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Learning Module Based on Brain Management and Mind Mapping to Train Mathematical Connection Abilities in Plane Geometry Course

Carolina Omega Putri Usdinoari[1],* & Hongki Julie[1]

[1]Department of Mathematic Education Program Magister, Universitas Sanata Dharma, Indonesia

Abstract: This research is motivated by the low level of mathematical connection ability, even though it is an important ability, also the need of teaching materials for students. In arranging teaching materials, brain management and mind mapping are used so that to help improve students' mathematical connection abilities. This research aims to develop modules based on brain management and mind mapping in plane geometry courses. The type of research used was research and development with ADDIE model. From the research that been conducted, it can be concluded that module is very valid with 91% validity from both material and media aspects, also effective as an individual learning material and for improving students' mathematical connections in Geometry Plane Course.

Keywords: mathematical connection, brain management, mind mapping, module.

Abstrak: *Penelitian ini dilatarbelakangi oleh rendahnya kemampuan koneksi matematis sekalipun itu adalah kemampuan yang penting, serta adanya kebutuhan bahan ajar bagi mahasiswa. Dalam penyusunan bahan ajar digunakan manajemen otak dan mind mapping agar dapat membantu meningkatkan kemampuan koneksi matematis mahasiswa. Penelitian ini bertujuan untuk mengembangkan modul berbasis manajemen otak dan mind mapping pada mata kuliah geometri bidang. Jenis penelitian yang digunakan adalah penelitian pengembangan model ADDIE. Dari penelitian yang dilakukan diperoleh bahwa modul sangat valid dengan 91% kevalidan dari kedua aspek materi dan media, serta efektif sebagai bahan belajar pribadi dan untuk meningkatkan kemampuan koneksi matematis mahasiswa pada mata kuliah Geometri Bidang.*

Kata kunci: *koneksi matematis, manajemen otak, mind mapping, modul.*

▪ INTRODUCTION

Mathematics is one of the most important subjects in a formal education—referred to Permendiknas No. 22 Th. 2006 (Puspitasari, Mulyanti, & Setiani, 2019), mathematics needs to be taught to all students from elementary school. In learning math, NCTM (2000) set five standards of process, which mathematical connection is one of it; also Kemendikbudristek BSKAP (2022) in their decree stated that one of the learning objectives in mathematic is mathematical connection so, basically mathematical connection abilities are one of the abilities that student need to have. Mathematical connection abilities are the ability to see the connections and to connect the mathematic ideas in/to other ideas in mathematic itself, another discipline, and real-world problems (NCTM, 2000; Son, 2022). This ability itself is important because it has positive and significant effect on learning motivation and achievement, also has a significant effect in problem solving ability one of the standards that set by NCTM (Wawan & Retnawati, 2022); since the process in problem solving requires student to build a connection in solving the problem itself, also mathematical connection can be a tool for solving mathematical problems and must be used effectively for a proper problem solving (Baki,

Carolina Omega Putri Usdinoari
*Email: omegaputri@gmail.com

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Çatlioğlu, Coştu, & Birgin, 2009; Kenedi, Helsa, Ariani, Zainil, & Hendri, 2019; Tasni & Susanti, 2017). Besides, when students can see the connection in what they've learn especially in real-world problem, their understanding can get deeper and more long-lasting, they will be able to see ideas as a whole and an integrated subject, also they can rebuild their understanding from what they've learnt and get more familiar with it (Jaijan & Loipha, 2012; Saminanto & Kartono, 2015; Suharto & Widada, 2018).

The importance of mathematical connection abilities does not necessarily indicate the high level in abilities, because in fact the mathematical connection abilities of students in various educational levels are still relatively low. From studies that had been carried out by some researchers at some schools or colleges, Kenedi et al. (2019) stated that the mathematical connection ability of students in third grade was still low; Siregar & Surya (2017) stated that most of the students in ninth grade had a very low mathematical connection ability; Rahmawati et al. (2019) stated that the students in eleventh grade had been categorized as very low in mathematical connection ability; Yolanda & Wahyuni (2020) stated that the mathematical connection ability of mathematics education students still low; and Rawa et al. (2016) stated that primary teacher education students still in a low category for mathematical connection ability specifically in geometry. Even for geometry as one of the standards of content that set by NCTM, is still considered in a low level.

Furthermore, based on the interview that had been done with Plane Geometry lecturers at Sanata Dharma University, in the last three years, the ability of mathematical connection of Mathematics Education students in a term "really need to be improved". In fact, it's said that they're still unable to see or recognize the connection between mathematical concepts or ideas in the rectangular material themselves, such as they cannot make the connection among the properties of flats. Also, they still had difficulty in seeing the connection between the mathematical concepts with other material or with real-life problems they've encounter, for example, they struggling to explain the practicality of learning the Pythagorean theorem on triangles.

One of the ways to improve students' mathematical connection ability is to use mind map in learning. mind mapping is a technique for storing or retrieving information in or to the brain by connecting information in the form of non-linear radial-hierarchical diagrams to accommodate all ideas, interests, and relations (Buzan, 2007; Tahir & Amin, 2016). According to Edwards & Cooper (2010), mind mapping can be used as a way of teaching, and further written by Brinkmann (2003) that mind mapping can be an efficient tool in Mathematics Education because it can help connect new information more meaningfully and show the relationship between mathematics. From some studies that included mind mapping in mathematic learning, students who were learnt with mind mapping has a better mathematical connection ability than students who were learnt with conventional method (Ainurrizqiyah, Mulyono, & Sutarto, 2015; Sirat, 2016), also there was a strong relationship between students' mathematical connection abilities and mind mapping (Ratnawati, Hidayah, & WIjayanti, 2016). The use of mind mapping in the learning process as an effort to improve mathematical connection abilities can be counted as a part of brain management.

Brain management is an effort to understand and improve the brain's abilities in developing its potential and capacity by paying attention to the traits and how the brain itself works or in short by balancing its activities (Somakim, 2008; Windura, 2016).

Moreover, Windura (2016) brain management activities in the learning process can be applied by using colors, using props, using imagination, giving students opportunities to express opinions, using computers, and mind mapping. Based on research conducted by Khasanah et al. (2015), the use of brain management has an influence on students' mathematics learning outcomes; also, by Hakim et al. (2017), the use of brain-based learning specific application of brain management strategies in education—show the increasement of students' mathematical connection abilities. From what has been described regarding mathematical connection abilities, in brain management there will also be emphasis on mind mapping.

The application of brain management and mind mapping in mathematics learning can be done by using modules such as those developed in research by Usdinoari (2022) in developing polyhedrons module based on brain management and mind mapping for eight grades. Another research by Telaumbanua (2019) concluded that using module in learning can improve students' mathematical connections abilities. Module itself is a printed teaching material that is arranged systematically and comprehensively which contains various learning experiences and other tools that can be used by students or pupils for studying independently to achieve certain learning objectives which also are adjusted to the level of difficulty as well (Badawi & Qaddafi, 2015; Directorate of Educational Personnel, 2008; Rahdiyanta, 2016). So, the development of modules based on brain management and mind mapping can be one of the solutions for mathematical connection abilities.

As has been explained above, this research aims to develop a module based on brain management and mind mapping that can be used for student of Mathematic Education from Sanata Dharma to individual learning also help their mathematical connection ability in Plane Geometry Course. For the development this research would use ADDIE model as the previous research conduct by Fadlurrochman et al. (2022) and Kuneni et al. (2017) that modul can be developed with that model. This module developed aims to be one of learning materials for students since, from the previous interview was revealed that students still need self-supporting learning material.

▪ METHOD

Research Design and Procedures

The method that was used in this research was Research and Development (R&D) with ADDIE model. ADDIE is a systematic learning and an instructional design model that commonly used in designing and developing teaching and learning modules (Arkün & Akkoyunlu, 2008; Kasi & Zaharudin, 2023; Widyastuti & Susiana, 2019). The procedure in this development with ADDIE model consists of 5 steps which are Analysis step, which includes observation the needs and characteristics of students also the curriculum that been used in learning; Design step, which includes the made of module's concepts and guidelines, also module validation form; Development step, which includes the development and validation test of module; Implementation step, which includes teaching in class with the module that been developed; and Evaluation step, which includes evaluation of each step and make the conclusion from the research that been conducted (Rochsun & Agustin, 2020; Setiyani, Putri, Ferdianto, & Fauji, 2020).

Participants

The participants of this research are students of Sanata Dharma University that take Mathematics Education Plane Geometry Class in 2023/2024. Also, there're three lecturers from Sanata Dharma University that were involved in this research as experts and two of them involved in the validation module process.

Instruments

The instruments used in this research are interview guideline, validation form, test, and observation sheets. The interview guideline used in first step, to learn about the students and the curriculum. Validation form was arranged in second step and used in third step, to validate the module that been developed. The test and observation sheets used in fourth step, to see the effectiveness of module and to describe students' mathematical connections after learning using the module.

Data Analysis

The data obtained from this data collection was qualitative and quantitative data. Qualitative data from interview and observation sheets been analyzed with the techniques from Miles and Hubberman (Abdussamad, 2021; Nugrahani & Hum, 2014) with some adjustment which are reducing data, displaying data, and drawing data conclusion. Quantitative data from validation form and test been analyzed with techniques that adapted from Hidayatullah & Ekawati (2021) research, for the validation, it categorized as bellow. And for the module effectiveness as learning material, it categorized as bellow.

Table 1. Category for modul validation

Percentage (%)	Category
0 – 55	Invalid
56 – 70	Less Valid
71 – 85	Valid
86 - 100	Very Valid

Table 2. Category for effectiveness of module

Percentage (%)	Category
$<$ 75 from standard	Ineffective
$\geq$ 75 from standard	Effective

▪ RESULT AND DISSCUSSION

Development of Module

The brain management and mind mapping based module is a teaching module which in its development applies the implementation of brain management and mind mapping in learning. This implementation was carried out by considering the characteristics of a good module and the application of brain management in learning and emphasizing mind maps as one of the implementations. The characteristics of a good module, taken from the Directorate of Educational Personnel (2008) that consist of five points, meanwhile, for the implementation of brain management in learning, taken from Windura (2016) that consist of six points. The principles that been arranged in this module is shown as below.

No.	Principles	Notes
1.	Module has a whole component that can help students do the individual learning process.	It satisfied that good module is self-instructional
2.	Module has a whole material description for the certain learning objectives.	It satisfied that good module is self-contained
3.	Module not limited or dependent on other sources.	It satisfied that good module is stand-alone
4.	Module has the compatibility with the development of science and technology.	It satisfied that good module is adaptive
5.	Module has the ease of use for students.	It satisfied that good module is user-friendly
6.	Module uses various representations or illustrations that can reduce cognitive load.	It satisfied the use of colors and imagination in brain management implementation
7.	Module uses supporting digital media that can help to concepts understanding.	it satisfied the use of props, imagination, computer, and give the opportunities to express opinions in brain management implementation; also fulfil that module is adaptive
8.	Module gives or shows mind map in some parts.	it satisfied the use of colors and mind map in brain management implementation
9.	Module gives some space to make mind maps.	it satisfied the use of imagination and mind maps, also give the opportunities to express opinions in brain management implementation

From the principles, the module itself developed as a teaching material that is created in a comprehensive and systematic manner by paying attention to the application of brain management and mind mapping in its development as well as in the use. The material in this module specifically was quadrilateral, because from the first step, in analysis step, showed that students' mathematical connection ability in quadrilaterals was not good—even, some are in a bad level, since they can't see the connection in itself.

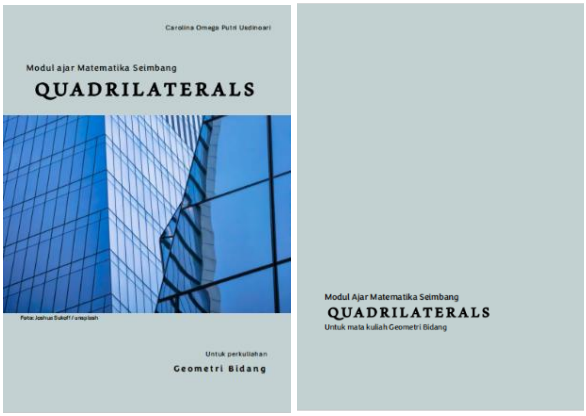

Figure 1. Front and back cover quadrilaterals module

This module has several differences from modules in general, such as the use and provision of space for mind maps as an application of mind mapping and brain management in this module. More specifically, the implementation is described in table below.

Table 3. Guidelines for module based on brain management and mind mapping

No.	Principles	Implementation in Module
1.	Module has a whole component that can help students do the individual learning process.	The module contains complementary components such as learning objectives, instruction, about mind map, summary, evaluation, enrichment, source, and answer key.
2.	Module has a whole material description for the certain learning objectives.	The material description is made complete, starting from the introduction as motivation, material description, example, to summary, and exercise. Also, it contains a glimpse of the prerequisite material, can be given in the beginning or among the material description.
3.	Module not limited or dependent on other sources.	The media included in the module is only supportive and can help users but is not a mandatory for learning process to use the module.
4.	Module has the compatibility with the development of science and technology.	The module includes several supporting digital media with GeoGebra and was made in the form of an e-module so it can be access more easily.
5.	Module has the ease of use for students.	The module is made to be easy to understand, such as considering communicative language, easy-to-understand displays, also included clickable links and QR-code. Also, the module and supporting medias are made to be easily accessible.
6.	Module uses various representations or illustrations that can reduce cognitive load.	The module contains various images and symbols using colors to represent various things, also using mathematical representations.
7.	Module uses supporting digital media that can help to concepts understanding.	The module contains supporting media that can be accessed online such as games and displays using *GeoGebra*.
8.	Module gives or shows mind map in some parts.	The module provides a mind map that has been created by the author at the beginning as an example and provides a general overview of the material.
9.	Module gives some space to make mind maps.	The module provides space for creating mind maps at the end of each module material to train and see the user's understanding and mathematical connection abilities

As the table above listed the implementation of brain management and mind map, there're specifically some features in the module that can be used to help students learning individually. There are nine features namely Concepts Map, Let's Remember, Examples, Let's Explore, Let's Play, W.I.W: What's in The World, Let's Practice, Let's Create, and Let's Share.

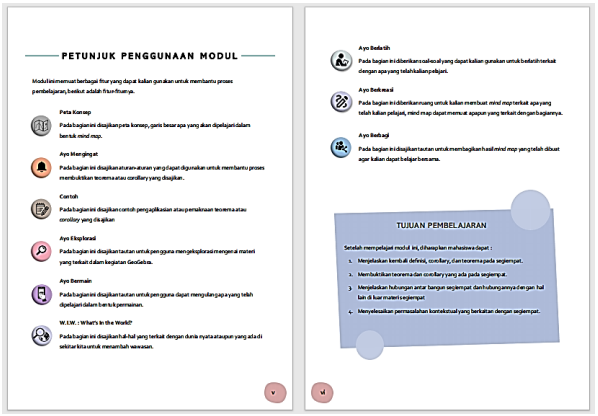

Figure 2. Features and its explanation in module

Validation of Module

Since the module has been developed, before it can get to next step for implementation, it needs to be validated. Validation process been conducted by two lecturers from Mathematics Education Program in Sanata Dharma University. The validation aspects of the module were material and media which total consisted of 54 points—24 points for material aspect and 30 points for media aspect. From the validation sheet, the percentage of the module validity is shown below.

Table 4. Module validation result

Aspects	Percentage	Result
Material	91%	Very Valid
Media	91%	Very Valid

From the validation score, it can be concluded that the module based on brain management and mind mapping developed is very valid with a total validity percentage is 91%. Also, it can be concluded that the module can be used in the next step of implementation, which is learning process in class.

Effectiveness of Module

Implementation of this module conducted in Plane Geometry Course in Sanata Dharma University. The learning model used in class was flipped learning, so the module became the learning source that needed to be studied before class. From the learning process, from a 15-questions test, it showed that 80% of students pass the test after learning the module. So, it can be concluded that the module based on brain management and mind mapping developed is effective for a learning material and can help individual learning of students.

The module effectiveness in students' mathematical connection shown as the learning process been conducted. From the observation in class, it showed that students can connected the quadrilateral's concepts to concepts in its material also concepts in other material, such as angles, lines, parallel lines, and triangles. From the test, it showed that specifically that students also can see the connection between parallelogram, rectangle, rhombus, and square—also for its properties. So, it can be concluded that the

that the module based on brain management and mind mapping developed is quite effective to improve students' mathematical connection—since, from the analysis step, it showed that students' mathematical connection in quadrilateral was not good.

Discussion

From this research the module developed is valid and effective for learning also in improving students' mathematical connection—and it supported by some studies. Azzatia & Suparman (2019) stated that the use of module based can improve students' mathematical connections. Yulian & Hayati (2019) stated that brain-based learning can help students' mathematical connections, and specifically Setyoningrum et al. (2020) stated that brain-based module can help the students' mathematical connections. And for mind map, Nurhayati et al. (2021) stated that it can help students' mathematics connections, and specifically (Loc & Loc, 2020) stated that the use of mind map helped student to connect their knowledge with logic, also easier to memorize and apply for later problems.

▪ CONCLUSION

Based on the results of the research that has been carried out, a module had been developed by combining implementation of brain management and mind mapping also the characteristic of a good module. The module validity is 91% in both material and media aspects so it's very valid and the effectiveness of is 80% so it's effective as an individual learning also it can help improve students' mathematical connections. This kind of module is few and far between to be found, so it can be good for teachers to try considering this module as an alternative learning material. Suggestion for another researcher or teachers that this module can be tested for another mathematical ability—since, the based theory can help with other abilities too.

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