JIPM (Jurnal Ilmiah Pendidikan Matematika) 8(2), 2020, 122-130
DOI : 10.25273/jipm.v8i2.5833

JIPM (Jurnal Ilmiah Pendidikan Matematika)
Journal homepage: http://e-journal.unipma.ac.id/index.php/jipm

Development of 3N-Oriented TPACK (Technology Pedagogy and Content Knowledge) Mathematical Computing E-Modules

Krida Singgih Kuncoro*, Tri Astuti Arigiyati

Universitas Sarjanawiyata Tamasiswa, Indonesia
* *krida.kuncoro@ustjogja.ac.id*

 ISSN 2337-9049 (print), ISSN 2502-4671 (online)

Abstract: Technology always develops from time to time and is very closely related to real-life, which is to solve everyday problems. This study aims to describe the design of 3N-oriented TPACK-based mathematical computing modules (niteni, nirokke, nambahi). The method used is descriptive qualitative part of development research. This research resulted in an E-module design. Mathematical Computing E-Module has the following characteristics (1) containing the TPACK concept and 3N teachings that are designed to be attractive, (2) showing the appropriate 3N activities in the lecture process, and (3) inviting students to carry out *niteni, nirokke*, and *nambahi* activities during lesson. The design of 3N-Oriented TPACK based on Mathematical Computing E-Modules is declared valid.

Keywords : e-Modul; TPACK; 3N

Introduction

Technology always develops from time to time and is very closely related to real-life in solving everyday problems (Mithas & Rust, 2016). Over the years, the number of technologies that can be accessed by teachers and students has increased sharply, including in learning mathematics (McCulloch, Hollebrands, Lee, Harrison, & Mutlu, 2018). However, it does not stop at students being able to access technology alone, and the teacher also plays an essential role in determining how technology is used (Lestari, 2018; Scherer, Tondeur, Siddiq, & Baran, 2018). In this regard, lecturers are required to be able to encourage creative students who can create solutions in solving real-life problems through students' IT and mathematics skills. (Mulyono, 2018). This is supported by Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 Pasal 36 that the curriculum for all levels and types of education must pay attention to the development of science and technology.

Program Studi Pendidikan Matematika Universitas Sarjanawiyata Tamansiswa organizes courses that support the development of students' IT skills through mathematics computing courses. The achievement of this course is that students can create a system that can solve mathematical problems by utilizing Matlab.

Matlab (Matrix Laboratory) is an advanced mathematical programming language formed based on thinking that uses the properties and shapes of matrices to carry out engineering and mathematical calculations (Ogata, 2007). Because Matlab is a high, closed, and case sensitive programming language in a numerical computing environment, it is often difficult for students to learn Matlab independently.

Initially, teacher candidates are required to master aspects of subject matter and pedagogical aspects only, but now they must also follow technological developments (Mairisiska, Sutrisno, & Asrial, 2014). For this reason, integration between material, pedagogy, and technology is needed. Through TPACK (Technology, Pedagogy, and Content Knowledge), students are expected to be able to integrate technology, pedagogy, and content in the form of learning tools (Maor, 2013).

Technology, Pedagogy, and Content Knowledge (TPACK) is a form of knowledge that includes three main components, Content, Pedagogy, and Technology (Malik, Rohendi, & Widiaty, 2019). Pedagogical content technology knowledge is an understanding that arises from the interaction between content, pedagogy, and knowledge technology. TPACK is the basis of teaching that is truly meaningful and highly skilled with technology, this is different from knowledge of the three concepts individually (Mishra & Koehler, 2006).

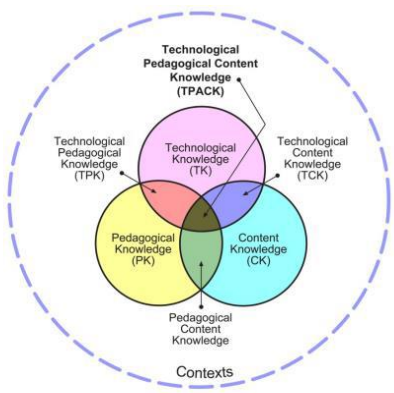

Figure 1: TPACK model

During learning, students are very dependent on the material delivered by the lecturer. PowerPoint media used in learning also have shortcomings. Namely, the material presented is less detailed, and the examples provided are less varied. The teaching materials available are less focused on Mathematics Education but rather lead to the field of Informatics Engineering. Plus, students are generally willing to do the exercises if the lecturer has instructed them. If a study group is held, only some of them do the work given by the lecturer, while some prefer to tell stories and disturb other friends.

One alternative that can be the leading choice to overcome these problems is that lecturers must be able to apply the concept of learning that can involve students, so they do not feel bored and lazy, namely through the 3N (Niteni, Nirokke, Nambahi) learning concept (Rahayu, Purnami, & Agustito, 2018).

Based on the description above, teaching materials are needed that can develop the ability of IT and mathematics students, especially mathematics education students. The teaching materials that will be developed in this study are e-modules. The application of modules in learning can foster student motivation and learn the ability of students in each unit of material (Peniati, 2012). The benefits of using modules in learning are streamlining student time to master learning material and existing assignments and providing time by the needs of each student (Susilowati & Indriyanti, 2010). The preparation of the module aims to enable students to study independently (Akbar, 2013).

Therefore, researchers are interested in developing 3N-Oriented TPACK-Based Mathematics Computation modules so that it is hoped that through the development of 3N-Oriented TPACK Computational Mathematics E-modules, students can be involved in finding concepts to be taught through given problems, formulating problem solving strategies and actively engaging in learning. The development model used by researchers is the 4-D model proposed by (Thiagarajan, Semmel, & Semmel, 1974), which consists of four stages. The four stages are defined, design, develop, and disseminate. However, in this study, dissemination was not carried out because this research focused on producing final devices that were ready to be implemented. The final set was only tested to assess validity.

Method

The research method used is a descriptive qualitative method. This method is part of development research (Sugiyono, 2014). A descriptive study done through the collection of data based on the factors supporting research object for later analyzed and searched role (Arikunto, 2010). Qualitative research is research related to a person's ideas, opinions and perceptions and all of them cannot be measured by numbers. The method in this study is limited to descriptive qualitative, describing how the design of the 3N-oriented TPACK-based Mathematics Computation design is produced.

Result and Discussion

The results of this study are in the form of teaching materials in the form of E-modules of Mathematical Computation-based courses in 3N-oriented TPACK. The e-module is a guidebook for students in learning activities that contain subject matter, examples, learning activities both in and outside the classroom, containing the teaching of 3N students (Niteni, Nirokke, and Nambahi) on affective variables, containing things that can improve students' abilities and formulate and solve mathematical problems and their applications using computational algorithms. Teaching materials created are electronic form teaching materials that can be accessed via the internet.

Design research on the development of learning devices using the 4-D model from Thiagarajan. This development model includes the stages of define, design, develop, and disseminate. However, in this research, the device development procedure is only carried out through three stages which include define, design, and develop.

a. Define Phase

The definition phase aims to establish and define the learning requirements. The final result of this activity is to determine the objectives and limits of learning material. Activities carried out in the defining phase include front end analysis, student analysis, task analysis concept analysis, and formulation of learning objectives.

1. Front End Analysis

At this stage, the process begins with data mining, which is carried out using observations and questions and answers with students. From the observations and questions and answers found three critical problems, including (1) the average value of students in computational mathematics courses still do not meet the target/learning objectives; (2) the weakness of students in completing and making programs in solving mathematical problems; (3) learning has not been supported by adequate learning tools.

The modules and assignments used are the products of others and are not intended for mathematics education students, so they tend to be incompatible with the conditions and learning needs. Based on this analysis, researchers consider the need to make improvements to the learning process in mathematics computing courses. Improvements include the "development of learning tools (e-module)."

2. Student Analysis

The subjects of this study were 6th semester students of Universitas Sarjanawiyata Tamansiswa mathematics computing courses. To be more accurate in finding solutions to solutions to existing strengths and weaknesses, it is essential to know the characteristics of students. The results of interviews with several students are stated as follows: (1) students prefer learning in groups, (2) students prefer to be actively involved in learning, (3) students like learning resources that are interesting in their appearance, (4) students like modules/teaching materials that are easily accessed anytime and anywhere.

The background of students' knowledge about the prerequisite material for learning, especially in mathematics computational subjects they have obtained in the 3rd semester. This is very helpful for teachers in exploring student knowledge, in order to connect old knowledge with the knowledge they will receive. Most of the 6th semester students are already familiar with technology, especially computer operation and internet usage, this shows that technological literacy as an initial ability in learning computational subjects has been fulfilled.

3. Task Analysis

Task analysis is carried out in order to identify the main tasks students must do as a basis for determining the form of assessment instruments and the design of learning tools. The tasks undertaken by students include: (1) formulating and solving mathematical problems and their application with computational algorithm approaches and (2) implementing them with Matlab and using the concepts given to re-express and/or communicate ideas related to the field mathematics both in writing and orally with individual and group performance in teamwork. (3) Develop the ability to formulate and solve mathematical problems using Matlab. The assignments given will be in the form of individual assignments and group assignments that have been adjusted to the indicators of goals and achievement of student competencies.

4. Concept Analysis

The concept of developing teaching materials is an e-module, which is an online module that can be accessed by students anytime and anywhere so that it gives students access and is easier to practice material inside and outside of class hours. The concepts of e-modules used in Technological Knowledge, Pedagogy, and Content Knowledge are based on the 3N Knowledge (Niteni, Nirokke, Nambahi) teaching.

5. Analysis of Learning Objectives

The specification of learning objectives refers to the achievement of learning subjects in the curriculum of UST mathematics education study programs, including (1) Mastering mathematical didactic-pedagogical concepts and principles as well as a mathematical scholarship to plan, implement, and evaluate science and technology-based learning. (2) Able to apply logical, critical, systematic, and innovative thinking in the context of the development or implementation of science and technology that pays attention to and applies humanities values by their fields of expertise. (3) Cleverly understand the basics of programming and be able to program daily problems, especially in the field of mathematics, using a programming language with a reliable and responsible by the values of the teachings of Tamansiswa.

Based on the description of the defining stage, there are still many problems that occur in the field. The process of learning mathematics will be more successful if the learning process involves students at each stage of learning. Active lecturers must help and guide students to be able to build their knowledge. One that can be used by lecturers is to provide e-modules that suit their needs and refer to the learning outcomes that have been determined by the study program; (4) learning has not been supported with adequate learning tools. At this stage of defining, the problem found in mathematics computing courses is that students still tend to be more passive during the learning process, students are still lacking in completing and making programs in solving mathematical problems. After seeing the description at the defining stage continued with the design of learning tools that will be used in research.

b. Design Phase

In the design phase, the researchers conducted an initial design of 3N-oriented TPACK-based e-modules. The learning tools produced in this stage are from now on, referred to as draft 1. The design phase is an essential part of this research; all learning tools in the study are arranged at this stage. In line with (Gorbi Irawan, nyoman Padmadewi, & Putu Artini, 2018) that at the design stage, the researcher must decide on the right media and format selection because this is the strength of the 4D model. The purpose of this stage is to develop learning tools that will be used in research. This level of planning covers four steps that are:

1. Test / Evaluation Feeds to be used

Criteria for preparing the test are based on the results of the analysis of the material, task analysis, and analysis of learning objectives. The evaluation used in this e-module focuses on the written evaluation, independent assignments, and the ability to write and present the assignments given.

2. Media Selection

Loads of material that talks a lot about how to solve a problem that is solved using a computer program requires teaching material. The use of teaching materials that are by the conditions at the time of learning and learning objectives have a critical role in the learning process. Modules used in the Computational Mathematics course are electronic modules or e-modules. It is designing and compiling e-modules to maximize the provision of learning resources in learning activities.

3. Format Preparation

The compilation of the e-module format was developed by TPACK oriented 3N, referring to the existing format. The contents of learning materials refer to the material analysis, task analysis, and the learning objectives analysis that have been formulated at the defining stage. In this stage, the activity is focused on making e-modules and research instruments. TPACK and 3N based modules are then online, which are then called E-modules. At the same time, the place or website that will be used can be accessed by students also began to be designed. The e-module is placed on the sub-domain of the Mathematics Education Study Program page using the Moodle LMS (Learning Management System), which can be accessed at http://kuliahonline.pmat.ustjogja.ac.id. Moodle was chosen because: a) network system and also security that can be set by itself, b) learning system that can be adapted to the learning needs, c) full features for a distance learning process, and d) a relatively easy and many customizing processes.

4. E-module Initial Design

This activity is the preparation of learning tools in the form of e-modules. Furthermore, the initial design of learning tools and research instruments is called draft 1. Based on the description, the stages of definition and design are shown in Figure 2.

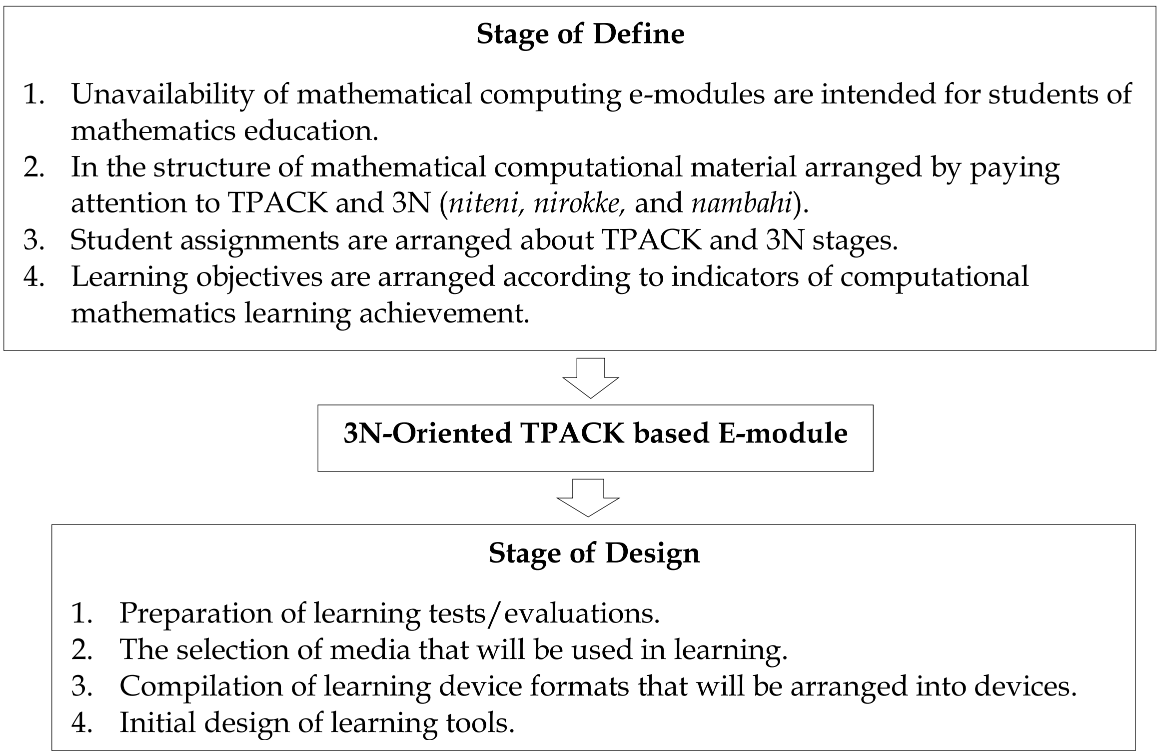

Figure 2. Workflow stage of define and design of the E-module

c. Development Phase

The development phase of the learning tools in draft one was then validated by experts about their feasibility using instruments in the form of validation sheets. Experts who act as validators are mathematic education experts and experienced in developing mathematical tools, mathematical education experts. Suggestions from experts (validators) are used as a basis for refinement or revision of the model. This is in line with (Novtiar & Fitrianna, 2019) that improvements were made to aspects considered to have a shallow level of validity in order to be used as a basis for improvement for draft II.

Expert Validation Results

The learning tool developed must be valid, according to (Sugiyono, 2014) valid if it meets the content validity and constructs validity set by several experts. In this study, the validity in question is content validity. The process of developing the device starts with preparing the initial draft (draft I). The first draft of the tool was validated by the expert (validator), then revisions were made according to the validator's input so that a draft II was obtained. This is in line with (Novtiar & Fitrianna, 2019) which states that in the development phase, validating the learning modules that have been developed at the design stage. This validation is carried out by experts as validators who evaluate draft I, then make improvements and obtain draft II. The draft II of the device is then ready to be trialed. Expert validation was carried out to see the validity of the contents of the device that had been compiled based on 3N oriented TPACK steps. The results of the learning device validity are used to determine whether the learning device can be used or not.

The validator's evaluation of the e-module is based on the instructions for completing the validation sheet. The e-module assessment is based on the presence or absence of e-module development components based on TPACK oriented 3N steps. This is in accordance with (Suartama, Setyosari, Sulthoni, & Ulfa, 2019) design experts and practitioners provide assessments, comments, and revision suggestions related to aspects to be developed. The results of the average score of assessment by the validator of the draft 1 Student Book = 4.23 (highest score of 5) means that the draft 1 Student Book is included in both categories, and it can be concluded that the e-module is valid and can be used.

The results of the e-module validation produce several suggestions and validator input for the revision of the e-module. The validator's evaluation of the e-module learning tool is seen from the indicators contained in the e-module. Some things to note are the 3N oriented TPACK. The ability to formulate and solve student problems is not evident in the contents of the book to practice these abilities, and the use of TPACK is also unclear.

The compilation of e-modules must also adjust the learning approach used, which is TPACK oriented to 3N and provides students, especially in solving problems with problem solving skills. A complete description of the revised E-module can be seen in Table 1.

Table 1. Student Book Revision Activities

The revised part	Validator notes	Revision
Learning objectives	Take the objectives in the RPS included in the e-module, so that students are directed towards learning.	Learning objectives in e-modules are in line with RPS.
Writing conventions	The writing needs to be in accordance with KBBI and EYD.	Replace writing that is not yet compliant with KBBI and EYD.

The revision activity was carried out as recommended by the validators, and the e-module was ready for use in the study.

Conclusion

Based on the results of research and discussion in the previous chapter, the conclusions in this research development are based on the considerations of experts in developing TPACK-oriented 3N based computational mathematics learning devices declared valid. This shows the average results of expert validation with a scale of 5 for the E-module is 4.23 (very good).

References

Akbar, S. (2013). *Instrumen Perangkat Pembelajaran. Bandung: Remaja Rosdakarya Offset* (Vol. 27).

Arikunto, S. (2010). Prosedur Penelitian Suatu Pendekatan Praktik, Jakarta: Rineka Cipta, Cet. *Ke-13*.

Gorbi Irawan, A., nyoman Padmadewi, N., & Putu Artini, L. (2018). Instructional materials development through 4D model. *SHS Web of Conferences*, *42*, 00086. https://doi.org/10.1051/shsconf/20184200086

Lestari, I. D. (2018). Peranan Guru Dalam Penggunaan Media Pembelajaran Berbasis Information And Communication Technology (ICT) Di SDN RRI Cisalak. *SAP (Susunan Artikel Pendidikan)*, *3*(2).

Mairisiska, T., Sutrisno, S., & Asrial, A. (2014). Pengembangan Perangkat pembelajaran Berbasis TPACK pada Materi Sifat Koligatif larutan untuk Meningkatkan keterampilan Berpikir Kritis Siswa. *Edu-Sains: Jurnal Pendidikan Matematika Dan Ilmu Pengetahuan Alam Universitas Jember*, *3*(1).

Malik, S., Rohendi, D., & Widiaty, I. (2019). Technological Pedagogical Content Knowledge (TPACK) with Information and Communication Technology (ICT) Integration: A Literature Review. *5th UPI International Conference on Technical and Vocational Education and Training (ICTVET 2018)*. Atlantis Press.

Maor, D. (2013). Does the use of the tpack model enhance digital pedagogies: We don't understand the present so how can we imagine the future? *30th Annual Conference on Australian Society for Computers in Learning in Tertiary Education, ASCILITE 2013*, 531–540.

McCulloch, A. W., Hollebrands, K., Lee, H., Harrison, T., & Mutlu, A. (2018). Factors that influence secondary mathematics teachers' integration of technology in mathematics lessons. *Computers & Education*, *123*, 26–40.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054.

Mithas, S., & Rust, R. T. (2016). How Information Technology Strategy and Investments Influence Firm Performance: Conjecture and Empirical Evidence1. *Mis Quarterly*, *40*(1).

Mulyono, M. (2018). Keefektifan Metode Problem Based Learning dalam Pembelajaran Fiqih di Perguruan Tinggi. *CENDEKIA: Jurnal Studi Keislaman*, *2*(2).

Novtiar, C., & Fitrianna, A. Y. (2019). Development of innovative teaching and learning module in linear algebra course assisted by Maple. *Journal of Physics: Conference Series*, *1315*(1). https://doi.org/10.1088/1742-6596/1315/1/012050

Ogata, K. (2007). *Matlab for control engineers*. Prentice-Hall, Inc.

Peniati, E. (2012). Pengembangan modul mata kuliah strategi belajar mengajar IPA berbasis hasil penelitian pembelajaran. *Jurnal Pendidikan IPA Indonesia*, *1*(1).

Rahayu, I., Purnami, A. S., & Agustito, D. (2018). Penerapan Konsep 3N (Niteni, Nirokke, Nambahi) untuk Meningkatkan Motivasi Belajar Matematika Siswa. *Prosiding Seminar Nasional Pendidikan Matematika Etnomatnesia*.

Scherer, R., Tondeur, J., Siddiq, F., & Baran, E. (2018). The importance of attitudes toward technology for pre-service teachers' technological, pedagogical, and content knowledge: Comparing structural equation modeling approaches. *Computers in Human Behavior*, *80*, 67–80.

Suartama, I. K., Setyosari, P., Sulthoni, & Ulfa, S. (2019). Development of an instructional design model for mobile blended learning in higher education. *International Journal of Emerging Technologies in Learning*, *14*(16), 4–22. https://doi.org/10.3991/ijet.v14i16.10633

Sugiyono. (2014). Metode Penelitian Kuantitatif, Kualitatif dan R&D. *Alfabeta. Bandung*.
Susilowati, E., & Indriyanti, N. (2010). Pengembangan Modul. *Diberikan Dalam Pelatihan Pembuatan E-Module Bagi Guru-Guru IPA Biologi SMP Se-Kota Surakarta MenujuOpen Education Resources. Pada Tanggal*, *7*.

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teachers of exceptional children*. Minneapolis, Minnesota: Leadership Training Institute/Special Education.