A hierarchical component model of students’ difficulties of learning mathematics in a distance higher education

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Abstract. The main purpose of the research was to explore the students’ difficulties in learning mathematics at a distance higher education. The method used was a survey of 304 students of the study program of S-1 PGSD in the Pontianak Regional office center of Universitas Terbuka (UPBJJ-UT Pontianak). The data analysis used a partial least squares structural equation model (PLS-SEM) to reveal the hierarchical component model of the students’ difficulties in learning mathematics at Universitas Terbuka. The research confirmed that the difficulties in learning mathematics were reflected by five latent variables as indicated by path coefficients and level of significance: (1) the nature of mathematics, (2) the characteristics of distance learning, (3) learning material, (4) learning support services, and (5) motivation. The recommendation was that to facilitate the students’ learning mathematics, an institution of distance higher education should be focused on resolving the difficulties perceived by the students, such as students’ mathematical background, self-directed learning skills, and skill for learning through media.

1. Introduction
Providing distance education was the choice of many universities during the Covid-19 pandemic. The development of information and communication technology had brought new developments to distance education [1] [2] [3]. Web-based distance education had gained popularity, and this education system has been applied everywhere due to becoming wide spreading of the internet. Distance education was characterized by five elements, namely: (1) separation between teachers and students; (2) the role of educational institutions in; (3) the use of media to unite teachers, learners, and learning materials; (4) availability of two-way communication between students and teachers; and (5) the learning process prioritizes the individual learning process [4-5].

One of the characteristics of distance education was the use of media - print, audio, video, computers, or gadgets - in the learning process. The effectiveness of using media in distance education was guaranteed by scientific knowledge about how effective learning through media was. Russell [6] reported the result of 355 studies conducted starting from 1928 that revealed there was no difference in learning outcomes between learners in distance education and learners in face-to-face education. With this proposition, distance education educator could convince themselves that the learning outcomes of its students were not different from the learning outcomes obtained by students who study face-to-face [7]. However, mathematics was a difficult subject for students to learn. The difficulty was doubled when students learn mathematics in distance education for students in a non-mathematics study program. For example, in the 2nd Semester of 2019, for mathematics courses in Elementary School Teacher Education Study Program at the Universitas Terbuka (UT) showed average scores ranging between 45 and 56 for...
a maximum value of 100 [7-8]. Therefore, it should be assumed that the students have difficulty learning mathematics material in distance education.

Research on mathematics learning in distance education settings had not been widely undertaken. Little research, if any, had investigated the identification of difficulties in learning mathematics in distance higher education. Several studies on learning mathematics in distance education are presented here. Smith & Ferguson [9] confirmed the difficulty of students studying mathematics material through e-learning which was shown by the high attrition compared to students who studied non-mathematics material through e-learning. In terms of learning outcomes, a study reported that there was no difference in learning outcomes between the application of objectivist-based teaching strategy and constructivist-based teaching strategy, for adult students learning mathematics at a distance [10]. Correspondingly, another study compared the mathematics teaching of two groups of students studying online and on-site and showed no different learning outcomes [11]. Different research results were presented by Safavil, Rostamy-Malkhalifeh, Behzadi, & Shahvarani. The study concluded that the mathematics learning process of high school students who learn through distance education was less efficient than their peers who learn face-to-face [12].

It could be concluded then that little research had been reported, specifically on what difficulties do students face in studying mathematics at distance education? This paper aimed to explore the difficulties of distance higher education students in learning mathematics. As a case study, this study took the case of students of the S-1 Primary School Teacher Education Program, Universitas Terbuka (UT) in the Pontianak Regional Office of UT (UPBJJ-UT Pontianak).

2. Methods

The approach used in this study was a quantitative approach to study the structure and components of student difficulties in learning mathematics at distance higher education. In this study, students' difficulties in learning mathematics would be seen as a hierarchical construct. Hierarchical constructs provided advantages, including reducing the number of connected paths, overcoming the dilemma between information variation and information clarity, and reducing collinearity between formative indicators [13]. The method used was a survey method followed by 304 students at UPBJJ-UT Pontianak. The questionnaire used consists of 20 statements in a Likert scale format. The indicators or dimensions of the questionnaire were derived from research by Sugilar in 2020 [14]. Data analysis used PLS-SEM which was run by SmartPLS 3.45 software to validate the hierarchical construct with the reflective-reflective type which represented the student's difficulty in learning mathematics at distance higher education.

Data analysis was intended to validate a hierarchical construct. In this study, a reflective-reflective tiered construct was applied with five sub-constructs as a low-level construct that reflected the main construct as a high-level construct, namely the difficulty of learning mathematics from distance higher education students. There were three aspects that need to be considered when validating hierarchical construction, namely: (1) high-level constructs do not have to be evaluated against the indicators used, because high-level indicators repeat the indicators of all low-level indicators, (2) discriminant validity for high-level constructs is indicated by discriminant validity on low-level constructs, and (3) for component relationships between high-level constructs, it is done not involving low-level constructs, and the structural model evaluation criteria apply by default [15].

3. Results and Discussion

The second-order factor of the reflective measurement model was used to measure the construct variables that were the focus of this study, namely the difficulties of distance higher education students in learning mathematics. In this case, the variable of learning difficulties was reflected in two stages; first, the variable was reflected by several sub-constructs; and then each sub-construct was reflected by the manifest variable or the observed variable or the indicators, as shown in Figure 1. The number adjacent to the arrow connecting the two latent variables, in Figure 1, showed the magnitude of the factor loading.
Figure 1. Hierarchical component model of the students’ difficulties of learning mathematics in distance higher education

Figure 1 showed that the difficulties of learning mathematics were reflected in five construct variables, namely (1) motivation, (2) mathematical characteristics, (3) learning materials, (4) learning support services, and (5) distance education characteristics. The five construct variables were previously reflected by 30 indicator items or manifest variables. Some of the indicators, 10 items, were eliminated because they had p-values of less than 0.05, while the other 20 were significant. The distribution of the 20 indicator items was scattered in the five construct variables, each construct was reflected in four manifest or indicator variables respectively.

The evaluation of the reflective measurement model focussed on the relationship between the sub-variables and the indicators to see how well the indicators measure the five construct sub-variables. The reliability of measuring used Cronbach's alpha and the validity of the measurements used an average variance extracted (AVE) [15]. The minimum score criteria for Cronbach's Alpha and Composite Reliability were between 0.60 to 0.70 [15]. The results of the calculation showed that the Cronbach Alpha for measuring mathematics learning difficulties was 0.858 and the composite reliability was 0.885. Thus, the internal consistency of measuring the teaching and learning activities had met the standards. Furthermore, the convergent validity of the teaching and learning measurement instrument was checked through the AVE value. The maximum value for AVE was 0.500 [16]. The calculation result showed that the AVE value was equal to 0.376. Thus, the Learning Difficulty instrument satisfied the convergent validity standard.

The structural model was to evaluate the magnitude and significance of the path coefficients of variables that reflected the difficulty variable. The magnitude of the path coefficient listed on each arrow from the learning difficulty variable to each variable in Figure 1 was emphasized in Figure 2. The path coefficient from the variable difficulty of distance higher education students in learning mathematics to the mathematical characteristic variable was the highest (b= 0.836, p <0.05). This means that the difficulty most distance education students felt in learning mathematics was the difficulty arising from the characteristics of mathematics itself. This was following the comments of face-to-face tutors who taught mathematics courses, the students' initial provisions regarding mathematics material from previous education were very limited, even though mathematical concepts were difficult to understand without understanding the concepts that supported them.
Mathematics was a difficult subject to teach and study since mathematics had a hierarchical structure of the material, namely that the ease of learning a topic depended on the success of studying the supporting topics that were previously studied [17-19]. The openness of distance education made it easy for citizens to access higher education, partly because there was no entry selection based on learning achievement tests in secondary schools. Thus, the higher distance education participants were diverse in terms of initial abilities. Students who lack the initial ability would find it difficult to study mathematics at the university level due to the hierarchical nature of the structure of mathematical material. Here, the difficulties in learning mathematics are occurring since learning mathematics is the organization and reorganization of cognitive structure that is progressive and multi-level, developing from low level to advanced level, and it is formed based on experience that is constantly changing in the process of learning [20 – 21].

The second factor that reflected the difficulty of learning mathematics in distance higher education was the characteristics of distance education itself (b=0.804, p<0.05). One of the characteristics of distance education was the separation between learning and teaching. Teachers deliver teaching materials and dialogue with students through media, printed and non-printed media. Apart from being separated from the instructor, distance education students were also physically separated from their peers. Students had limited support both socially and emotionally which might easily be obtained by face-to-face education students. In this study, the students identified that their separation from teachers and fellow students was one that reflected learning difficulties, in this case learning mathematics difficulties.

The third factor that reflects the difficulties of distance education students was the learning material (β=0.781, p<0.05). The learning materials in distance higher education were designed in the form of modules to be studied independently. This module could be seen as a substitute for face-to-face lectures. In this case, the module was designed in such a format that when students learn it, it seemed as if students were taking face-to-face lectures. Educators on distance education had argued that if a piece of writing can take the reader as if he is traveling to a certain tourist spot then the writing in the module can make students seem to be taking face-to-face lectures. However, for mathematics courses, this seemed difficult to achieve, so this study showed that mathematics teaching materials were the third biggest difficulty factor, after the mathematics material and the nature of distance teaching, in learning mathematics from a distance.

The fourth factor, namely the learning support service factor, seemed to be related to the third factor. Learning assistance services were needed by students to overcome learning difficulties in isolation from
teachers and fellow students. In this study, students had rated learning assistance services as one of the factors reflecting the difficulty of learning mathematics in distance tertiary education \((b=0.732, p<0.05)\). There were two possibilities for the student's perceived difficulties related to learning support services. First, students could not access the learning support services provided by their institutions. Distance higher education institutions at least provide online tutorial services and face-to-face tutorials for students. However, most distance education students were students who work or live in remote areas, making it difficult to access the tutorial services provided. Second, students could access learning assistance services, but the learning assistance was not successful in solving student problems in learning mathematics courses. If the second thing happens, this problem actually returns to the problem of mathematical characteristics which was difficult to learn because it is hierarchical.

Student motivation was the smallest reflection on the difficulty of learning mathematics in distance higher education \((b=0.716, p<0.05)\). The problem of student learning motivation in distance higher education could not be separated from the separation among learners and teachers. This separation made students feel that they did not have the motivation to learn.

4. Conclusion
The study concluded that the biggest obstacle factor in studying mathematics in distance higher education was the nature of mathematics factor. The difficulty in learning mathematics caused by these mathematical characteristics contributes to other factors. Cognitive structure theory can be applied in mathematics learning in distance higher education. The theory states that the essence of learning is connecting similar things and organizing them into meaningful structures, and learning is the organization and reorganization of cognitive structures which is progressive and multi-level, developing from low level to advanced level, and it is formed on the basis of experience and is constantly changing in the process of learning. Thus, if students of distance higher education have difficulty learning a mathematical topic, the student needs learning assistance in the form of an explanation of similar mathematical topics taught at lower levels of education. For example, if a student has difficulty in learning the topic of integral then the learning aid that needs to be given is the topic about the series of numbers that are usually presented at the high school level.

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