Tetra-Helix Concept Model Based on Vocational Realistic Education (VRE)

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ABSTRACT
Even though many studies have been conducted regarding realistic mathematical concepts, there is only a little research on their implementation in vocational mathematics learning. This study aims at producing a mathematics instructional materials development model. This study was a research and development and involving students (Diploma III and Diploma IV) of vocational universities in Bali who were selected by purposive random sampling. This development resulted in a conceptual model involving four stakeholders (tetra -helix) of development research, such as researchers, industry workers, teachers, and students. The tetra -helix model concept based on vocational realistic education is a model for developing mathematics instructional materials which can be used at a vocational institution in the form of textbooks, job sheets, syllabus, and lesson plans. They integrate the mathematical concepts learned with their realistic applications in industry (tourism, engineering, and e-commerce).

***Keywords**: Vocational realistic education, Tetra-helix, Mathematics instructional materials.*

1. INTRODUCTION

The concept of *merdeka belajar-kampus merdeka* (Independent Campus, Freedom to Learn) in the Indonesian current curriculum for higher education provides flexibility for lecturers in planning and implementing learning in accordance with the strategic plan of each university. For vocational universities, the implementation of the concept aims to improve the quality and relevance of education to the industrial world.

The vocational education program, as already mentioned, is an education system designed to prepare certain knowledge, skills, and competencies for students to enter the world of work, industry, or trade [1]. Characteristics of students who take lessons at vocational education institutions are different in terms of age, educational background, and cognitive abilities, especially memory performance [2]. Learning for vocational program students is focused on the development and application of acquired skills [3]. Therefore, the teaching materials used are designed in such a way that the resulting competencies can be applied and developed according to market needs [4].

Furthermore, the paradigm of learning mathematics in the polytechnic campus environment is directed at implementing the concepts taught (realistic mathematics-based). Through this approach, abstract mathematical objects are represented by concrete objects as a bridge to enter the knowledge that students already have [5]. Students are also easier to understand mathematical concepts by looking for links between the material being studied and problems that are commonly encountered [6]. Through this approach, students will feel learning as a personal experience, not the experience of others that they have not experienced [7]. Furthermore, realistic mathematics education-based learning is a theory that refers to the assumption that mathematics must be related to reality and mathematics is a human activity [8]. This means that mathematics must be close to students and relevant in everyday life. This effort is carried out by exploring various situations and realistic problems. Realism is meant here not only refers to the real world (reality), but also to something that can be imagined and is in the mind so that it can be seen clearly the relationship between one problem and another. This approach connects mathematics with various realities that are close, familiar, experienced, and relevant to the lives of students or those who are studying mathematics.

Previous research has found that learning that is carried out with a realistic approach further improves students' problem-solving abilities and mathematical understanding [9,10]. However, based on observations made by researchers, the learning tools used by mathematics lecturers in the current polytechnic campus environment have not integrated realistic mathematical approaches and the application of material learned in industry. The learning tools used are still limited to textbooks which contain a collection of theories and formulas. This has implications for the still abstraction of mathematical concepts and the lack of understanding of students regarding how and for what mathematical material is studied in lectures. Furthermore, the different targets for learning mathematics achievement in each department in the vocational education unit have made a general model regarding how to develop valid, practical, and effective realistic mathematics learning tools.

This research was conducted to obtain a model for developing a Vocational Realistic Education (VRE)-based mathematics learning tool that can be used as a basis and reference for the development of mathematics teaching materials in the polytechnic campus environment. In addition to this, a valid, practical and effective prototype of realistic mathematics learning tools was also developed. To bridge the abstraction of mathematical concepts with their realistic application in the field, intensive assistance in class from stakeholders in the industry is needed to find out when and how to apply the concepts learned in the world of work.

2. METHODS

The study was conducted using a research and development (R&D) approach to produce a model for developing vocational realistic education (VRE)-based mathematics learning tools. The research procedure is carried out with the following stages. 1) learning model design which includes initial investigation, planning, realization, evaluation, and implementation [11]. (2) learning development which includes syntax, reaction principle, social system, support system, and instructional impact and accompaniment [12]. (3) quality of learning materials (products) which include validity, practicality, and effectiveness [13]. (4) learning instructional system development [14].

The research subjects involved were students (Diploma III and Diploma IV) of vocational universities in Bali who were selected by purposive random sampling. Primary data were collected through focus group discussions (FGD), interviews and direct observation. The sample involved consisted of industry practitioners, students, and teachers in vocational education institutions. The practitioners involved came from the fields of tourism, engineering, and e-commerce. The FGD was conducted by giving each participant an instrument feasibility assessment sheet, followed by a discussion on the results of the FGD. The instruments in question are (1) observation sheets (observations) on the implementation of the model, (2) observation sheets for the ability of teachers to manage to learn, (3) observation sheets for student activities in learning, (4) student response questionnaires to the implementation of learning, and (5) competency test student learning outcomes. Secondary data is collected through a review of the results of previous related studies.

Determination of the validity of the developed model adapted from the categorization of learning quality adapted from [15]. Table 1 shows the Criteria of the Development Model Validity.

Table 1. Criteria of the Development Model Validity

Rate	Indicator
$V < 1{,}5$	Invalid
$1{,}5 \leq V < 2{,}5$	Less valid
$2{,}5 \leq V < 3{,}5$	Quite valid
$3{,}5 \leq V < 4{,}5$	Valid
$4{,}5 \leq V$	Very valid

The criteria used to decide that the model has an adequate degree of validity is that the value of V for all aspects is in the valid or very valid category. If this is not the case, it is necessary to make revisions based on the validator's suggestions or by reviewing the aspects that have less value.

In addition to the above, to determine the level of implementation of the learning tools developed with the steps in the developed model, the following implementation criteria are used and shown in Table 2.

Table 2. Criteria of the Implementation

Rate	Indicator
$T < 1,5$	Unreliable
$1,5 \leq T < 2,5$	Less reliable
$2,5 \leq T < 3,5$	Quite reliable
$3,5 \leq T < 4,5$	Reliable
$4,5 \leq T$	Very reliable

The criteria used to decide that the learning device development model has a degree of implementation is that the T value is in the implemented or very implemented category. If the T value is in another category, it is necessary to revise it by looking back at the aspects that have less value.

3. RESULTS AND DISCUSSION

The quality of the model is determined through validity and implementation tests. Based on the validation process carried out by two experts, it was found that the model for developing vocational realistic education-based mathematics learning tools was in the valid ($3,5 \leq V < 4,5$) and reliable ($3,5 \leq T < 4,5$) category. The model for developing mathematics learning tools based on vocational realistic education begins with a theoretical study of learning theories as supporting theories for the model, the factual conditions of learning, and current industry demand. Based on the results of the study, the initial design of the model components was obtained, namely as follows.

Sintax

Stage 1: At this stage, FGDs were conducted involving representatives of parents (Industry and the World of Work), academics or vocational high school teachers, as well as the researchers themselves. This discussion was conducted to gain a thorough understanding of the conditions of students, the curriculum and content of mathematics provided during learning, as well as the types of skills needed by industry and work in the future. This is done to find out the potential problems raised in the learning tools so that the content presented can support the link and match program between parents and vocational education institutions.

Stage 2: In the prototyping phase, a prototype design for mathematics learning tools based on vocational realistic education is carried out by taking into account the study of the relevant literature as well as the relevant previous research results. The preparation of teaching content is adjusted to how the material presented in the syllabus is used directly or indirectly in practice in the industry. This process is also accompanied by validation carried out by experts in the field of mathematics education and industry.

Stage 3: Prototypes of learning tools that have been declared valid are then tested by involving vocational education program students. The selection of students is adjusted to the teaching content that is prepared as well as the problems in the industry that are raised. Even though the teaching materials presented in the same device are the same, the presentation of the material and the realistic problems raised are different. This depends on what industry and business the student is studying. In the research conducted, product trials are still carried out in a limited manner to know the implementation of mathematics teaching tools which are arranged based on the stages of the developed model.

Stage 4: Dissemination is carried out in the form of exposure to research results to stakeholders to obtain suggestions and improvements to the developed model.

The development procedure above is then presented in a conceptual model that involves four stakeholders (tetra-helix) of development research, namely researchers, parents, academics, and teachers, as well as students. Based on this, the tetra-helix model concept created in the development of vocational realistic education (VRE)-based mathematics learning tools is presented in Figure 1.

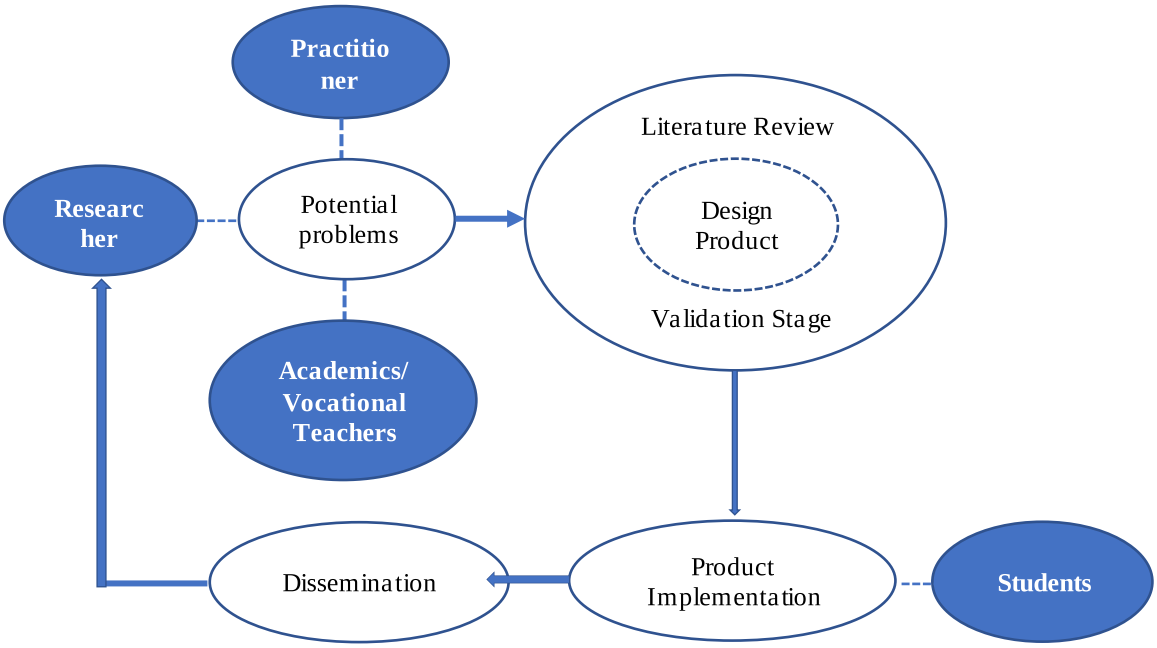

Figure 1 Tetra-Helix Model Concept Based on Vocational Realistic Education (VRE).

The tetra-helix model concept based on vocational realistic education is a model for developing mathematics learning tools in the form of textbooks, job sheets, syllabus, and lesson plans that integrates the realistic application of the mathematical concepts learned.

4. CONCLUSION

The temporary conclusion from this research is that the development of a vocational realistic education (VRE)-based mathematics learning device model has been successfully carried out in stages. This can be seen from the production of a tetra-helix model concept based on vocational realistic education which is a reference in the development of further learning tools.

AUTHORS' CONTRIBUTIONS

All authors conceived and designed this study. All authors contributed to the process of revising the manuscript, and in the end, all authors have approved the final version of this manuscript.

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