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Factor analysis for instruments of science learning motivation and its implementation for the chemistry and biology teacher candidates

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Abstract. The purpose of this study is to test the learning motivation of science instruments and compare the learning motivation of science from chemistry and biology teacher candidates. *Kuesioner Motivasi Sains* (KMS) in Indonesian adoption of the Science Motivation Questionnaire II (SMQ II) consisting of 25 items with a 5-point Likert scale. The number of respondents for the *Exploratory Factor Analysis* (EFA) test was 312. The *Kaiser-Meyer-Olkin* (KMO), *determinant*, *Bartlett's Sphericity*, *Measures of Sampling Adequacy* (MSA) tests against KMS using SPSS 20.0, and Lisrel 8.51 software indicate eligible indications. However testing of *Communalities* obtained results that there are 4 items not qualified, so the item is discarded. The second test, all parameters of eligibility and has a magnitude of *Root Mean Square Error of Approximation* (RMSEA), P-Value for the Test of Close Fit (RMSEA <0.05), *Goodness of Fit Index* (GFI) was good. The new KMS with 21 valid items and composite reliability of 0.9329 can be used to test the level of learning motivation of science which includes *Intrinsic Motivation*, *Self-Efficacy*, *Self-Determination*, *Grade Motivation* and *Career Motivation* for students who master the Indonesian language. KMS trials of chemistry and biology teacher candidates obtained no significant difference in the learning motivation between the two groups.

1. Introduction

Traditional learning methods have failed to help students solve practical problems and improve critical thinking skills. According to some educators, traditional learning methods that are too simple can't improve students' learning motivation compared to student-centered modern learning. Student-centered learning model that can be applied in science learning that provides an authentic experience and student learning motivation such as discovery-based learning, inquiry-based learning, problem-based learning and project-based learning [1,2,3,4,5 6,7,8,9].

The student-centered learning model can make students more active, critical, creative and will gain authentic experience in solving real-world problems as well as showing positive contributions in



enhancing academic success, understanding conceptual knowledge, increasing student interest and motivation [10]. The student-centered learning model is recommended as an effective learning model to be applied in college. Some aspects of improving student learning motivation to the highest level are first, complex, authentic, exciting, relating to the real world; second is that students can choose their task/project completion method, and the third is the Collaboration and teamwork in making decisions [9].

Motivation means encouragement that comes from within and outside of yourself, the desire that leads, the desire that controls and affects behavior for a target or goal. Increasing motivation will improve the effectiveness and efficiency of learning and teaching. But to improve motivation is not always easy because students are social beings who have psycho-social characteristics (different) with each other, so different ways to increase motivation. To motivate students with different individual characteristics in the teaching and learning process is also different ways to increase motivation. When these differences are considered, then motivation becomes an important variable in the learning process. The teaching approach and teaching and learning strategies influence students' learning motivation [11].

Teacher motivation is significant to improve student motivation in the classroom and to reform the better education system. With teacher's motivation will ultimately provide success and satisfaction for students. Motivation has an important role in improving student success in education. This becomes even more important for lessons that include difficult and abstract material, which is difficult to teach and learn [12]. Science teachers (chemistry, biology, and physics) have a very important place in improving students' motivation in learning science. It is very important for these teachers to know their students' feelings and individual learning styles during the learning process [13]. In higher education, it is important to improve the motivation of science learning for prospective science teachers. As a prospective science teacher, students need to have high motivation in learning science and need to be motivated in the teaching process that eventually after graduation they are expected to improve motivation to learn their students.

This study aims to determine the level of science learning motivation to science teacher candidates (chemistry and biology teacher candidates). Therefore, an instrument is needed to measure KMS. KMS before being used as an instrument to measure the level of motivation to learn science need to be tested the accuracy level includes validity and reliability test, so that obtained a fit instrument. Tests conducted are EFA test using SPSS 20.0 and Lisrel 8.51 software. The questions in this study are 1) Does KMS instrument have high validity and reliability as a measure of motivation to learn science, 2) Is there a significant difference between the level of motivation to learn science for prospective science teachers based on differences in the study program.

2. Methods

In this research, because the purpose of this research is to perform KMS testing adopted from SMQ II, it is necessary to test with a large number of respondents. For that, it is determined that the respondents are science teacher candidates from chemistry, biology, and physics education courses) who have taken the course of education, ie, students in the sixth semester. The number of respondents taken as many as 312 teacher candidates. Quantitative statistical evaluation of data collected through questionnaires using SPSS 20.0 and Lisrel 8.51 software to conclude. The KMS that has been tested is then used to determine the level of science learning motivation for chemistry and biology teacher candidates.

2.1. Data collecting instruments

SMQ II is translated into Indonesian and adapted as KMS (consisting of 25 items) consisting of 5 sub-dimensions: intrinsic motivation (5 items), self-efficacy (5 items), self-determination (5 items), grade motivation (5 items) and career motivation (5 items) [13].

2.2 Data analysis

Students of science teacher candidates were given 5 choices in the survey. Items are scored on five-point scale of Likert-type (5 = always, 4 = usually, 3 = sometimes, 2 = rare, 1 = never). The data collected through the survey was tested by EFA using SPSS 20.0 and Lisrel 8.51 software. After the KMS was obtained a fit, then conducted trials of 31 chemistry teacher candidates and 100 biology teacher

candidate FMIPA UNNES. The two groups were then compared using independent t-test analyses to compare the statistical significance of the mean differences between the two groups.

3. Results and discussion

3.1 EFA test results against KMS

KMS instruments adopted from SMQ II need to be tested EFA to see the validity and reliability. The SMQ II instrument with the reliability of 0.82 and the number of items 25 as the main source of the KMS instrument is translated into Indonesian [14]. After passing through several stages of improvement by the research team, KMS was then tested for teacher candidates from chemistry, biology, and physics courses in the 6th semester (assuming they had taken courses on education and teaching). The trial involved 312 respondents at the end of the semester of the academic year 2016/2017. The number of respondents as many as 300 included in the good category [15,16]. EFA test results on KMS using SPSS 20.0 and Lisrel 8.51 software obtained by KMO data of 0.892 (minimum requirement of 0.5) indicating a correlation between interrelated variables (conditions met) [16,17]. The determinant quantity of 5.57×10^{-6} (requirement close to 0) shows the comparison index of the distance between the correlation coefficient with the low partial correlation coefficient [17]. Magnitude Bartlett's Sphericity 3651.408 with Sig. 0.000 (Sig requirement <0.05 (5%)) hence the conditions are met [18]. MSA quantities of 25 items none smaller than 0.5 (MSA > 0.5 requirement) hence the conditions are met. Further test results obtained by the Communalities data of item 7 (0.424), item 16 (0.487), item 19 (0.470) and item 25 (0.451) do not meet the minimum requirement of 0.5. Hence the items must be discarded [17,18]. Since there are 4 items removed, the EFA test must be repeated from the beginning. Hence KMS has only 21 items left. The repetition of the EFA test must be done continuously until it is obtained that the overall data meets the minimum requirements [17].

The second stage of EFA test for KMS obtained results of KMO data amounted to 0.880 which indicates the minimum requirements are met. The determinant quantity of 4.725×10^{-5} indicates the conditions are met. Bartlett's Sphericity 3019.537 with Sig. 0.000 hence minimum requirements are met. The MSA quantity of 21 items is no smaller than 0.5 hence the minimum requirements are met. The magnitude of Communalities of 21 items no one has a price less than 0.5 hence minimum requirements are met. As all requirements have been met, the EFA test on KMS can proceed. Advanced test results on Total Variance Explained (TVE) obtained data that KMS has 5 factors (sub-dimensions) that have Initial Eigenvalue greater than 1 [18]. This means KMS has 5 sub-dimensions with Cumulative% of 65.509%. From TVE data shows that the variant of the first factor has a value of 7.157 out of 21 factors. This first factor can explain 34.079% of the total variance. The second factor was able to explain 9.711% of the total variance, the third factor was able to explain 8.800% of the total variance, the fourth factor was able to explain 7.522% of the total variance, and the fifth factor was able to explain 5.396% of the total variance. The total variance that can be explained by the five factors to the variable used is 65.509% (minimum requirement of 60%, it qualifies). The result of EFA test to KMS further that is Rotated Component Matrix obtained information that there is no item having loading factor amount less than 0.3. The smallest value of the loading factor is 0.513, and no items are experiencing cross loading, i.e. items that have a loading factor in two sub-dimensions with the same amount of loading factor. From the Rotated Component Matrix data, there is 1 item that undergoes a sub-dimensional shift, that is item 15 from the Self-Determination sub-dimension to the sub-dimension of Grade Motivation. Distribution of 21 items of KMS into sub-dimensions obtained are as follows: 1). The sub-dimension of Intrinsic Motivation consists of 5 items (items 1, 2, 3, 4, and 5), 2). The Self-Efficacy sub-dimension consists of 4 items (items 6, 8, 9, and 10), 3). The Self-Determination sub-dimension consists of 4 items (items 11, 12, 13, and 14), 4). The sub-dimension of Grade Motivation consists of 4 items (items 15, 17, 18, and 20), 5). The sub-dimension of Career Motivation consists of 4 items (items 21, 22, 23, and 24).

Further test results include Reproduced Correlations obtained information that there are 51 (24.0%) non-redundant residuals with absolute values greater than 0.05 (terms $<50\%$) [18]. This indicates the KMS instrument is fit. The results of the test using Lisrel 8.51 software obtained information that of the 21 items KMS has a value of t count greater than t table, then the overall KMS instrument items are

considered valid. Testing of Goodness of Fit Statistics obtained information as follows: Degrees of Freedom of 179, Minimum Fit Function Chi-Square of 433.65 ($P = 0.0$), Root Mean Square Error of Approximation (RMSEA) of 0.065, P-Value for Test of Close Fit (RMSEA < 0.05) of 0.0011 and Goodness of Fit Index (GFI) of 0.89.

EFA of testing concluded that the KMS which consists of 21 items and has 5 sub-dimension had been declared fit as an instrument to measure the level of motivation to learn science. The next step is to test reliability. Because KMS consists of 5 sub-dimensions, then the reliability testing can't be done directly but made by testing the reliability of each sub-dimensions and total reliability. Sub-dimensional Intrinsic Motivation has a magnitude of Cronbach's Alpha 0.823 and Variance of 7.724, sub-dimensions of Self-Efficacy has magnitude Cronbach's Alpha 0.791 and Variance of 4.733, sub-dimensions of Self-Determination has a magnitude of Cronbach's Alpha 0.789 and Variance of 5.386, sub-dimensions grade Motivation has a magnitude of 0.846 and Cronbach's Alpha Variance at 6.7561, sub-dimensions of Career Motivation has a magnitude of Cronbach's Alpha Variance 0.854 and amounted to 5.805, and the total variance of 79.749. After the calculation obtained the result that the KMS instrument has a composite reliability value of 0.9329. A full summary of EFA test results against KMS is shown in Table 1.

Table 1. EFA test results against KMS

Testing	Criteria	Results
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)	Greater than 0.5	0.880
Determinant	Small	4.725×10^{-5}
Bartlett's Sphericity	Sig. < 0.05 (5%)	3019.537 Sig. 0.000
Measures of Sampling Adequacy (MSA)	Greater than 0.5	No items with MSA less than 0.5
Communalities	Greater than 0.5	All items > 0.5
Total Variance Explained (TVE)		
1. Initial Eigenvalue	Greater than 1	5 Factors
2. Cumulative %	Min. 60%	65.509%
Sub-dimension KMS	Each sub-dimension is at least 3 items	
1. Intrinsic Motivation		1, 2, 3, 4, 5
2. Self-Efficacy		6, 8, 9, 10
3. Self-Determination		11, 12, 13, 14
4. Grade Motivation		15, 17, 18, 20
5. Career Motivation		21, 22, 23, 24
Reproduced Correlations	Less than 50%	24.0%
Degrees of Freedom		179
Minimum Fit Function Chi-Square		433.65 ($P = 0.0$)
Root Mean Square Error of Approximation (RMSEA)		0.065
P-Value for Test of Close Fit (RMSEA < 0.05)		0.0011
Goodness of Fit Index (GFI)		0.89
Composite Reliability		0.9329

3.2 Comparison of science learning motivation for chemistry and biology teacher candidates

In this subchapter, the findings and interpretations of the findings are obtained as a result of analyzing the collected data. Comparative analysis of different levels of science learning motivation from different study programs presented. The result of a comparative test of science learning motivation level from teacher candidates from chemistry and biology study program is presented in Table 2.

In Table 2, the results of t-test on the level of science learning motivation for chemistry and biology teacher candidates are presented. Statistically, there was no significant difference between the level of science learning motivation from chemistry and biology teacher candidate ($p < 0.05$). The results of KMS, also seen regarding Intrinsic Motivation, Self-Efficacy, Self-Determination, Grade Motivation, Career Motivation, found no statistically significant differences ($p < 0.05$) between chemistry and

biology teacher candidates. From table 2, there is a slight difference in the level of Self-Efficacy of chemistry teacher candidates ($x = 3.645$) and biology teacher candidates ($x = 3.593$), and Career Motivation rates of chemistry teacher candidates ($x = 3.863$) and biology teacher candidates ($x = 3.776$), but statistically the two sub-dimensions were not significantly different ($p < 0.05$).

Table 2. Science learning motivation levels of the science teacher candidates based on their study program differences

Dimension/ Sub-Dimension	Department	<i>N</i>	<i>x</i>	<i>sd</i>	<i>t</i>	<i>p</i>
Science Motivation	Chemistry Education	31	3.840	0.396	0.348	0.728
	Biology Education	100	3.811	0.413		
1. Intrinsic Motivation	Chemistry Education	31	3.929	0.572	-0.048	0.962
	Biology Education	100	3.934	0.486		
2. Self-Efficacy	Chemistry Education	31	3.645	0.527	0.493	0.623
	Biology Education	100	3.593	0.517		
3. Self-Determination	Chemistry Education	31	3.807	0.527	0.013	0.990
	Biology Education	100	3.805	0.547		
4. Grade Motivation	Chemistry Education	31	3.944	0.676	0.225	0.822
	Biology Education	100	3.915	0.598		
5. Career Motivation	Chemistry Education	31	3.863	0.516	0.726	0.469
	Biology Education	100	3.776	0.588		

$p < 0.05$ (significance level)

There are several reasons why the two groups have a science learning motivation that is not different, namely the fact that chemistry and biology teacher candidates have chosen to study in science (chemistry, biology, and physics) since they were in high school, so the desire and interest in scientific study remain high. Also, the curriculum structure in chemistry and biology courses for students at the initial level is almost the same. Chemical students, in addition to studying chemistry also studied biology, physics, and mathematics. Conversely, biology education students, in addition to studying the biological sciences also study chemistry, physics, and mathematics. Another reason is the educational environment (regarding the physical structure of the classroom environment, laboratory, and materials to be used in the classroom), as well as teaching methods in chemistry and biology courses, are almost identical. The results of the level of science learning motivation will be different if the measurements for two different study programs are quite remote as teacher candidates from MIPA and elementary teacher candidates who are both studying science or from two courses the same but from different institutions.

The comparative level of science learning motivation is not done on gender differences, both for teacher candidates from chemistry and biology courses. This is because the number of male teacher candidates is much less than the female teacher candidates. Of the 31 chemistry teacher candidates, there were only 2 men and 29 women, as well as the composition of the biology course was not much different.

4. Conclusion

KMS instruments adopted from SMQ II need to be tested EFA before use, although SMQ II has a high degree of reliability. EFA test results obtained KMS still has 5 sub-dimensions with the number of items to 21. Although there are 4 items that are not used, KMS is still very fit used to measure the level of science learning motivation. This can be seen from the amount of reliability of 0.9329. The result of a comparison test of science learning motivation level between teacher candidates from chemistry and biology study program of FMIPA UNNES showed no significant difference.

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