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Factor Analysis in Constructing Mathematical Disposition Instrument: Affective Domain

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Abstrak

Keberadaan dari peran disposisi matematis menjadi aspek yang masih dinilai vital ketika siswa berhadapan dengan pembelajaran matematika. Di tengah beragam penelitian terkait hal ini, masih minim studi yang mengkonstruksi instrumen disposisi matematis yang memenuhi kaidah statistik. Penelitian ini bertujuan untuk mengkonstruksi instrumen disposisi matematis yang telah melewati kajian statistik, dan difokuskan pada konstruksi instrumen untuk domain afektif. Penelitian yang melibatkan 185 mahasiswa S1 ini menggunakan instrumen berupa 33 butir pertanyaan 4 skala Likert yang dianalisis menggunakan analisis faktor konfirmatori melalui IBM SPSS 20. Metode ekstraksi menggunakan Maximum Likelihood dan menerapkan rotasi Varimax untuk membedakan antar dimensi dengan lebih maksimal. Uji prasyarat mengindikasikan terpenuhinya kecukupan sampel dan korelasi yang kuat untuk dilanjutkan dalam proses pengelompokkan dimensi. Hasil analisis faktor konfirmatori memberikan 7 dimensi disposisi matematis domain afektif, di mana nilai reliabilitas Cronbach Alpha dari tiap dimensi cukup tinggi, di mana mengindikasikan validitas yang baik. Secara keseluruhan, konstruksi instrumen memuat 33 butir pertanyaan yang valid dan reliabel. Konstruksi instrumen yang telah teruji secara statistik ini dapat digunakan untuk keperluan penelitian lanjutan yang hendak menelaah secara komprehensif terkait disposisi matematis yang menyoroti domain afektif.
Kata Kunci: disposisi matematis; domain afektif; analisis faktor konfirmatori.

Abstract

The existence of the role of mathematical disposition is still vital in dealing with mathematics learning. Among various researches discussing this issue, there are still few studies that deal with constructing mathematical disposition that fulfill adequate statistical review. This study aims to construct mathematical disposition instrument, which is well-tested through statistic review, and focused on affective domain. Methods: This study which involved 185 undergraduate students utilized instrument consisted of 33 four-Likert scale items analyzed using Confirmatory Factor Analysis (CFA) through IBM SPSS 20. The extract method was using Maximum likelihood and applied Varimax rotation to distinguish among dimensions optimally. Findings: The assumption tests indicate the sampling adequacy and strong correlation to be further conducted into the dimensions grouping process. The result of CFA brings 7 dimensions of mathematical disposition in the affective domain, where the value of Cronbach Alpha reliability of each dimension is quite high, which indicates good validity. Overall, the instrument construction provides 33 items which are all valid and reliable. Conclusion: The instrument construction which has been statistically tested, can be used for the purposes of further research seeking to comprehensively examine mathematical dispositions that highlight affective domains.
Keywords: mathematical disposition; affective domain; confirmatory factor analysis.

I. INTRODUCTION

Mathematical dispositions are closely related to students' level of confidence, interest, and proficiency when facing mathematical problems (Hutajulu et al., 2019; Fatimah & Sundayana, 2022). The existence of the role of mathematical disposition is still vital in dealing with mathematics learning. Until now, there is still a stigma that mathematics only applies to a certain group of people (Agyei et al., 2021), and it significantly affects the mathematical disposition of adherents of the quote. As the mathematical disposition is affected, it will certainly affect its mathematical achievements. Discussing about mathematical dispositions, several studies have also strengthened the importance of dispositions in determining student competencies. A mixed methods study conducted by Kusmaryono et al. reveals that the role of mathematical dispositions can nurture students' ability to connect mathematical ideas to solve problems (Kusmaryono et al., 2019). Other study also supports the importance of mathematical disposition, because if students choose mathematics positive attitude, this will also increase motivation in learning mathematics (Hutajulu et al., 2019; Minggi, Arwadi, & Bakri, 2022).

In the context of the affective domain, it is also discussed about areas where difficulties in comprehending math topics and lack of fair delivery of instruction also contribute to influence mathematical dispositions (Almerino, Jr. et al., 2019; Capuno et al., 2019). Furthermore, negative levels of disposition can increase mathematical anxiety (Macher et al., 2013; Samuel & Warner, 2021) and lowering self-efficacy (Rozgonjuk et al., 2020) which will ultimately reduce student achievement and mathematical competence, as confirmed in several previous studies (Luttenberger et al., 2018; Poladian, 2013; Woltering et al., 2009). In addition, the influence of negative dispositions in the affective context can also affect the way students perceive nature of mathematics. Several studies have revealed that students will tend to see mathematics as procedural rather than conceptual when it has a bad disposition (Beyers, 2011; Soesanto et al., 2020; Vukovic et al., 2013). In fact, students' sensitivity in seeing the relationship between mathematics and daily life is also influenced by the mathematical disposition they have (Beyers, 2011; Machmud, Pusi, & Pauweni, 2022). Therefore, it is very noticeable that the position of this mathematical disposition is so important in playing its role when students learn mathematics. The level of self-confidence, worldview, and belief as part of an affective disposition is such an element that cannot be ignored and should be a concern of the teacher when dealing with pedagogic strategy to teach mathematics.

For a moment, flashbacks during the past pandemic, emergency learning also brings its own dynamics for each stakeholder (Galoyan et al., 2021; Wong, 2020). This crisis situation urges parents, students, and teachers to get used to utilizing technology as a means of learning. Likewise in mathematics learning, which also requires the use of technology to create a conducive learning environment (Syarif et al., 2021). The weak proficiency of educators in exploring mathematics

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learning technology, especially at the higher education level (Kusmaryono et al., 2019; Irfan et al., 2020) is also the cause of students having negative dispositions. This is because the lack of teacher skills in applying learning technology will make the learning atmosphere uncomfortable and less meaningful. Students become increasingly anxious (Adedoyin & Soykan, 2020; Kalogeropoulos et al., 2021), do not understand the nature of mathematics as a conceptual science (Lu'luilmaknun et al., 2021), have a bad self-concept towards mathematics (Warren et al., 2020), and have negative emotions towards mathematics (McMinn et al., 2020).

All of these perceptions eventually make students feel that the pressure experienced in emergency learning is greater than the face-to-face learning period before the pandemic. This fact makes the majority of students at every level of education want to return to the face-to-face model (Soesanto & Dirgantoro, 2021). Entering the post-pandemic period, also does not mean that learning conditions become easier. The problem of mathematical disposition is also still in the spotlight for educators to gradually begin to create a pleasant atmosphere of mathematics learning. Various kinds of training related to the application of technology in mathematics learning have also been attended by educators, including lecturers as teachers who teach in the scope of higher education (Aeni & Afriansyah, 2022).

The terminology "Mathematical Disposition" contains several terminologies such as belief, emotion, attitude, and worldview (Almerino, Jr. et al., 2019). Beyers classifies dispositions into three domains, namely cognitive, affective, and conative (Beyers, 2011; Rizky & Sritresna, 2021; Sovey, Osman, & Matore, 2022). As a research gap, studies that examine mathematical dispositions is still descriptive and there is no quantitative instrument that covers this need. Several studies tried to examine the disposition using questionnaire instruments (Agyei et al., 2021; Hutajulu et al., 2019) but still have weaknesses in the construction of instruments that lack statistical reviews. Therefore, this study aims to construct mathematical disposition instruments that have passed statistical studies, and focus on the construction of instruments for the affective domain. The researchers hope that the existence of this instrument can accommodate other researchers as they want to investigate the phenomenon of mathematical disposition affectively in their follow-up research, especially in the post-pandemic period that is happening today.

II. METHOD

The study involved 185 undergraduates students from various study program, consisting of 49 males (26.49%) and 136 females (73.51%). In addition, the researchers took the participants who are and have dealing with mathematics courses. Participants were spread from various provinces in Indonesia and came from different student levels. Table 1 depicted the demographics of the respondents who were joining into this study.

Table 1.
Participants' Demography

Aspect	Detail	N	%
Gender	Male	49	26.49
	Female	136	73.51
Provinces	Bali	2	1.08
	Bangka Belitung	1	0.54
	Banten	14	7.57
	Bengkulu	1	0.54
	DKI Jakarta	6	3.24
	West Java	40	21.62
	Central Java	7	3.78
	East Java	5	2.70
	West Kalimantan	2	1.08
	East Kalimantan	1	0.54
	Lampung	1	0.54
	Riau	3	1.62
	Maluku	22	11.89
	East Nusa Tenggara	19	10.27
	Papua	3	1.62
	North Sumatera	27	14.59
	North Sulawesi	7	3.78
	West Sulawesi	1	0.54
	South Sulawesi	23	12.43
Students' Year Level	Freshmen (1st year)	38	20.54
	Sophomores (2nd year)	51	27.57
	Juniors (3rd year)	56	30.27
	Seniors (4th year)	32	17.30
	More than 4 years	8	4.32

This study aimed to construct mathematical disposition instruments in the affective domain that have passed statistical studies. Therefore, the researchers used quantitative design. Indeed, there were procedure stages that must be taken to produce a solid construction. Figure 1 displayed the stages performed by the researcher.

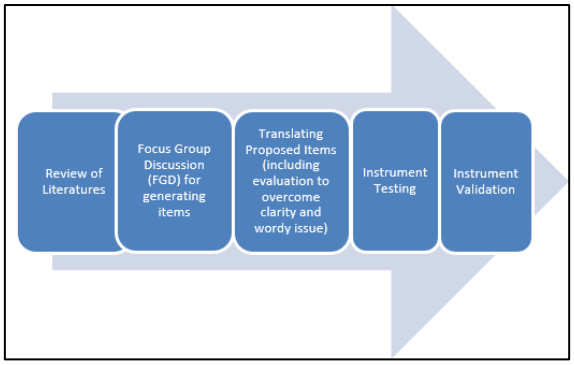

Figure 1. Procedure Stages of the Research

The instrument was created in the form of a Microsoft Form questionnaire and contained 37 items. In detail, 37 items consisted of 3 items asking about demographics, 1 item asking for the limitations of research respondents, and 33 items in the form of Likert-scales related to mathematical dispositions. The ranges used were: 4 (Strongly agree), 3 (Agree), 2 (Disagree), and 1 (Strongly disagree). After the questions were compiled through the FGD, the translation process into English was then carried out. After being translated, the researchers took an evaluation process of the instrument. The process was conducted by an expert in English. The researchers asked one lecturer from English Education study program to perform the evaluation by giving feedbacks. The purpose of the evaluation process was to overcome clarity and wordy issues. Table 2 pointed out sample of items that were revised through this process.

Table 2.
Evaluation Process of the Instrument (Sample Items)

Before	Feedback	After
Math helps me to develop accuracy	One thing that needs to be paid attention is: "to improve" means "to make better", whereas "to develop" means "to change with direction"	Math helps me to improve my accuracy
Through math subjects, I learn to be responsible over the ways that I choose.	What do you mean by "ways"? Is it method? This might create confusion. Probably give clarity.	Through math subjects, I learn to be responsible over the formulas and solution methods that I choose.

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Based on the focus of research that highlighted mathematical dispositions, coupled with the context of pandemic learning that has occurred for 2 years, the researchers added an item that asked if respondents have experience in learning mathematics courses during their emergency learning on campus. This restriction was necessary to ensure that data processing became valid, as there were no students outside the context of the research. Respondents who had no experience in learning mathematics during the pandemic, were not included in data processing.

After the data collection from respondents was completed, the data acquisition was then analyzed using a statistical study. For instrument construction purposes, researchers used Confirmatory Factor Analysis (CFA) through IBM SPSS 20. The reason for using CFA was because there was already a theoretical basis that has been determined in advance through literature studies (Creswell, 2014; A;-Mamary & Alshallaqi, 2022), namely by adapting the 7 components in the affective domain of mathematical disposition based on Beyers' research (Beyers, 2011). This type of factor analysis requires the fulfillment of 2 assumption tests first, namely the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Bartlett's Test of Sphericity. KMO needed to be examined to detect similarities between items by looking at indicators of their values, while Bartlett's Test of Sphericity dealt with correlations between variables. These two assumption tests were met when the KMO value > 0.5 and the Bartlett's Test value < 0.05 to ensure that the items were correlated with each other. In terms of extraction, researchers used the Maximum Likelihood as extraction method. Furthermore, researchers used Varimax rotation to distinguish between dimensions more optimally.

III. RESULT AND DISCUSSION

Before conducting CFA, there are 2 assumptions that must be met, namely the value of KMO and Bartlett's Test. Through statistical testing, the KMO value was 0.863 (> 0.5) and the Sig. value on Bartlett's Test was 0.000 (< 0.05). These two values give the meaning that between the items are correlated with each other and have similarities that are incorporated into several dimensions. Therefore, CFA can be performed to answer the formulation of this research problem. As previously explained, researchers adapted the affective domain from Beyers (2011) which consists of 7 elements or dimensions, so that in the implementation of CFA, researchers extract 7 factors. Moreover, from Total Variance Explained as shown at Table 3, it can be seen that these 7 dimensions are able to explain 47.275% of the variation.

Table 3.
Total Variance Explained

Extraction Sums of Squared Loadings		
Total	% of Variance	Cumulative %
8.575	25.985	25.985
2.331	7.063	33.049
1.832	5.552	38.601
0.851	2.578	41.179
0.741	2.246	43.425
0.637	1.930	45.355
0.633	1.919	47.275

Furthermore, items that have similarities are indicated in the Table Rotated Factor Matrix, where the researcher will elaborate in detail into 7 points that represent the dimensions of the mathematical disposition on the affective domain.

A. Nature in Mathematics

This dimension focuses on the belief in mathematical characteristics that basically contain various concepts that are interconnected with each other, including the relationship of mathematical concepts studied to daily life. Based on statistical studies conducted, the items included in this dimension are shown in Table 4 along with the reliability value of the Cronbach Alpha, as follows:

Table 4.
Items in "Nature in Mathematics" Dimension

Items	Cronbach Alpha
I don't see the benefit of Math in my life	0.808
Math is not beneficial for me because the concepts are not directly related to a job that I want in the future	
Each topic in Math is a separate item (not intercorrelated)	
For me, Math is simply counting numbers, not more than that	
I see Mathematical concepts as interconnected with each other	
I hope I never have to deal with Math again	
Math tasks that I do help me understand concepts being explained	
I hate it when I have to learn Math	
For me, Math is a bunch of numerical information	

B. Usefulness

This dimension focuses on the application of mathematics in life aspects and also its interrelationships in other subjects. Table 5 shows the items that fall into this dimension as well as the Cronbach Alpha values.

Table 5.
Items in "Usefulness" Dimension

Items	Cronbach Alpha
I feel that Math is useful in my daily life.	0.690
I feel that Math is useful to other subjects taught in school	

C. Worthwhileness

This dimension refers to the suitability of mathematics learning with learning targets so that the impact is that students can do tasks optimally. Subsequently, this dimension also emphasizes the adequacy of proportions between theories and concepts of mathematics during learning given. Table 6 exposes the items that fall into this dimension as well as the Cronbach Alpha values.

Table 6.
Items in "Worthwhileness" Dimension

Items	Cronbach Alpha
Math tasks are worthwhile for me as they are aligned with the learning objectives.	0.762
Mathematical concepts and theories that I learn make sense	
I am sure that I can do the math tasks given	

D. Sensibleness

This dimension underlines mathematics ideas that can be understood, thus impacting the belief that mathematics has

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relevance to the future profession and a feeling of comfort when dealing with math. Table 7 shows the items that fall into this dimension as well as the Cronbach Alpha values.

Table 7.
Items in "Sensibleness" Dimension

Items	Cronbach Alpha
I feel uncomfortable attending Math class.	0.662
More than half of the math materials learn in school are boring for me	
I am unsure that I can get good score during the test even though I learn prior to that	
I feel that Math is useful for my future career	

E. Mathematics Self-Concept

This dimension emphasizes to what that the student believes about himself as a mathematics learner. Table 8 shows the items that fall into this dimension as well as the Cronbach Alpha value.

Table 8.
Items in "Mathematics Self-Concept" Dimension

Items	Cronbach Alpha
Math helps me improve accuracy	0.675
Through math subjects, I learn to be responsible over the formulas and solution methods that I choose	
There is kind of "mathematical talent" that makes someone better in Math than me	

F. Attitude

This dimension looks at the student's emotional reaction to mathematical activity, which is reflected in the form of self-confidence and the feeling that the student understands the mathematical material. Table 9 shows the items that fall into this dimension as well as the Cronbach Alpha values.

Table 9.
Items in "Attitude" Dimension

Items	Cronbach Alpha
I feel confident in answering questions related to Math	0.804
I can understand concepts presented in Math Class	
I feel confident in taking math exam because I have prepared myself well	
I am confident enough to ask questions about mathematical concepts that I don't yet understand to my lecturers	
I like learning Math	
I try to do all Math tasks no matter how difficult they may be because they surely are useful for me	

G. Math Anxiety

This last dimension has provided clarity from the name, which focuses on the anxiety experienced by students when learning math. Table 10 shows the items that fall into this dimension as well as the Cronbach Alpha values.

Table 10.
Items in "Math Anxiety" Dimension

Items	Cronbach Alpha
It is hard for me to really understand Math well	0.718
I feel anxious when given tasks even though I have not yet seen the question items	
I feel stressed out during Math exams	
I easily give up when learning Math	

I only can understand mathematical concepts that have direct connection with my daily life	
No matter how hard I try to do math tasks, I am never able to get good grades	

Overall, the construction of the mathematical disposition instrument of the affective domain also has good validity and reliability. In terms of validity, researchers involved 185 respondents to fill out the questionnaire, so that a degree of freedom (df) = 185 – 2 = 183 was obtained. This df value indicates r table = 0.145 with the level of significance 5%. Through data processing with IBM SPSS 20, it can be viewed that 33 items show > 0.145, ranging from 0.273 (the least) to 0.643 (the highest). The overall reliability of the instrument also indicates a high Cronbach Alpha value, which is 0.911. Therefore, instrument construction is claimed to be a valid and reliable instrument by statistical test (Creswell, 2014).

Discussing about the importance of affective mathematical disposition is absolutely vital because it can affect the students' performance when dealing with mathematics courses, as claimed by several studies (McMinn, Aldridge, & Henderson, 2020; Vukovic et al., 2013). Educators must concern to help the students in improving their affective disposition by providing sufficient pedagogy strategies during the learning process (Samuel & Warner, 2021). Therefore, the researchers provide the statistical-tested instrument to help educators in ensuring the degree of students' mathematical disposition, particularly in the affective domain.

IV. CONCLUSION

The existence of mathematical dispositions is considered as an element that exerts an influence on students' perspectives, beliefs, and understanding of mathematical nature. In fact, dispositions are also considered to affect students' achievement and mathematical competence when faced with conceptual problems. This research has constructed disposition instruments, but is limited to the affective domain. There needs to be other research that contributes to structuring the cognitive and conative domains, which obviously through statistical tests. The affective domain instruments that have been developed through this research, presumably can be used for comprehensive studies in the future, in connection with the mathematical disposition of students, ranging from schools to higher education. Furthermore, this affective disposition instrument can be applied at any level of students, and some scholars can administer it in the form of e-questionnaire, so it would be more effective.

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