Boyson, 2009), (Farrand P et all, 2002 ), (Karen Goodnough and Robin Wood, 2002). Furthermore, Brian Holland et al (2004) reported the results of his research on 40 students studying digital media and 79 students studying computer history. This mind mapping technique has been successful in helping students manage their projects and improve effective feedback. Likewise Roger Sperry (2009) at the University of California found that the human brain consists of 2 parts, namely the left and right, each of which has a different function/task. The function of the human brain is not inherited but can be trained by balancing the functions of the right brain and left brain can increase creativity, critical thinking, collaboration and communication.

Based on the study of Problems and the need for learning achievement goals (CPL) in the Health Law and Ethics Lecture of FKM Unand students, the author has tried to develop a Problem Based Learning learning model by integrating the Mind-mapping learning method, into a new learning model, namely the Problem Based Learning by Using Mind Model. -mapping. For this reason, it is necessary to measure the level of effectiveness of using this model in Health Ethics and Law Lectures for Undergraduate (S1) Public Health Sciences FKM Unand students.

Methodology
This research is a Research and Development research on a learning model using the ADDIE development method (Analysis, Design, Development, Implementation, and Evaluation). This study aims to determine whether the developed model is good and able to answer the learning challenges that exist in the Faculty of Public Health, especially the Health Ethics and Law courses.

This research begins with developing a Problem Based Learning learning model that integrates mind-mapping learning methods into it, so that it becomes a Problem-based learning by Using main-mapping learning model. Regarding the validity and practicality of the model, previous validation tests have been carried out through the assessment of relevant experts (experts), and peer lecturers, as well as students. So that on this occasion a limited test of the effectiveness of the model application will be carried out on students.

The effectiveness test through a limited trial of the model on students was divided into the experimental class and the control class. This pilot study uses the Pretest-Tratment-Postest type of research. To draw conclusions, a statistical analysis of the Difference Test was carried out on the posttest value of the experimental class and the control class, as well as the gain score between the posttest and pretest scores of the experimental class.

Results and Discussion

This section will explain the process of developing the model, the syntax of the model and the results of testing the effectiveness of the model.

II. MODEL DEVELOPMENT

The model development method uses the ADDIE approach (Analysis, Design, Development, Implementation, and Evaluation). This model was chosen because it is often used to describe a systematic approach in the development of instructional learning. In addition, the ADDIE model is a systematic approach model to describe the learning process. When used in the development of this process is considered sequential but also interactive, where the results of the evaluation of each stage can bring the development of learning to the previous stage. The final result of one stage is the initial product for the next stage.

From the results of the development of learning models that try to integrate the mind-mapping method into the Problem-based learning model, a new model has been named: Problem Based Learning by Using Main-mapping. This model produces 8 syntaxes, namely:

1. Understand the learning process plan guided by the RPS and lecture contracts (The same perceptions, contracts are guided by the Semester Learning Plan Orientation)
2. Organizing students to learn to look for real problems and how to use mind mapping (Organizing students to study real problems and study about mind-mapping)
3. Guiding individual and group investigations with radiant thinking
4. Develop and create group work in problem solving using mind mapping (Develop and present the work)
5. Analyze and evaluate the problem-solving process using mind mapping (Analyze and evaluate the problem-solving process)
6. Looking for references related to the topic of the problem independently and communicating with the group (Self Study with many references)
7. Presenting the results of group discussions using mind mapping with moderators and meeting minutes (Presentation and discussion)
8. Concluding the results of the presentation of problem solving and follow-up discussion plans in the form of a policy brief and or policy (Conclusion and follow-up)

The syntax of this model can be seen diagrammatically in Figure 1.
a. Model Test

The model has been tested for model validity and model practicality tests through the assessment of experts (experts) in their respective fields, namely: (1) language experts, (2) model experts, (3) content experts, (4) CAR experts, and (5) Evaluation experts, (6) Peer lecturers, and (7) students as users. Where validity and practicality testing is carried out on (a) model concept/model syntax, (b) model book, (c) lecturer manual, (d) student manual, and (e) teaching material book. The results of the assessments of experts, peer lecturers, and students conclude that the model is quite valid and practical to implement.

b. Model Effectiveness Testing

Before testing the effectiveness of using the Problem Based Learning by Using Mind Mapping model, normality testing was carried out, namely (1) visually on the data distribution graph, (2) Statistical Test (Kolmogorof-Smirnov and Shapiro-Wilk) Normal data if sig > 0.05. Furthermore, homogeneity test is also carried out to determine whether the variance of the data distribution is homogeneous or not, if the Significance Value > 0.05 means homogeneous and vice versa. These two tests are prerequisites for the different analysis (T-test).

1. Data Normality Test

The results of the normality test for the experimental class pretest value visually look quite normal (Fig. 2) and from the Kolmogorof-Sminov statistical test it is known that a significance value of 0.200> from 0.05 means normal (Table-1).

The results of the normality test on the pretest value of the control class through visuals also look quite normal (Figure-3), and the Kolmogorof-Sminov statistical analysis test obtained a significance value of 0.200> 0.05 (Table-2) which means that the data from the control class pretest also normal.
The results of the normality test on the posttest value of the experimental class through visuals also look quite normal (Figure 4), and the Kolmogorof-Sminov statistical analysis test obtained a significance value of 0.200 > 0.05 (Table 3) which means that the data from the experimental class pretest also normal.

The results of the normality test on the control class posttest value through visuals also look quite normal (Figure 5), and the Kolmogorof-Sminov statistical analysis test obtained a significance value of 0.200 > 0.05 (Table 4) which means that the data from the control class pretest also normal.

**Homogeneity Test**

The homogeneity test aims to determine whether the variance of the distribution of the data concerned is the same or not, and is required as a requirement in the independent sample T-test for parametric statistics. The decision in the homogeneity test is determined if:

- If the Significance Value > 0.05, then the data distribution is homogeneous
- If the Significance Value < 0.05, then the data distribution is not homogeneous

**Pretest experimental and control classes**

Table 5 Statistical Analysis of Homogeneity Test of Pretest Value of Experimental Class and Control Class

<table>
<thead>
<tr>
<th>Test of Homogeneity of Variances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest kelas eksperimen dengan pretest kelas kontrol</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.307</td>
<td>1</td>
<td>80</td>
<td>.581</td>
</tr>
</tbody>
</table>

From the statistical test, the sig data was 0.581 > 0.05 and the data was declared homogeneous (table-5), and thus qualified for the t-test.

**Posttest experimental and control class**

Table 6 Statistical Analysis of Data Homogeneity Test Value of Posttest Experiment Class and Control Class

<table>
<thead>
<tr>
<th>Test of Homogeneity of Variances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postest kelas Eksperimen dengan postes kelas Kontrol</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.256</td>
<td>1</td>
<td>80</td>
<td>.266</td>
</tr>
</tbody>
</table>
From the statistical test, the sig data is 0.266 > 0.05 and the data is declared homogeneous (Table-6), and thus this data also meets the requirements for the t test to be carried out.

**Pretest and posttest experimental class**

Table-7 Statistical Analysis of Homogeneity Test Data Values Pretest and Posttest Experiment Class

<table>
<thead>
<tr>
<th>Test of Homogeneity of Variances</th>
<th>Pretest dengan postest kelas Ekperimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levene Statistic</td>
<td>df1</td>
</tr>
<tr>
<td>1.854</td>
<td>1</td>
</tr>
</tbody>
</table>

From the statistical test, the sig data was 0.177 > 0.05 and the data was declared homogeneous (Table-7), and thus this data also met the requirements for the t-test to be carried out.

1 **Differential Test (T-test)**

In this section, 3 different types of tests will be carried out, namely:

- Different test on the pretest value of the experimental class with the control class, the aim is to ensure that the experimental class sample has the same ability before the experiment begins.

- The difference test between the posttest value of the experimental class and the control class to see whether the impact due to different treatments on the experimental class and control class will result in a significant difference in the class average value.

- The difference test on the pretest value of the experimental class is different from the posttest value of the experimental class, to see whether the gain-score obtained between the two values produces a significant difference due to the treatment given.

From the results of statistical analysis using SPSS version 17, the following data were obtained:

**a. The difference test between the experimental class pretest and the control class pretest**

From the results of the statistical difference test analysis (T-test) between the Pre-test value of the Experimental class and the Pre-test value of the control class using SPSS software, Table-8 explains that the average value of the experimental class is 60.54 and the control class is 58.10. :

**Table 8.** Description of statistical data Pre-test scores for Experiment class and Control class

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest experimental class</td>
<td>41</td>
<td>60.54</td>
<td>6.797</td>
<td>1.062</td>
</tr>
<tr>
<td>Pretest pretest control</td>
<td>41</td>
<td>58.10</td>
<td>7.861</td>
<td>1.228</td>
</tr>
</tbody>
</table>

Furthermore, a T-test will be carried out on the two values above, the results are shown in table 9, and with a significance value (2-tailed) is 0.137. i.e. greater than 0.05 then **there is no significant difference** between the two.

It can be seen that the average value between the pre-test experimental class and the control class is not significantly different. This means that the initial abilities of students before the learning process of Health Ethics and
Law are the same or not different, so that differences in post-test scores can be compared as a result of differences in learning treatment later.

**Table 9.** T-Test test data, the value of the Experiment class Pre-test with the Control class Pre-test

<table>
<thead>
<tr>
<th></th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>.307</td>
<td>.581</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>1.503</td>
<td>78.368</td>
</tr>
</tbody>
</table>

**C. Difference Test between Experiment class Posttest and Control class Posttest**

From the results of the posttest data processing of the experimental class and control class, it is known that the average value of the experimental class is 82.73, while the average posttest value of the control class is 69.51 (table 10).

**Table 10. Statistical description of the post-test scores for the experimental class and the post-test for the control class**

<table>
<thead>
<tr>
<th>Class</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment class posttest</td>
<td>41</td>
<td>82.73</td>
<td>5.723</td>
<td>.894</td>
</tr>
<tr>
<td>with Control class posttest</td>
<td>41</td>
<td>69.51</td>
<td>4.664</td>
<td>.728</td>
</tr>
</tbody>
</table>

After calculating the T-test value through SPSS, the significance value (2-Tailed) is 0.000, which is smaller than 0.05 (Table 11), which means that there is a significant difference between the average post-test value of the experimental class and the mean score of control class post-test. This is also evidenced by the large difference between the post-test average value of the experimental class = 82.73 and the average value of the control class 69.17. This means that the competence (CPL) of students between the experimental class is significantly different from the competence (CPL) of the control class students after carrying out the learning process for 7 weeks by applying different learning models, namely the Problem Base Learning by Use Mind-mapping learning model in the experimental class and the Ordinary learning model in the control class.

**Table 11.** T-Test test data, Post-test scores of Experiment class with Post-test of Control class

**Independent Samples Test**
d. The difference test between the Pre-Test of the Experimental class and the Post-test of the Experimental class

From the results of the statistical difference test analysis (T-test) between the Pre-test value of the Experimental class and the Pre-test value of the control class using SPSS-ver17 software, the average value of pretest = 60.54 and the average value of posttest is 82.73 (table 12).

Table 12. The Description of statistical data Pre-test scores with post-test Experiment class

<table>
<thead>
<tr>
<th>Group Statistics</th>
<th>Class</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest and Posttest Experiment</td>
<td>Pretest</td>
<td>41</td>
<td>60.54</td>
<td>6.797</td>
<td>1.062</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>41</td>
<td>82.73</td>
<td>5.723</td>
<td>.894</td>
</tr>
</tbody>
</table>

Table 13. T-Test test data for Pre-test and Post-test scores for Experiment class

<table>
<thead>
<tr>
<th>Independent Samples Test</th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Pretest and Posttest Experiment</td>
<td>Equal variances assumed</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
<td>11.46</td>
</tr>
</tbody>
</table>

Based on the data in table 13, it is known that the T-Test test value at significance (2-Tailed) is 0.000 <0.05, it means that there is a significant difference between the average pre-test and post-test scores of the experimental class. This value is also the Gain-score value between the pre-test and post-test as a result of the application of the Problem Based Learning by Using Mind-mapping learning model that was developed. This means that the
competence (CPL) of students’ increases significantly after students get the learning process using the Problem Base Learning by Use Mind-mapping learning model in the experimental class compared to the initial competence (pre-test).

The final conclusion from this test is that the implementation of the learning model that has been developed, namely the Problem Based Learning by Using Mind-mapping Learning Model is Effective in achieving the learning objectives (CPL) of Health Ethics and Law.

III. CONCLUSION

From the results of the study, it was found that the use of Problem Based Learning by using mind mapping in the Health Law Ethics course was very effective because there was a significant increase in scores in the experimental class compared to the control class. In the experimental class, the increase was very significant with an increase in the average value of 60.54 pretest and 82.73 posttest.

This is in line with a study conducted by Farrand, Hussain and Hennessey (2002), aimed at testing the effectiveness of using Mind Map techniques to improve factual recall of written information, to see if Mind Mapping overcomes many of the limitations of more conventional study techniques. Medical undergraduate students who participated in this study were exposed to a 600-word scientific text section and given three short text-based tests to establish baseline data. They were then divided into two groups before being tested again. A week later the students took a third test to evaluate long-term memory. Significant improvements in recalling factual material were found in both groups on the second test compared to the baseline (first test). However, only the Mind Map group maintained their improvement after one week with a 10% increase from baseline compared to a 6% increase for those using the study method of choice. This suggests that the Mind Map technique improves the long-term memory of factual information in these medical students. However, motivation was found to be higher in the self-selecting group than in the Mind Map group, possibly due to a reluctance in students to use what are perceived as memory strategies as learning aids. Researchers theorize that improvements in the Mind Map group will reach 13% having higher motivation to use techniques. Only the Mind Map group maintained their upgrades after one week. It was concluded that "Mind Maps provide effective learning techniques when applied to written material" and are likely to "encourage deeper levels of processing" for better memory formation.

Goodnough and Woods (2002) found that participants in their study found Mind Mapping a fun, interesting and motivating learning approach. Some of these participants linked the fun aspect to the opportunity to be creative when creating Mind Maps through a large selection of colors, symbols, keywords and designs. Al-Jarf, R. 2009 designed to test the effectiveness of Mind Map software as a way to improve writing skills. Participants were divided into two groups with one group receiving traditional in-class instruction that relied on textbooks only, while the other group received the same instruction but was pushed to Mind Maps. Before learning, both groups took the same initial writing test. Writing instruction was then given over a 12-week period and students in both groups were tested biweekly, with a final test at the end of the experiment.

The results of the post-test showed that the group that used Mind Maps obtained higher scores in writing. They show more relevant details and ideas that are more organized and connected. Students find Mind Mapping fun and helpful in generating and organizing ideas, and enjoy personalizing maps, so they can build meaningful relationships between ideas in a visual way.

The authors conclude that "Mind Maps provide an effective study technique when applied to written material" and tend to "promote deeper levels of processing" for better memory formation. Therefore, the increased use of Mind Maps in the medical curriculum should be welcomed. As a note of caution, it is recommended that consideration be given to ways of increasing motivation among users before Mind Maps are generally adopted as a study technique. The author suggests that effective training be provided so that students are enthusiastic to adopt this approach rather than other conventional study techniques.

Conclusion

From the development of the Problem Based Learning by Using Mind Mapping model, the following conclusions can be drawn:
a. The characteristics of the right Problem Based Learning model to be developed in order to improve 4C in accordance with the demands of CPL in the Industrial Revolution 4.0 era, namely a learning model that is not only able to increase knowledge, and partially critical thinking, but is also able to comprehensively and critically find constructive solutions and systematic solutions in dealing with every public health problem that arose at that time.

b. By integrating the Mind-Map tools into the Problem Based Learning Model, it produces a new learning model, namely Problem Based Learning by Using Mind-Mapping, supported by 8 model syntaxes.

c. The Problem Based Learning by Using Mind-Mapping model is declared valid by experts according to their field of expertise.

d. The Problem Based Learning by Using Mind-Mapping model was also considered practical by the assessment team, which consisted of Experts, Peer Lecturers and Students.

The Problem Based Learning Model by Using Mind-Mapping is considered Effective in improving the Creative and Critical Thinking Skill, Collaboration and Communication competencies of students through statistical data analysis of pretest and posttest students in the experimental class and control class.

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