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Chemistry Motivation of High School Students in Indonesia: Grade Level and Gender Differences

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Abstract: Chemistry motivation is one of the research topics that continues to grow today. This study aims to explore the chemistry learning motivation of high school students in Indonesia with a focus on differences based on gender and student grade. The research method used was a cross-sectional survey using an adapted questionnaire from the Chemistry Motivation Questionnaire II (CMQ II). The research sample consisted of 753 high school students from 9 schools in Yogyakarta and Bengkulu. The results of the validity and reliability analysis of the instrument showed that the CMQ II questionnaire used in this study was valid and reliable. The five dimensions of chemistry learning motivation measured through 25 question items are intrinsic motivation, self-efficacy, self-determination, career motivation, and grade motivation. The two-way ANOVA test was used to analyze significant differences in students' chemistry learning motivation based on gender and grade between populations. The results of quantitative data analysis also show that the interaction between gender and class has a significant difference with a significance level of 0.003, which means that there is a significant difference in students' chemistry motivation based on gender and class.

Keywords: Chemistry motivation questionnaire; Gender difference; Grade level; Learning motivation

Introduction

Motivation is an important part of the learning process (Marpaung, 2021). Students will tend to understand and remember what they learn better if they are motivated to do so. Especially in subjects that are difficult to understand such as chemistry (Cardellini, 2012). Some chemical materials that are categorized as difficult to understand are molecular shapes (Behmke et al., 2018), materials within the scope of organic chemistry (Dwyer & Childs, 2017), chemical kinetics (Stroumpouli & Tsaparlis, 2022), and many more. The main factor causing chemistry to be difficult for students to learn is that most of the material contains visualization, representation, and submicroscopic topics that require high-level reasoning (Berg et al., 2019; Slapničar et al., 2018; Visser et al., 2018). One of the best ways to overcome this is to foster motivation to learn chemistry from within students. Students' enthusiasm and curiosity are the key to successful chemistry learning on difficult topics. That is the most rational reason why teachers must understand student motivation when teaching chemistry in class. The problem is, teachers do not have more time to care about students' chemistry learning motivation. It is undeniable that teachers have a heavy burden of administrative tasks outside of their teaching obligations (Sahito & Väisänen, 2019). Based on researcher observations, teachers tend to focus on teaching without caring about students' attitudes, enthusiasm, and satisfaction when learning chemistry. Even though without motivation, students will not enjoy the learning process, so understanding will not be achieved. Motivation to learn is an absolute requirement of meaningful learning, because both are the main goals of education itself (Rahman, 2022).

Learning motivation is closely related to achievement and learning outcomes (Hidayati et al.,

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2022; Palittin et al., 2019; Rahman, 2022; Sari & Paidi, 2023; Sirait, 2023; Tokan & Imakulata, 2019). Various ways have been done by educators to increase students' motivation to learn science, such as learning modifications and innovations, gamification (Rincón Flores et al., 2016), augmented reality based learning (Lai et al., 2018), interactive e-books (Sung et al., 2018), and many more. Nevertheless, students' learning motivation towards science and chemistry still does not reach expectations. It is no wonder that motivation will always be an interesting research variable to uncover in education. This is also related to the fact that students' interest in learning chemistry decreases as they move up the grades (Molnár & Hermann, 2023; Vedder-Weiss & Fortus, 2012) or in other words, the higher students' education, the lower their motivation towards science. This should raise a big question: "why is this happening? Why is science and chemistry becoming less and less desirable as students grow up?".

Investigation of student learning motivation towards chemistry has been carried out in various countries, ranging from the United States (Austin et al., 2018), Taiwan (Hsieh, 2014), China (Xu et al., 2022), Greece (Salta & Koulougliotis, 2022b), Spain (Ardura & Pérez-Bitrián, 2018) and in other countries. Most of these studies focus on identifying the motivational profile of students in terms of gender and regional origin. In addition, these studies focus more on the adaptation and validation of the Science Motivation Questionnaire II instrument by (Glynn et al., 2011). Another finding comes from research (Souza et al., 2022) which reveals if there are significant differences in motivation between male and female students in Brazil, where female students are more motivated to study chemistry for career reasons. In addition, the academic experience factor also contributes a significant effect on students' chemistry learning motivation (Salta & Koulougliotis, 2015). Factors causing differences in student motivation to learn chemistry certainly vary, not only depending on gender but also the environment and intrinsic factors. It is possible that the teacher's learning method also plays an important role in this, so it is important to investigate more deeply with the right instrument.

There are many instruments used to assess the affective side of students (Abdullah et al., 2021; Dani et al., 2021; Dini et al., 2023; Susilawati et al., 2022), in the context of chemistry motivation a familiar and relevant choice is the Science Motivation Questionnaire II (SMQ II). This questionnaire is free to use and licensed for all science educators, including adapting it in the fields of physics, chemistry, and biology education. In its development, this instrument is based on Bandura's (1986) social-cognitive theory. A theory that posits that learning does not occur due to external influences such as punishment, but through self-observation of the environment. In this context, humans can learn about behaviors, beliefs, concepts, skills, and attitudes (Bandura, 2002), even in online learning. This instrument specifically measures student motivation from various aspects, ranging from aspects of intrinsic motivation, self-efficacy, self-determination, career motivation, and grade motivation (Glynn et al., 2011; Salta & Koulougliotis, 2022b). SMQ II has been widely adapted to various languages in the context of Chemistry Motivation Questionnaire II. Unfortunately, in Indonesia (Huda & Rohaeti, 2023), motivation research with this instrument has not been conducted widely. Some small-scale studies may have been conducted, such as cross-cultural research by Wardhany et al. (2018) and medical education research by (Rahmayanti et al., 2020). Meanwhile, the subject of high school students is still rarely found on a wide scale, let alone those that only focus on chemical motivation. According to the results of previous studies, chemistry learning motivation differs significantly, based on gender differences (Zhang & Zhou, 2023) and differences in students' learning experiences (Ardura & Pérez-Bitrián, 2018; Salta & Koulougliotis, 2022b).

Considering that Indonesia is a vast country, there should be interesting findings in this study. The purpose of this study is to explore students' attitudes and opinions towards learning chemistry in Indonesia. In line with this objective, the main focus of this study is to answer the questions: Does high school students' motivation to learn chemistry differ based on students' gender and grade?

Method

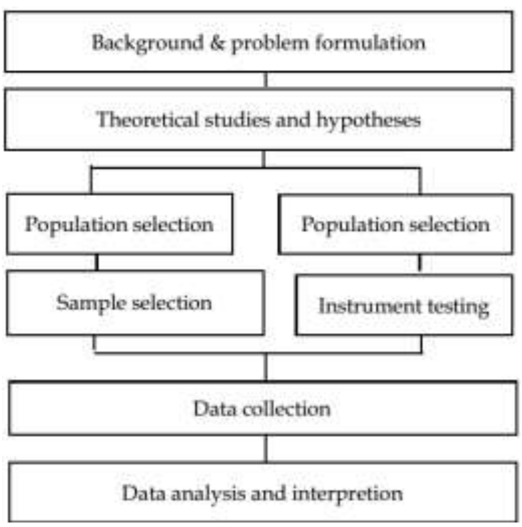

Figure 1. Research flow chart

This research was designed with a quantitative approach based on the survey method. The type of survey used is a cross-sectional survey at one point in time. One of the most popular forms of survey design in education (Creswell, 2012; Huda et al., 2023). The cross-sectional survey type was used because it is in accordance with the research objectives which focus on studying, comparing, and describing participants' attitudes, beliefs, opinions, and behaviors (Dani et al., 2021). This research design was used to examine the motivation of high school students in various schools in Yogyakarta and Bengkulu. The research flow can be seen in figure 1.

The samples of this study were high school students (N=753) in 9 schools in Yogyakarta and Bengkulu. The students were science class students who had studied chemistry. The participants were predominantly male (N=383; 50.9%), while the rest were female (N=370; 49.1%). Some other important characteristics that will be compared are achievement index based on regional origin, age, economic status, study intensity, and additional learning outside school according to the following participant characteristics table:

Table 1. Characteristics of Survey Participants

Attribution	Category	N	Percentage
Gender	Male	383	50.9%
	Famale	370	49.1%
Area of origin	City/municipality	364	48.34%
	Village/remote area	389	51.66%
Level grade	X (tenth grade)	101	13.41%
	XI (eleventh grade)	410	54.45%
	XII (twelfth grade)	242	32.14%
Age	14 years	2	0.26%
	15 years	77	10.23%
	16 years	251	33.33%
	17 years	289	38.4%
	18 years	127	16.9%
	19 years	7	0.93%
Economic status	Top	27	3.58%
	Middle	643	85.4%
	Lower middle	83	11.02%
Learning intensity	Not studying	144	19.12%
	1 hour	328	43.56%
	2 hours	189	25.1%
	3 hours	56	7.4%
	>4 hours	36	4.78%
Additional learning outside of school	Yes	193	25.63%
	No	560	74.37%

Survey Instrument

Data from this study was collected through a valid questionnaire adapted from Glynn et al. (2011). Online and offline forms were completed via Google Form and printed questionnaires. The CMQ II is scored on a Likert scale consisting of 5-point answers (strongly disagree, disagree, neutral, agree, and strongly agree). The adapted CMQ II consists of 25 questions with 5 main aspects, namely: intrinsic motivation, self-efficacy, self-determination, career motivation, and grade motivation.

Data Analysis

The data obtained from Likert scores are used as the basis for assessing the validity and reliability of the instrument with confirmatory factor analysis (CFA) tests based on Goodness of Fit criteria that meet the requirements. The software used is Lisrel version 8.8. Only questionnaire items that have factor loading ≥ 0.5 will be analyzed. While the reliability is calculated with Cronbach alpha, the decision-making criteria are if the Cronbach Alpha coefficient> 0.70, the question is declared reliable or a construct or variable is declared reliable (Ghozali, 2018).

The difference test for several participant characteristics was analyzed and interpreted through the calculation of the two-way anova test through the Statistical Package for the Social Sciences (SPSS) software. If the significance value is ≤ 0.5, it can be said that there is a difference between two or more populations. Before conducting the two-way anova test, the data must be homogeneous with a significance level ≥ 0.05 through the homogeneity test. From the results of the two-way anova test conducted, it can be seen whether there is a significant difference in the perspectives of high school students based on gender. In addition, descriptive analysis was also conducted to interpret the results of the percentage calculation of students' choices of their motivational factors in learning chemistry.

Result and Discussion

The results of the research instrument validity data with valid and reliable categories were obtained for use in data collection. Confirmatory Factor Analysis (CFA) is conducted to analyze whether the instrument construct is still in accordance with the theoretical basis or not (Hair, 2010). The five dimensions measured through 25 question items are: intrinsic motivation (IM), self-efficacy (SE), self-determination (SD), career motivation (CM), and grade motivation (GM). The IM, SE, SD, CM, and GM dimensions each contain 5 questionnaire items. The CFA method was conducted using Lisre 8.80 software.

From the five-factor (dimensional) fit model, all existing items are stated to be valid and nothing must be omitted. Items can only be included in one particular factor if the factor loading is > 0.4 (Azwar, 2004). Another source states that the minimum loading factor for each item is ≥ 0.5 (Hair, 2010). Questionnaire items that have factor loading ≤ 0.5 are eliminated because they are considered invalid. A five-factor (dimension) fit model with 25 questionnaire items was obtained.

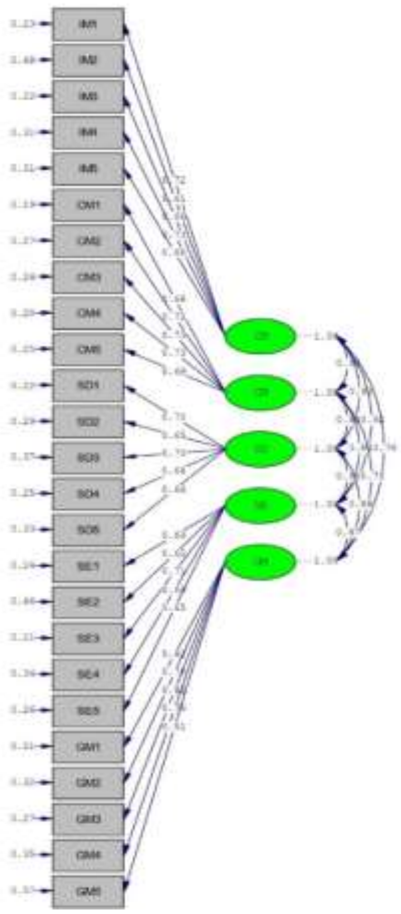

Figure 2. Five-factor (dimensional) model fit

Table 2. Goodness of fit Indicaces CFA Results and Their Cut-Offs

Goodness of Fit Indices	Result	Minimum requirements	Information
Chi-Square	1916.39	Expected small	-
Chisq/df	265	1-3	Fit
RMSEA	0.11	≥ 0.08	Fit
GFI	0.97	≥ 0.90	Fit
NFI	0.95	≥ 0.95	Fit
CFI	0.95	≥ 0.95	Fit
AGFI	0.87	≥ 0.80	Fit

*The minimum criteria for Goodness of Fit indices above are as suggested by (Hair, 2010; Hu & Bentler, 1999).

The results of confirmatory factor analysis state that 25 questionnaire items are valid and significant with loading factors above ≥ 0.5. So that 25 questionnaire items can be used to measure the learning motivation of high school students in chemistry learning. The following is the valid item code, loading factor, and significant value of the adapted instrument.

Table 3. Valid questionnaire items

Code	Item	λ	Sig.
IM1	I enjoy learning chemistry	0.72	0.00
IM2	I am curious about discoveries in chemistry	0.61	0.00
IM3	Learning chemistry makes my life more meaningful	0.66	0.00
IM4	Learning chemistryis interesting	0.62	0.00
IM5	The chemistry I learn is relevant to my life	0.73	0.00
CM1	I will use chemistry problem-sloving skills in my career	0.66	0.00
CM2	My career will involve chemistry	0.72	0.00
CM3	Understanding chemistry will give me a career advantage	0.73	0.00
CM4	Knowing chemistry will give me a career advantage	0.73	0.00
CM5	Learning chemistry will help me get a good job	0.69	0.00
SD1	I study hard to learn chemistry	0.70	0.00
SD2	I prepare well for chemistry tests and labs	0.65	0.00
SD3	I spend a lot of time learning chemistry	0.70	0.00
SD4	I use strategies to learn chemistry well	0.68	0.00
SD5	I put enough effort into learning chemistry	0.66	0.00
SE1	I am sure I can understand chemistry	0.69	0.00
SE2	I believe I can earn a grade of 'A' in chemistry	0.65	0.00
SE3	I believe I can master chemistry knowledge and skills	0.71	0.00
SE4	I am confident I will do well on chemistry labs and projects	0.69	0.00
SE5	I am confident I will do well on chemistry tests	0.65	0.00
GM1	Scoring high on chemistry tests and labs matters to me	0.82	0.00
GM2	I think about the grade I will get in chemistry	0.70	0.00
GM3	It is important that I get an 'A' in chemistry	0.80	0.00
GM4	Getting a good chemistry grade is important to me	0.76	0.00
GM5	I like to do better than other students on chemistry tests	0.61	0.00

The decision-making criteria are if the Cronbach Alpha coefficient >0.70 then the question is declared reliable or a construct or variable is declared reliable(Ghozali, 2018). Factors can only be used when they have a Cronbach Alpha coefficient> 0.70. This means that all of the above factors can be used for further data analysis.

Difference Test with Two-Way Anova

Then, a univariate two-way anova test was conducted to determine the difference in population means. The total score of the questionnaire will be compared with the type of population based on aspects of the independent variables, namely: gender, and class. However, the homogeneity test was conducted first as a condition for the two-way anova test. Data can be said to be homogeneous if the significance value > 0.05. The results of the homogeneity calculation are shown in the following table:

Table 4. Results of Homogeneity Test of Questionnaire Data

		Levene Statistic	df1	df2	Sig.
Motivation	Based on Mean	0.17	1	751	0.68

The Sig. value obtained is 0.683 (>0.05), meaning that the data tested is homogeneous. The data tested qualify for the two-way anova test. The hypothesis of this two-way anova test is; if the sig value <0.05, then it can be said that there is a significant difference between the two types of samples or populations being compared. The two-way anova test conducted produces the following table:

Tabel 5. Two-way Anova Test Results

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	47268.04	5	9453.6	43.73	> 0.001
Intercept	4397914.362	1	4397914.362	20343.57	> 0.001
Gender	141803.679	1	14803.679	68.48	> 0.001
Kelas	11388.573	2	5694.3	26.34	> 0.001
Gender* kelas	2561.248	2	1280.6	5.92	0.003
Error	161487.995	747	216.18		
Total	6265650	753			
Correted Total	208756	752			

a. R Squared = 226 (Adjusted R Squared = 0.221

From the results it can be interpreted that the aspects compared, two variables show significant comparisons, namely: gender aspect with significance level > 0.001 and class aspect with significance level > 0.001. It can be seen from the data analysis that the interaction between gender and class has a significant difference with a significance level of 0.003. That is, there is a significant difference in students' chemical motivation based on gender and class.

Discussion

Adaptation of questionnaires and translations is fundamental when instruments are tailor-made in specific language and cultural contexts, so that they can be applied in different conditions (Beaton et al., 2000). This research has the main objective of studying students' attitudes and opinions towards learning chemistry. For this purpose, the SMQ II was validated, which was originally designed for US university students (Glynn et al., 2011). Therefore, the research presented in this article extends the application of the instrument to high school students with the Indonesian language.

The instrument has 25 questions that were translated into Indonesian. Based on the CFA analysis conducted, it was shown that all questionnaire items were valid with loading factor values > 0.5. The reliability of the questionnaire was also found to be high with Cronbach's alpha > 0.7. The results of this analysis can be said to be the same as previous studies conducted in various countries, such as those conducted by Ardura & Pérez-Bitrián (2018) in Spain, Zhang et al. (2023) in China, and Souza et al. (2022) in Brazil.

The results obtained overall from the two-way Anova analysis show that there is a significant difference in learning motivation between male and female students of Indonesian high schools. This suggests that gender is one of the independent variables to consider in chemistry motivation research. Some literature states that women are more motivated to learn chemistry than boys (Salta & Koulougliotis, 2022). This is due to chemistry learning which is dominated by the provision of theory, not practice in the laboratory (Mulyatun, 2013). This means that male students are more motivated by chemistry when learning in the laboratory (practicum, experiment, or experiment). Most likely, men tend to be more challenged by learning that is practical or takes action, not theory. Another factor that causes chemistry motivation to differ based on gender is the characteristics of chemistry materials. Chemistry is a material that requires higher-level thinking (Romandona & Adila, 2020), where such things are preferred by women rather than men, especially in the context of chemistry learning in Indonesia.

Another independent variable analyzed in this study is class difference. Statistically, the chemistry motivation of high school students turned out to be different. This means that students in grades X, XI, and XII have different motivations when learning chemistry. The statistical fact is supported by the fact that chemistry learning tends to be interesting at the beginning. That is, the higher their class, the less motivated they are to learn chemistry. Another factor that causes class differences to affect students' chemistry motivation is teacher differences. In some schools where this study took place, chemistry teachers in class X are different from class XI, as well as class XII. These teacher differences certainly affect the motivation to learn chemistry (Lestari & Maharani, 2019). Each teacher has their own teaching characteristics. There are teachers who are rigid, fun, and even temperamental. It is this teacher's learning that affects the chemistry motivation of high school students. Participants in this study consisted of various schools. This certainly also affects student motivation, because not all schools have complete facilities to support chemistry learning. The facilities in question could be an experimental laboratory (Yuliana et al., 2017), learning media (Prasetyo et al., 2015), and others. Schools that have a complete laboratory can certainly be more competent to create a more interactive and applicative chemistry learning atmosphere, so that students' chemistry motivation is higher than schools that do not have a complete lab. Basically, in this digital era, laboratory learning can be replaced by a virtual laboratory (Sugiharti & Sugandi, 2020). So that students can get chemistry experimental material even though they do not enter the laboratory.

Conclusion

The results obtained from confirmatory factor analysis and Cronbach Alpha reliability calculations provide support for the application of the Indonesian version of the CMQ-II to measure chemistry learning motivation among high school students in Indonesia, especially in the Bengkulu and Yogyakarta regions. Quantitative analysis of valid questionnaire data showed that there is a significant difference in learning motivation between male and female high school students in Indonesia. Another independent variable analysed in this study is class difference. The results of quantitative analysis also show that there are differences in chemistry learning motivation of high school students according to class differences. This research is expected to contribute to the investigation of students' chemistry motivation in Indonesia.

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Author Contributions
T.S.: Conceptual, methodology, format analysis, investigation, data curation, writing original draft preparation, and.writing review and editing. .S: resources, validation, data curation, rormal analysis, writing review and editing. N.H.: methodology, resources, data curation, writing original draft preparation, and.writing review and editing. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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