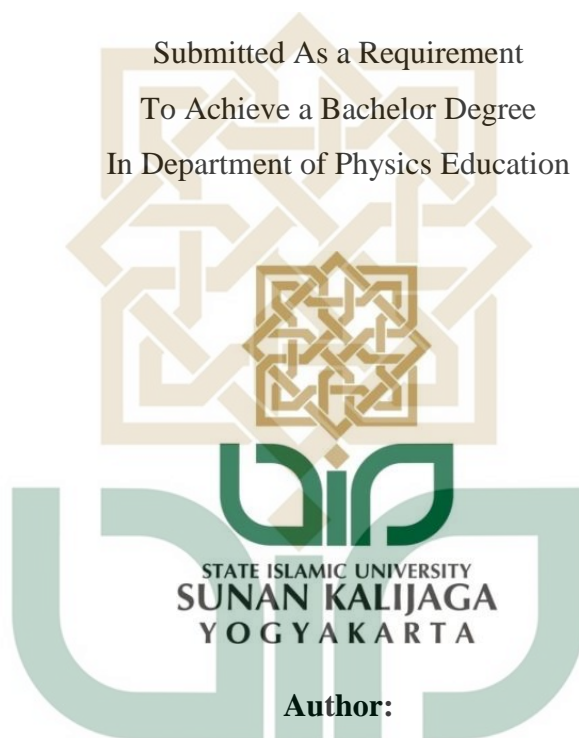


**COMPARISON OF STUDENTS' PERFORMANCE ON
VECTOR CONCEPTS BETWEEN PRINCE OF SONGKLA
UNIVERSITY (PSU) AND STATE ISLAMIC UNIVERSITY
(UIN) SUNAN KALIJAGA STUDENTS USING TEST OF
UNDERSTANDING OF VECTORS (TUV)**

BACHELOR THESIS

Submitted As a Requirement
To Achieve a Bachelor Degree
In Department of Physics Education



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YOGYAKARTA**

2019



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BACHELOR THESIS APPROVAL LETTER

About : Bachelor Thesis
Enclosure : -

To
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Assalamu'alaikum. wr. wb

After readings, checking, giving guidance, correcting and repairing, we are an advisor, have decided that a bachelor thesis of:

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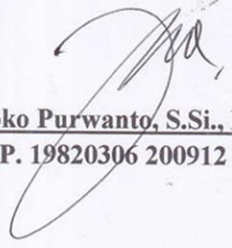
have been submitted to Faculty of Science and Technology, Department of Physics Education, State Islamic University of Sunan Kalijaga of Yogyakarta as one of the requirements to get Bachelor degree (S-1) in Physics Education.

By those conditions, we hope the bachelor thesis can be examined as soon as possible. Thank you.

Wassalamu'allaikum. wr. wb.

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AND STATE ISLAMIC UNIVERSITY (UIN) SUNAN KALIJAGA
STUDENTS USING TEST OF UNDERSTANDING OF VECTORS (TUV)**
which is my own opus or research. As long as I know, there is no opus or research
written or published by another person except as guidance or citation in following
opus grammar standardly.

Yogyakarta, 22 Oktober 2019

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MOTTO

“Allah will not give you a burden you cannot handle”

(QS. Al-Baqarah: 286)

It's not that I'm so smart, it's just that I stay with problems longer

(Albert Einstein)

“Keep your eyes on the stars, and your feet on the ground”

(Diego Hernandez)

Hitch and efforts must be equal to your great wishes

(Betavia.K)



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DEDICATION

Every challenging work that increases your ability requires a great self-effort as well as the guidance of elders especially those who were very close to our heart.

This research is wholeheartedly dedicated to my lovely

Father & Mother,
Sisters,

who have given me strength when I thought of giving and own source of encouragement when a much hitch happened, who continually gave me lessons in spiritual, moral, emotional, and financial support.

To the hundreds of friends helped me unconditionally, and my alma mater,
Department of Physics Education of State Islamic University of Sunan Kalijaga of
Yogyakarta.

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PREFACE

Bismillahirrahmanirrahim

I would like to acknowledge the countless thank to the Most Merciful God who always gives his blessing in my life and there is no doubt about it. Finally, the author can complete this bachelor thesis entitled “Comparison of Students’ Performance on Vector Concepts between Prince of Songkla University (PSU) and State Islamic University (UIN) Sunan Kalijaga Using Test of Understanding of Vectors (TUV)”

The success of this research was supported by several institutions. I would like to thank Department of Physics, Faculty of Science and Technology, State Islamic University of Sunan Kalijaga who gave me the golden opportunity to take Student Receiving Exchange and Credit Transfer Scholarship in Prince of Songkla University so that I can carry out Project in Physics in one semester. I also thank Department of Physics, Faculty of Science, and Prince of Songkla University for the opportunity and financial support during my research through Thailand's Education Hub for ASEAN Countries (TEH-AC) scholarships.

In particular, I would like to express my sincere gratitude to my advisor Joko Purwanto S.Si., M.Sc who given guided, valuable comments, suggestions for completing this Bachelor thesis. I’m also countless thank and express my gratitude to Asst. Prof. Dr. Suttida Rakkapao as my advisor in PSU for providing me an opportunity, encouraging guidance, knowledge, and motivation during my research.

This Bachelor thesis as a final research intended to help teachers and researchers to find a proper way to assess and evaluate students’ understanding in classrooms. The main goal of this Bachelor thesis is to compare of students’ performace on vector concepts between Prince of Songkla University (PSU) and State Islamic University (UIN) Sunan Kalijaga using Test of Understanding of Vectors (TUV). It is important to understand what and how students think about the vector concept because it serves as a mathematical tool for many physics topics.

I realize there are unintended errors in writing this paper. I really allow all readers to give their suggestions to improve in content in order to be made as one of the good examples for the next one. I also hope that our report will be useful for other science educators.

Yogyakarta, 15th Oktober 2019

Betavia Kusindrastuti

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COMPARISON OF STUDENTS' PERFORMANCE ON VECTOR CONCEPTS BETWEEN PRINCE OF SONGKLA UNIVERSITY (PSU) AND STATE ISLAMIC UNIVERSITY (UIN) SUNAN KALIJAGA STUDENTS USING TEST OF UNDERSTANDING OF VECTORS (TUV)

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ABSTRACT

This research focuses (1) to compare five statistical tests of the TUV results obtained from PSU students and UIN Sunan Kalijaga students, and (2) to compare the knowledge states between PSU and UIN Sunan Kalijaga students.

The Test of Understanding of Vectors (TUV) is a reliable assessment tool in Physics Education Research (PER) that was translated into the Thai and Indonesia language, checked technical terms and validated by a group of Thai physics lectures and three of Indonesia physics lecturers. It was administered to 858 first-year Prince of Songkla University students (60% male) and 282 students (68% female) at UIN Sunan Kalijaga at times ranging from three to eight semesters after completing their introductory physics course (fundamental of physics I) evaluated in the TUV. The deeper interviews on ten respondents were also conducted at UIN Sunan Kalijaga students by online system and paper. This research was analyzed using five statistical tests namely difficulty index, discrimination index and point biserial coefficient to test per item, whereas the Kuder-Richardson reliability index, and Ferguson's delta to analyze the instrument test of the TUV, meanwhile to compare the knowledge states both universities using an independent t-test and model estimation of the model analysis technique.

It was found that the results of the five statistical tests between PSU and UIN Sunan Kalijaga students were comparable as performed by discrimination index, point-biserial coefficient, although some TUV items were difficult for PSU students than UIN Sunan Kalijaga students. The TUV is a reliable test by Kuder Richardson-20 and Ferguson's delta test. The participants correctly answered ($\pm 45\%$) on vector component as the best understanding. The most popular incorrect ideas on cross-product as reported by eigenvalues < 0.65 . Overall, both UIN Sunan Kalijaga and PSU students almost had similar knowledge states and most located in the mixed model region of model estimation.

Keywords: *vector, Test of Understanding of Vectors, model analysis.*

**PERBANDINGAN PEMAHAMAN MAHASISWA PADA KONSEP VEKTOR
ANTARA *PRINCE OF SONGKLA UNIVERSITY (PSU)* DAN *UNIVERSITAS
ISLAM NEGERI (UIN) SUNAN KALIJAGA* MENGGUNAKAN *TEST OF
UNDERSTANDING OF VECTORS (TUV)***

Betavia Kusindrastuti (15690031)
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ABSTRAK

Tujuan dari penelitian ini yaitu, (1) untuk membandingkan evaluasi tes TUV antara mahasiswa PSU dan UIN Sunan Kalijaga, dan (2) membandingkan pemahaman konsep fisika antara mahasiswa PSU dan UIN Sunan Kalijaga.

Instrumen penelitian menggunakan Test of Understanding of Vectors (TUV) yang merupakan instrumen penilaian yang reliabel dalam *Physics Education Research (PER)*. Soal TUV diterjemahkan dahulu dalam bahasa Thailand dan Indonesia, memeriksa persyaratan teknis, dan divalidasi oleh sekelompok dosen fisika Thailand dan tiga dosen fisika Indonesia. Sampel penelitian ini adalah 858 mahasiswa tahun pertama (60% mahasiswa laki-laki), Prince of Songkla University, Thailand dan 282 mahasiswa UIN Sunan Kalijaga, Yogyakarta dari semester III-VIII yang telah menyelesaikan fisika dasar I. Selain itu, wawancara lanjutan juga dilaksanakan pada sepuluh mahasiswa UIN Sunan Kalijaga. Analisis penelitian ini menggunakan lima uji statistik yaitu, indeks kesulitan, indeks diskriminasi, dan koefisien poin biserial untuk menguji per soal TUV, sedangkan reliabilitas Kuder-Richardson dan uji delta Ferguson untuk menganalisis soal TUV secara keseluruhan, sementara untuk membandingkan pemahaman konsep vektor dianalisis dengan menggunakan independent t-test dan model estimasi dari model analisis teknik.

Signifikansi hasil uji lima statistik menunjukkan kesebandingan dari kedua universitas (PSU dan UIN Sunan Kalijaga) yang ditunjukkan pada perolehan index kesulitan, indeks diskriminasi, koefisien poin biserial, meskipun pada beberapa soal TUV lebih sulit untuk mahasiswa PSU dibandingkan dengan mahasiswa UIN Sunan Kalijaga. Berdasarkan analisis Kuder-Richardson-20 dan uji delta Ferguson, soal TUV merupakan soal yang reliabel. Responden menjawab dengan benar ($\pm 45\%$) pada konsep komponen vektor sebagai konsep yang paling paham. Sedangkan gagasan salah yang paling banyak pada konsep vector perkalian yang dilihat dari nilai eigen < 0.65 . Secara keseluruhan, mahasiswa PSU dan UIN Sunan Kalijaga memiliki pengetahuan pada konsep vektor yang hampir sama dengan hasilnya kebanyakan berada pada model pemahaman campuran (*mix model*) dari model estimasi.

Kata kunci: vektor, *Test of Understanding of Vectors*, model analisis

CONTENTS

TITLE	i
<i>PENGESAHAN SKRIPSI/TUGAS AKHIR</i>	ii
BACHELOR THESIS APPROVAL LETTER.....	iii
CERTIFICATE OF ORIGINALITY	iv
MOTTO	v
DEDICATION.....	vi
PREFACE.....	vii
ABSTRACT	viii
ABSTRAK	ix
CONTENTS.....	x
LIST OF TABLES	xii
LIST OF FIGURES	xiii
LIST OF APPENDICES	xiv
CHAPTER I INTRODUCTION	1
A. Significance of the research.....	1
B. Problem Identifications.....	5
C. Scopes	5
D. Problem Formulations	6
E. Objectives	6
CHAPTER II THEORITICAL BACKROUND	7
A. STUDY OF THE THEORY	7

1. Five statistical tests based on the Classical Test Theory (CTT)	7
2. Independent t-test.....	13
3. Model Analysis	13
B. LITERATURE REVIEW	17
CHAPTER III RESEARCH METHODOLOGY	20
CHAPTER IV RESULTS AND DISCUSSION	22
CHAPTER V SUMMARY	45
A. Conclusions	45
B. Applications of this Research for Instructions	46
C. Limitations and Recommendations	47
REFERENCES.....	48
APPENDICES.....	52



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LIST OF TABLES

Table 2. 1 The 10 vector concepts evaluated in the 20-item TUV	17
Table 2. 2 Students' misconceptions about vectors reviewed by literature	19
Table 4.1 The Item difficulty index (P), discriminatory index (D), and point-biserial coefficient r_{pbs} between UIN Sunan Kalijaga (UIN) and PSU students	22
Table 4. 2 Result of the five statistical test between UIN Sunan Kalijaga (UIN) dan PSU students suggested by (Ding et al., 2006).....	26
Table 4. 3 Group statistic to asses the normality	28
Table 4. 4 Descriptive statistic for two universities.....	28
Table 4. 5 Independent sample t-test	28
Table 4. 6 Three common models (model 1 = correct, model 2 = popular incorrect, model 3 = other choices) of the six vector concepts of TUV based on Thai students' responses.....	29
Table 4. 7 Result of class density matix, primary eigenvalue, and eigenvectors from PSU and UIN Sunan Kalijaga students fro the concept of dierction and component of vectors.....	31
Table 4. 8 Results of class density matrix, primary eigenvalue, and eigenvector from PSU and UIN Sunan Kalijaga students for the concept of addition and subtraction of vectors.....	37
Table 4. 9 Results of the class density matrix, primary eigenvalue, and eigenvector from PSU and UIN Sunan Kalijaga students for the vector concept of dot product and cross product.....	41

LIST OF FIGURES

Figure 2. 1 Model plot reflects the distributions of students' knowledges in the class (Bao&Redish, 2006).....	16
Figure 4. 1 Item 2 is about unit vector	24
Figure 4. 2 Item 15 is about a cross product of a vector	24
Figure 4. 3 The model plot displays two colors: black for UIN Sunan Kalijaga students, white for PSU students. Those show 2 vector concepts for the vector durement (a) and the component of vectors (b)	31
Figure 4. 4 Item 17 of TUV	32
Figure 4. 5 Item 14 of TUV	35
Figure 4. 6 The model plot displays two colors: black for UIN Sunan Kalijaga students, white for PSU students. Those show 2 vector concepts for the vector addition (a) and subtraction of a vector (b).	36
Figure 4. 7 Item 1 of TUV	38
Figure 4. 8 Item 19 of TUV	40
Figure 4. 9 The model plot displays two colors: black for UIN Sunan Kalijaga students, white for	41
Figure 4. 10 Item 8 of TUV	43

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YOGYAKARTA

LIST OF APPENDICES

Appendix 5. 1 The percentage of selecting each choice of the six vector concepts for PSU (N=858) and UIN Sunan Kalijaga (N=282) students.	52
Appendix 5. 2 First year physics curriculum at PSU	53
Appendix 5. 3 TUV tested	54
Appendix 5. 4 Interview session	55
Appendix 5. 5 Validated by Physics Lectures.....	56
Appendix 5. 6 Samples of TUV Test	62
Appendix 5. 7 Letter of Agreement	71
Appendix 5. 8 Topic Approval of Project in Physics II at PSU	72



CHAPTER I

INTRODUCTION

A. Significance of the research

One of physics concepts need a mathematical formalism with several quantities that have both magnitude and direction, named vectors to describe (Knight, 1995). The good basic knowledge of the vector concept influences the high-quality of understanding of other related physics topics (Ozcan & Gercek, 2015). In most cases, at a university level, the vector concept is firstly considered in an introductory physics course since it is applied to other subsequent physics concepts in mechanics, electricity, magnetism, and modern physics

Previous studies on student difficulties such as the cross product found that students had more difficulty interpreting the geometry of the cross product as a vector perpendicular to the right-hand rules (RHRs). They are difficult to determine which the first vector in the cross product is, or misinterpretation of the vector plane of the symbol used to represent 3-dimensional vectors on a 2-dimensional page (Kustusch, 2018; Barniol & Zavala, 2010; Susac *et al*, 2018).

At UIN Sunan Kalijaga, an introductory physics course namely a fundamental of physics I which is a required subject and prerequisite for students to take the higher concept in a fundamental of physics II. In a class, students have different abilities, as well as their comprehension of physics

concepts, furthermore the students' understanding of different universities. Olusola *et al* (2016) identified there are several factors which impact student's performance are as follows, study habit, student's self-concept, teachers' ability, instruction method, school environment included living conditions and campus facilities, government (Ilgan, Ataman, Ugurlu, & Yurdunkulu, 2018), and the home as the primary environment of the students. Based on the factors that were mentioned before, actually we cannot compare the students' understanding of vector concepts both PSU and UIN Sunan Kalijaga. However seen from the physics topics in the PSU curriculum and curriculum of UIN Sunan Kalijaga, two universities have same physics topics in introductory physics course. The physics topics that used vector are kinematics, work, energy and momentum, forces and motions, gravitational interaction, the systems of particles and motion of the rigid bodies. Several vector concepts are included in Test of Understanding of Vectors (TUV). It can be compare the students' understanding both universities from the common misconceptions of each vector concept.

TUV is a first multiple-choice test instruments that reliable evaluation tool which exam the student's performance of vector problems without physical context (Barniol & Zavala, 2014). TUV consist of 20-item with 10 vector concepts. The researcher designed a complete taxonomy of the most frequent errors as distracters in four options and one correct option. The test is a well-known standard multiple-choice test that validated by Physics Education Research (PER). TUV can be used to identify in detailed the initial

student's knowledge of each vector concepts (without physical context), requires a less time that easier for teachers and researchers to evaluate after completing their introductory physics courses, analyze in detail the students' understanding of each concept on TUV in different institution (Barniol & Zavala, 2014; Rakkapao *et al*, 2016; Susac *et al*, 2018).

Students were disturbed in completing advanced physics concepts when they had difficulty in learning vectors (Nguyen& Meltzer, 2003). It is crucial to teachers as well important things in education research, is to gain insights about the knowledge students learn after studying in the classroom (Bao, 2006). Based on the constructivism learning theory, three key ideas should be considered in order to promote students' learning (Duit, Goldberg, & Niedderer, 1992):

- (1) Teachers play an important role in supporting what and how students learn,
- (2) Knowledge cannot be transmitted by telling, but students have to construct the body of knowledge by themselves, and
- (3) Teaching is a social activity, but learning is a personal action (Van den Berg, 1991).

Students always brought some understanding and attitudes towards learning into classrooms at a university level. What and how they learn in high schools influences ways to re-organize their old ideas and construct new knowledge in further steps (Nguyen & Meltzer, 2003; Redish, 2004). Constructing a new concept strongly depends on contexts. If students cannot

appropriately understand how physics situations work, it is difficult to succeed and also leads to misunderstanding (Bao&Redish, 2006).

In several physics studies have found that students had different concepts by experts (Trisianawaiti, 2014). This is indicated by the many responses of students who are inconsistently in answering questions (Bao & Redish, 2006). The accurate step to learning mathematical physics is to understand the concept first (Emanuel, 2016). Solving physics problem can be done in three important steps, (1) to the identification of problems, (2) determine the appropriate equation or method, (3) calculate the mathematical problem. The candidates of physics teachers have to understand the material well especially in vector concept (Handika, 2014).

This research use five basic statistical tests based on Classical Test Theory (CTT) comprising difficulty index, discrimination index, point-biserial coefficient, Kuder-Richardson reliability index, and Ferguson's delta test are evaluated. The Classical Test Theory (CTT) used to evaluate the assessment tool of a research. It can analyze each item in the test and also evaluated the entire test to ensure that the test is reliable. The technique of conventional methods, which only analyses the total scores before and after instruction (Hake, 1998). Teachers can not know the student's performance on vectors for each class. In contrast, the model analysis will guide teachers which common vector ideas should be revised and how in order to develop the students' performance. The model analysis can identify a single student mental state to representation an average mental model for the whole class. As

well as the model analysis technique that is based on the matrix representation of quantum physics.

This research is advanced study of my project at PSU. However, data were also conducted on Faculty of Science and Technology (physics and physics education) at UIN Sunan Kalijaga students. Based on several problems that found, therefore this research wants to find out how well the comparison of students' performance between PSU and UIN Sunan Kalijaga students on vector concepts, not to find the students who have a better understanding on vector concept, but only to describe the level an understanding of students from both universities.

B. Problem Identifications

Based on the significance of the research, some problems can be identified such as:

1. Less of understanding on vector concept between PSU and UIN Sunan Kalijaga.
2. Constructing new vector concept at the university level can lead the student to misunderstand.

C. Scopes

This research is limited to:

1. The 20-item TUV is analyzed by t-test and the model analysis since the technique requires a set of equivalent-concept questions.
2. We employed a basic idea of correct, popular incorrect and other choices to design three common mental models of the TUV test.

3. Collected data from science students of UIN Sunan Kalijaga and PSU.

D. Problem Formulations

Based on the significance of the research, problem identification, and scopes that lies above, problem formulation can be inferred such as:

1. How does the TUV to measure the students' performance of vector concepts?
2. How does the knowledge states between PSU students and UIN Sunan Kalijaga students?

E. Objectives

The research aims to:

1. compare the result of five statistical tests such as difficulty index, discrimination index, and point-biserial coefficient (item analysis), whereas Kuder- Richardson reliability index and Ferguson's delta test (test analysis) of the TUV between UIN Sunan Kalijaga students and PSU students.
2. compare the knowledge states between PSU students and UIN Sunan Kalijaga students using a model estimation of the model analysis technique.

CHAPTER V

SUMMARY

A. Conclusions

This research aimed to study three main objectives, which all were addressed.

Objective 1: Five statistical tests (difficulty index, discrimination index, point-biserial coefficient, Kuder-Richardson reliability index, Ferguson's delta test) were applied to computed TUV data collected from PSU and small students of UIN Sunan Kalijaga (N= 1,140). The findings will be compared with a first research at PSU students (N= 858). Overall, the TUV both Indonesian and Thai version is a reliable test reported by Kuder Richardson-20, and Ferguson's delta test. It is able to distinguish between students who understand vector concepts well and students who do not, as demonstrated by moderate discrimination index, point-biserial coefficient. Some TUV items were more difficult for PSU students than UIN Sunan Kalijaga students illustrated by low item difficulty index.

Objective 2: UIN Sunan Kalijaga students (Mean \pm SD of 20-item TUV= 7.62 \pm 3.74) had background knowledge of vectors greater than SC students (Mean \pm SD of 20-item TUV= 5.74 \pm 3.06) reported by independent t-test. Moreover, the model analysis interpreted details about students' misconception for each physics concept. The technique generated the class model vectors for each vector concept which demonstrated the trend of using common mental models to solve a set of equivalent-concept questions. For example, the direction was the most problem

for both participants of two universities, whereas the vector components were found to be the best understood by students. Overall, the participants from UIN Sunan Kalijaga and PSU students had knowledge about vector concept in the mixed model states. Essentially, many factors affect test results. The different number of participants can also be a factor for the results of the test. It was analyzed because the small number of participants would minimize errors of the average score for the whole students, rather than the large participants would get a lower average score divided by all students.

B. Applications of this Research for Instructions

The result of this research highly expected giving more information and was followed up by relevant parts, in particular, teachers, researchers, and students. In this project, we re-confirmed that the TUV is a standard vector concept test in PER which can apply to general physics classes.

For the model analysis, it can be applied to detect pre-and-post class model vectors of students of a given topic, as well as comparing class model vectors between two classrooms, two groups in different university and more. Provide alternative media that easier for evaluating students' understanding in more details on vector concepts in physics learning. It is expected that the evaluation results can be used as a reference for teachers in examining the knowledges states students in one class that can cover the students' performance and students' misconception in introductory physics courses. Researchers can evaluate understanding using TUV test to improve the education system at a

higher level. For students, rehearsed the students to be understood in vector concepts with the TUV test.

C. Limitations and Recommendations

1. We employed a basic idea of correct, popular incorrect and other choices to design three common mental models of the TUV test. A more concrete analysis may need for a further research.
2. A model analysis will not be appropriate to explain a large distribution of single students' ideas in one class (eigenvalue < 0.65). Other assessment methods should be introduced.
3. We presented a model analysis of only six vector concepts of TUV. A set of equivalent-concept questions about other vector concepts needs for a model analysis in the next step.

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