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THE EFFECTS OF CURRICULUM, GENDER AND STUDENTS' FAVORITE SCIENCE SUBJECT ON INDONESIAN HIGH-SCHOOL STUDENTS' CONCEPTIONS OF LEARNING SCIENCE

Arif Rachmatullah,
Sariwulan Diana,
Minsu Ha

Abstract. *Conceptions of learning have been known as having influence on students' learning outcomes, the one of which is science learning as to be a scientifically literate person. Even, the effects of students' conceptions in learning have been known, but the contributing factors are still vague. This research aims to explore Indonesian high-school students' conceptions of learning science (COLS), to find out if gender and students' favorite science subject cause differences in their COLS, and to validate the COLS instrument by using Rasch analyses. Thirty-one items measuring six COLS were administered to 609 Indonesian high-school students. Rasch analyses, an independent sample t-test, analysis of variance (ANOVA), and cluster analyses featuring chi-square tests of interdependence were used to answer the research questions. Based on the analyses, it was found that the COLS instrument was best fitted as six-dimensional. Gender difference was emerged in memorizing, and differences based on students' favorite science subject were also found in memorizing and calculating and practicing. Finally, the results of cluster analyses showed that Indonesian students were divided into three different classes based on their COLS, and that the clusters were significantly related to the school locations.*

Keywords: *conceptions of learning science, gender, Indonesia, science learning, secondary level.*

Arif Rachmatullah
Kangwon National University, Republic of Korea
Sariwulan Diana
Indonesia University of Education, Indonesia
Minsu Ha
Kangwon National University, Republic of Korea

Introduction

For more than a century of research, students' cognitive aspects when learning have been scrutinized in the fields of educational studies, cognitive sciences, and psychology. In science education, students' cognitive constructs have been recognized because of the association issue with the science contents that are well known to need more cognitive processing when being learned. In addition, they are also being scrutinized because, in this century, people believe that persons who have higher level cognition in science can be more valuable and efficient workers (DeBoer, 2000). Nevertheless, in the last few decades, researchers in various education-related fields have found out that there is an affective aspect that equally contributes to students when they are learning. Many have suggested (e.g. Osborne, Simon & Collins, 2003; Schumm & Bogner, 2016; Thompson & Mintzes, 2002; Vermunt, 1996; Watts & Alsop, 2000) that students' affective aspects can also positively or negatively influence the students' cognitive constructs. Therefore, recently the research of students' affective aspects when learning has been rapidly increasing. Among students' affective aspects when learning science, studies on motivation in learning science (e.g., Glynn, Taasoobshirazi & Brickman, 2009; Lee, Hayes, Seitz & O'Conner, 2016; Schumm & Bogner, 2016) and self-efficacy in learning science (e.g., Robnett, Chemers & Zurbriggen, 2015; Wang, Tsai & Wei, 2015) have been the most prevalent, while there are few studies of conceptions of learning science.

"Conceptions of learning science" refers to how students conceive of their science learning based on their experiences (Chiou, Liang & Tsai, 2012; Sadi & Uyar, 2013; Tsai, 2004; Vermunt & Vermetten, 2004). Buehl & Alexander (2001) and Tsai (2004) noted that conceptions of learning are related to students' academic epistemological beliefs. Even though there have been few studies of students' conceptions of learning science, compared to other affective aspects, earlier studies have noted that students' conceptions of learning science are highly correlated with their academic outcomes (Allan, 2003; Dart et al., 2000; Pillay, Purdie & Bopulton-Lewis, 2000; Purdie, Hattie & Douglas, 1996; Sinatra,

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2001) and cognitive strategies (Hong & Salili, 2000; Purdie, Hattie & Douglas, 1996). In addition, Tsai, Ho, Liang & Lin (2011) noted that students' conceptions of learning science are a crucial part of the affective aspects of learning that can offer more insight into the way students learn science. Thus, it could show how a science curriculum has been implemented in the perspective of learners, which can be considered an attempt to evaluate the science curriculum.

In Indonesia, in 2013 a new curriculum was implemented in some regions, and in 2015 all Indonesian schools implemented it. To date, around four years after the implementation of the 2013 curriculum, there have been few studies conducted to evaluate this new curriculum, especially in the field of science subjects. This new curriculum is focused on increasing students' scientific literacy, as a response to various international reports, such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) (Mendikbud, 2016). The reports from PISA and TIMSS noted that Indonesian students' science literacy in the few last decades has always been in the bottom tenth among participating countries (Mullis, Martin, Foy & Hooper, 2016; OECD, 2016). As some studies of conceptions of learning science mentioned earlier have noted that it is related to science achievements which is one of them is science literacy, by conducting this research, it can measure how far along the implementation of this new science curriculum is. Thus, based on the findings later, it can be used to suggest what efforts are needed to change students' conceptions of learning science. As Gummer & Shepardson (2001) have suggested, changes in students' conceptions of learning in a specific subject are not aimed only at obtaining better concepts, but also at producing coherence between two important aspects, learning and assessments. It also should be noted here that one finding from the refining of the science curriculum in Turkey has shown that a better revised science (biology) curriculum has highly influenced the students' conceptions of learning towards the subjects (Sadi & Lee, 2017).

Besides the influence of curriculum on students' conceptions of learning science, some factors were also found to significantly contribute to students' conceptions of learning science, particularly gender (e.g., Den Brok, Telli, Cakiroglu, Taconis & Tekkaya, 2010; Lonka & Lindblom-Ylänne, 1996; Sadi & Çevik, 2016) and the specific domain of science subjects (e.g., Buehl & Alexander, 2001; Lin, Liang & Tsai 2015; Sadi & Lee, 2017; Sadi, 2015; Tsai, 2006). In terms of the gender issue in cognitive and affective aspects of learning science, Severiens & Dam (1997), in their research of gender differences in learning styles, have pointed out that the differences in learning and learning outcomes are derived from the inequality in learning environments that may result from teachers' and society's stereotyping of gender. In fact, UNESCO and OECD have reported that in the field of Science, Technology, Engineering, and Mathematics (STEM), Indonesia was identified as one of the countries that have the most equality in gender (OECD, 2015; UNESCO, 2015). The UNESCO and OECD reports have motivated the current research to scrutinize whether gender differences exist in Indonesian high-school students' conceptions of learning science or not. Another issue brought out in current research is about the differences in domain-specific science. Chiou, Liang & Tsai (2012), Lee, Johanson & Tsai (2008), and Tsai (2004) have noted that students' conceptions of learning science differ from the different domains of science; so the measurement should be handled differently and aimed more specifically toward different science subjects. That is, if we want to understand students' concepts about learning biology, the instrument should be only focused on biology (Sadi & Lee, 2017). But, since some studies of students' views toward science have found differences based on different students' majors (e.g., Perkins, Barbera, Adams & Wieman, 2007), hypotheses are established on when students are being asked about their conceptions about science learning in general, their conceptions would be based on their favorite science subjects, because the image of science conceived by students is closely related to their favorite subject. In fact, science in an Indonesian upper-secondary level is divided into three branches, namely, Biology, Chemistry, and Physics. Entwistle & Tait (1990) have also suggested that students differ in their approaches to learning based on their preferred or favorite course. Therefore, current research also attempts to find out whether differences in conceptions of learning science are based on students' favorite science subjects or not.

Literature Review

Conceptions of Learning Science

The term "conceptions of learning" was first used by Säljö (1979) in the study on interviewing adults with different levels of education about their experiences; one of the questions was 'what they think about learning'. Many have followed Säljö's study, and the exact definition of "conceptions of learning" has been established, specifically related to science subjects. The conceptions of learning science are defined as the learner's beliefs and knowledge about learning science and about the context of learning science (e.g., learning tasks, activities, and strategies) that were established based on their experiences, leading to their interpretation, framing, and reflection on those learning science experiences (Chiou, Liang &Tsai, 2012; Lai & Chan, 2005; Liang & Tsai, 2010; Lee, Lin & Tsai, 2013; Vermunt & Vermetten, 2004). In the first study of conceptions of learning conducted by Säljö (1979), five conceptions were found: (1) increasing knowledge, (2) memorizing, (3) acquiring facts and methods, (4) abstraction of meaning, and (5) interpretative process intended to understand the reality. Some have found new conceptions of learning held by students (e.g., Marton, Dall'Alba & Beaty, 1993; Marshall, Summer & Woolnough, 1999), but there were no studies of conceptions of learning in science subjects, until the study conducted by Tsai (2004).

In the field of science, Tsai (2004) suggested seven kinds of conceptions based on his phenomenographic study of 120 Taiwanese high-school students. Those seven conceptions were concisely summarized by Lee, Johanson & Tsai (2008) as follows:

1) memorizing (e.g., learning science is memorizing definitions, formulae, and terms in science textbooks),
2) testing (e.g., learning science is viewed as a way to pass science exams and obtain high science scores),
3) calculating and practicing (e.g., learning science is regarded as practicing on solving science problems and manipulating numbers and formulae),
4) increasing knowledge (e.g., learning science is viewed as one's acquisition of scientific knowledge),
5) applying (e.g., learning science is perceived as generalizing the obtained scientific knowledge into other types of unknown problems),
6) understanding (e.g., learning science means integrating the consistent theories of science) and
7) seeing in a new way (e.g., learning science is perceived as obtaining new perspectives towards the acquired scientific knowledge which later can be used to interpret natural phenomena in a new way). (p. 198).

The last conception – seeing in a new way - was rarely possessed by students. Therefore, in the later study of Lee, Johanson & Tsai (2008), who conducted a study on validating the instrument used to measure conceptions of learning science (COLS), that seventh conception was merged with the understanding dimension, and formed the 'understanding and seeing in a new way' conception. This merging of conceptions, whereby understanding is placed in the highest hierarchy of concepts, is also supported by Biggs (1994), who argued that learning should be concerned with connecting new knowledge to earlier knowledge to establish the understanding held by learners.

For the higher categorization of conceptions of learning, whether learning in general or specifically in science, Marton, Dall'Alba & Beaty (1993), later supported by Tsai (2004), stated that those five, six, or seven conceptions of learning are categorized into two distinct groups: reproductive and constructivist. Both of these studies suggested that students who hold the first three conceptions of learning be recognized as the reproductive group, who view learning only quantitatively, that is, as just acquiring and accumulating knowledge. In contrast, students who hold the remaining three or four higher conceptions are categorized as constructivists, who conceive of learning qualitatively, not seeing learning as the outcome/achievements solely, but as how they can understand the knowledge and apply it in their lives. That is why Tsai et al. (2011) argued that constructivist students are more intrinsically motivated or more oriented toward mastery.

The framework and assessment of conceptions of learning suggested by Tsai (2004) and Lee, Johanson & Tsai (2008) are used in current research. But to date, there is no research of COLS which has used Rasch analysis, which is the method suggested by Lee, Johanson & Tsai (2008), because they did not test the COLS instrument by using that method when they developed the instrument. Thus, this research also aims to uncover whether the COLS instrument is a best fit in the Rasch model or not. It also should be noted here that Rasch analysis is emphasized for use in validating the science education instrument (Boone, Townsend & Staver, 2011; Johnson & Sondergeld, 2014; Romine, Walter, Boose & Todd, 2017).

The Indonesian 2013 Science Curriculum

In 2013, a new science curriculum was published and implemented in Indonesia and then revised at the minor level in 2016. Despite the 2016 revision, the contents of the curriculum are still the same. As aforementioned, this new curriculum 2013 is one effort by the Indonesian government to respond to international reports, such as PISA and TIMSS, about to the low level of science literacy achieved by Indonesian students during recent decades. Thus, the main goal of this new curriculum is to improve Indonesian students' science literacy in international assessment (Mendikbud, 2016). There are several new points of this curriculum, especially in terms of learning and assessment.

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First, this new curriculum brings up the notion of 'one subject for all competencies,' which means that one subject, for instance, science, should not only increase knowledge (cognitive domain) more than the previous curriculum had, but also should cover skills and attitudes. Thus, the way to assess students has also changed, from the previous one of just testing students to measure their knowledge, but now to also measure their skills and attitudes and this effort leads to the decrease in frequency of testing. In fact, whereas the national examination was the main way in which students were judged as ready for graduation from high school, now schools want to find out how good the attitudes of the students are in order to decide whether students can graduate or not. That is, in this new curriculum, attitude is most important.

The second aspect is that all subjects, not only science, should be taught by employing a scientific approach. This is an effort to increase students' science literacy by emphasizing the connection of science with other daily-life concerns. Teachers are encouraged to use teaching methods that are closely related to a scientific approach, such as problem-based and project-based learning, and using discovery learning rather than traditional methods. Finally, a combination of the "Structure of Observed Learning Outcome (SOLO) Taxonomy" suggested by Biggs & Collin (1982) and Bloom's Taxonomy is used as the framework for developing students' knowledge, skills and attitudes. The use of those taxonomies as a framework allows the teaching methods in high school to focus not on the lower levels of cognitive process or surface knowledge, such as remembering facts and terms, but on applying (C3 Bloom) and analyzing (C4 Bloom), which focus more on constructed knowledge, as suggested by Biggs & Collin (1982).

Research Questions

Based on the background and descriptions above, three research questions as the focus of the current research are as follows:

1. How well does the conceptions of learning science (COLS) instrument perform in the sample of Indonesian high-school students based on Rasch analyses?
2. Do students' conceptions of learning science differ by gender and favorite science subject?
3. How do Indonesian high-school students conceive of their science learning?

Methodology of Research

General Background

The current research was conducted by using the principle of quantitative survey method. The data were collected through the research process to examine Indonesian upper-secondary level students' conceptions of learning science. The survey was carried out starting from March to May 2017 to upper-secondary level students in West Java province, Indonesia.

Participants

The data on Indonesian high-school students' conceptions of learning science were gathered from students in eight high schools that differed in their accreditation level (from A to C level), school type (Islamic-based and general type), and location in four different cities. The total number of participants was 609 students. The participants also differed in their high-school grade, from first year to third year, but predominantly were in the first and second years, because the third-year students were preparing for the national examination and so, many could not participate. Demographically, the participants were 37% male and 63% female, but two students did not indicate their gender. In religion, 98% of the participants were affiliated with Islam.

For the third research question, data on the students' favorite science subjects were gathered by asking them to choose one of the three science branches, biology, chemistry, and physics; Indonesia does not provide earth and space science as a school science subject. Of the 609 students, 25 students (around 4%) did not indicate their preference in science subject. It was found that 59% chose Biology, 29% participants liked Chemistry, and the rest (12%) liked Physics. The participants who liked Biology were 66% female, participants who liked Chemistry were 67% female, and students who liked Physics were 57% male.

Instrument

The instrument administered to the participants in this research was 31-item measuring conceptions of learning science (COLS) developed by Lee, Johanson & Tsai (2008). The measurement was developed based on the research of Tsai (2004) on exploring Taiwanese high-school students' conceptions of learning science through phenomenographic research. The instrument measures six types of conceptions of learning sciences: memorizing (M), testing (T), calculating and practicing (CP), increasing one's knowledge (IOK), applying (A), and understanding and seeing in a new way (US), as described earlier in the literature review section. The instrument was a Likert-scale type whereby students were asked to choose answers ranging from 1 (strongly disagree) to 5 (strongly agree) indicating how much they agreed with each statement.

When Lee, Johanson & Tsai (2008) were developing the COLS instrument, they used classical test theory (CTT) for validating the instrument, but recently the use of the Rasch model for validating instruments is rapidly being emphasized in the field of science education (Boone, Townsend & Staver, 2011; Johnson & Sondergeld, 2014; Romine et al., 2017). Therefore, one goal of current research is to validate the COLS instrument by using Rasch analyses, such as the multidimensionality of the instrument, which is considered to be the decisive issue for an instrument (Boone, Townsend & Staver, 2011; Romine et al., 2017). In order to find out the best model of the COLS instrument based on dimensionality, the method suggested by Adams & Wu (2010) and Bond & Fox (2015) was used, by comparing the value of the Akaike Information Criterion (AIC) and the final deviance of the comparable models. Six dimensions of COLS based on Lee, Johanson & Tsai (2008), two dimensions of COLS based on the reproductive-constructivist idea, and COLS as one dimension were compared to find the best model of the instrument. A five-dimensions model, based on factor analysis (Appendix 1) of the Indonesian data in which US and A were loaded together in the same factor (eigenvalues = 1.50, percentage of variance = 4.84, cumulative percentage = 52.21) was also added as the comparable model. Thus, those four models were compared, and the best model based on the smaller AIC and final deviance was selected.

The benchmark suggested by Wright & Linacre (1994) was employed to identify misfitting items based on weighted (infit) MNSQ and unweighted (outfit) MNSQ. The benchmark for rating scale items indicated good item-fit ranges from 0.6 to 1.4. Furthermore, the benchmark suggested by DeVellis (2003) was used on interpreting reliability values (Cronbach's alpha, plausible value (PV) reliability, and separation/item reliability), by considering coefficient values above .80 as 'very good', between .70 – .80 as 'respectable', between .60 to .69 as 'undesirable but minimally acceptable,' and below .60 as 'unacceptable.'

Data Analysis

Prior to the main analysis, factor analysis with Varimax rotation was performed to identify the number of COLS factors based on Indonesian high-school data. In order to conform in more detail to the number of COLS factors, multidimensional Rasch analyses were used, as mentioned above. Multidimensional Rasch analyses were performed by utilizing software called ACER ConQuest version 4.5. Once Rasch analysis was run, a set of values for every student was also obtained. This set of values is called plausible value (PV), or person measure, or person ability, indicating a Rasch logit score for every student in every COLS construct. Thus, every student had six values of PV, and one for a construct of COLS. These PVs were in the form of an interval scale, which is required to fulfill the assumptions of further statistical analysis, especially parametric tests. These six PVs were used for further statistical tests. The Pearson correlation tests were run to find out the correlations between COLS constructs. In addition, gender differences in COLS were explored by performing an independent sample test, while differences in COLS based on students' favorite science subject were explored by means of a one-way ANOVA test followed by Tuckey HSD as a *post hoc* test. The statistical analyses were performed in SPSS version 22.

A cluster analysis was used to uncover how Indonesian students conceive of their science learning, as addressed in the third research question. Another purpose for using this cluster analysis was to find out how many types of Indonesian students there were based on their conceptions of learning science. One package for analysis-based multivariate clustering called *mclust* from R-software environment was used to cluster the students. The fundamental process of mclust is to find out the number of clusters by using the interval-scale data (Scrucca et al., 2016), which in current data were PVs. The mclust process provided a Bayesian Information Criterion (BIC) value of 14 models of data; the best model for the Indonesian data was identified by using the smallest BIC value. After the best model and the number of clusters were found, every student was also automatically assigned to his or her own cluster.

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Later, in order to investigate the characteristics of every cluster, Pearson chi-square tests were also performed by employing gender, students' favorite science subjects, and school location (inside and outside the capital city of the province) as the independent variables. School location was selected, because there were different periods of new Curriculum 2013 implementation, and the capital city of the province was the first.

Results of Research

COLS Construct Based on the Multidimensional Rasch Model

The results from multidimensional Rasch analyses that aimed to find the best model of the Indonesian students' COLS data are shown in Table 1. As shown, the final deviance and AIC values of the six-dimension model were smaller (FD = 37596.76, AIC = 37706.76) than other comparable models: the one-dimensional (FD = 39734.79, AIC = 39804.79), two-dimensional (FD = 38695.67, AIC = 38769.67), and five-dimensional (FD = 37620.64, AIC = 37718.64). It indicated that the COLS instrument is better treated as six-dimensional. Furthermore, the six-dimensional model of COLS is also suggested by the item fits, reliabilities, and number of misfitting items, shown in Table 2.

Table 1. Results from multidimensional Rasch analyses.

COLS Model	Final Deviance (FD)	AIC	χ^2	df	p-value
One Dimension	39734.79	39804.79	6522.21	30	.01
Two Dimensions	38695.67	38769.67	5761.03	29	.01
Five Dimensions	37620.64	37718.64	5183.76	26	.01
Six Dimensions	37596.76	37706.76	5191.55	25	.01

It can be seen, from Table 2, that the memorizing construct (M) had weighted and unweighted MNSQ that ranged from 0.98 to 1.43 and 0.99 to 1.42, respectively. In this memorizing construct, one misfitting item (M3) was found. For the testing construct (T), the ranges of MNSQ were 0.93 to 1.48 and 0.97 to 1.46, and there was one misfitting item, T3. The four remaining COLS constructs were found better fitted to the Rasch Model than memorizing and testing were, because they had no misfitting item. The ranges of MNSQ for calculating and practicing (CP) were 0.81 to 1.33 and 0.82 to 1.31; for increasing one's knowledge (IOK) were 0.87 to 1.15 and 0.81 to 1.19; for applying (A) 0.73 to 1.18 and 0.72 to 1.22; and for understanding and seeing in a new way (US) were 0.72 to 0.90 and 0.70 to 0.92. Moreover, the reliability values (alphas and Rasch) were also in the level of respectable instrument.

Table 2. Cronbachs' alpha (α) and Rasch item-fits and reliabilities.

COLS Constructs	α if Item Deleted	α	Measure	Weighted MNSQ	Unweighted MNSQ	PV Reliability	Separation Reliability	Number of Misfitting items
M	.620 ~ .668	.701	–0.239 ~ 0.142	0.98 ~ 1.43	0.99 ~ 1.42	.723	.994	1
T	.588 ~ .693	.684	–1.517 ~ 1.558	0.93 ~ 1.48	0.97 ~ 1.46	.734		1
CP	.760 ~ .810	.812	–0.228 ~ 0.087	0.81 ~ 1.33	0.82 ~ 1.31	.809		0
IOK	.711 ~ .787	.783	–0.581 ~ 0.836	0.87 ~ 1.15	0.81 ~ 1.19	.801		0
A	.709 ~ .775	.785	–0.252 ~ 0.302	0.73 ~ 1.18	0.72 ~ 1.22	.859		0
US	.797 ~ .836	.838	–0.289 ~ 0.391	0.72 ~ 0.90	0.70 ~ 0.92	.840		0

Correlations among COLS Construct

To find the correlations between COLS constructs, Pearson correlation tests were performed; the results are shown in Table 3. Based on the results, it was found that memorizing was positively correlated ($p < .01$) with testing ($r = .312$), calculating and practicing ($r = .376$), increasing one's knowledge ($r = .339$), applying ($r = .319$), and

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understanding in a new way (r = .367) in the low-middle level. Besides being positively correlated with memorizing, testing was positively correlated with CP in the low level ($r = .190$), but not significantly correlated ($p > .05$) with IOK ($r = .029$), A ($r = .028$), and US ($r = .024$). Calculating and practicing was weakly positively correlated with IOK ($r = .289$) and CP ($r = .383$), while moderately correlated with A ($r = .438$). Furthermore, the constructivist constructs were moderately and highly correlated with one another: IOK and A ($r = .548$), IOK and US ($r = .529$), A and US ($r = .640$).

Table 3. Correlation coefficients among COLS construct.

	T	CP	IOK	A	US
M	.312‡	.376‡	.339‡	.319‡	.367‡
T	1	.190‡	**.029**	**.028**	**.024**
CP		1	.289‡	.438‡	.383‡
IOK			1	.548‡	.529‡
A				1	.640‡
US					1

‡ $p < .01$, † $p < .05$

Gender Differences in COLS

In comparing COLS based on gender, it was found that in memorizing, females were higher ($M = 1.89$, SD = 1.59) than males ($M = 1.48$, SD = 1.62). In the calculating and practicing and understanding and seeing in a new way, females ($M = 2.58$, SD = 2.31 and $M = 3.03$, SD = 2.19, respectively) were also slightly higher than males ($M = 2.40$, SD = 2.18 and $M = 2.77$, SD = 2.49, respectively). It was found that males were slightly higher in testing ($M = -0.39$, SD = 1.25), increasing one's knowledge ($M = 3.12$, SD = 2.25), and applying ($M = 2.66$, SD = 2.78) than females ($M = -0.44$, SD = 1.11; $M = 2.99$, SD = 2.11 and $M = 2.62$, SD = 2.49, respectively). The differences in terms of gender are shown in Figure 1.

The independent sample *t*-test did not reveal many statistically significant gender differences. Based on the findings, significant gender difference was found only in memorizing (t(608) = –3.06, $p < .01$) with a small effect size (d = 0.26), but gender differences in testing (t(608) = 0.48, $p > .05$, d = 0.04), calculating and practicing (t(608) = –0.97, $p > .05$, d = 0.08), increasing one's knowledge (t(608) = 0.72, $p > .05$, d = 0.06), applying (t(608) = 0.19, $p > .05$, d = 0.02), and understanding (t(608) = –1.33, $p > .05$, d = 0.11) were not statistically significant.

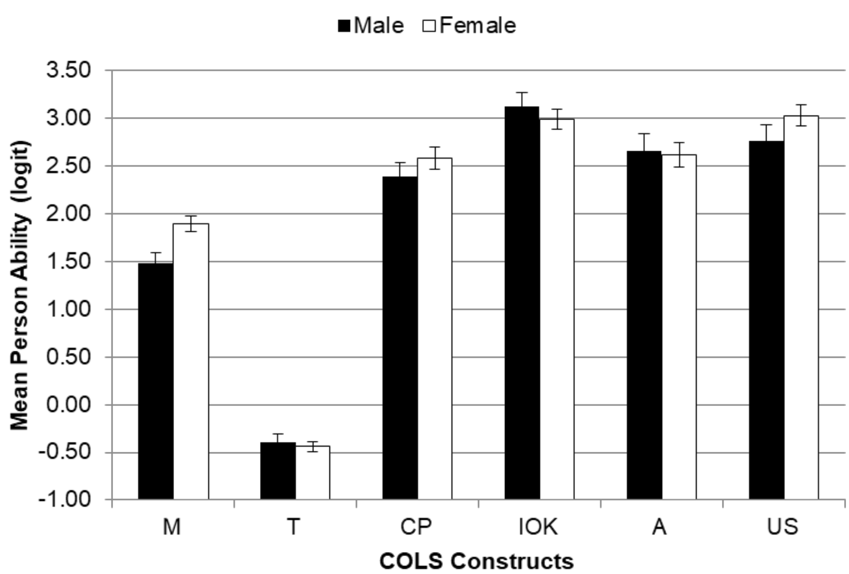

Figure 1: Gender differences in COLS constructs.

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The Influence of Favorite Science Subject on COLS

The mean differences of every COLS construct based on students' favorite science subject are shown in Figure 2, which reveals that students who liked biology (M = 1.80, SD = 1.61) and chemistry (M = 1.80, SD = 1.54) were higher in memorizing than those students who liked physics (M = 1.30, SD = 1.82). In testing, students who liked chemistry (M = –0.37, SD = 1.20) had higher means than students who liked biology (M = –0.401, SD = 1.100) and physics (M = –0.68, SD = 1.38). In contrast, for calculating and practicing, students who liked physics (M = 3.13, SD = 2.29) were higher than students who liked chemistry (M = 2.89, SD = 2.07) and biology (M = 2.19, SD = 2.230). Similar to the findings from testing, in the increasing of knowledge construct and understanding construct, students who liked chemistry (M = 3.12, SD = 2.02 and M = 3.13, SD = 2.29, respectively) were slightly higher than students who liked biology (M = 3.06, SD = 2.23 and M = 2.93, SD = 2.29, respectively) and physics (M = 3.03, SD = 2.18 and M = 2.87, SD = 2.59, respectively). On the contrary, in term of applying, students who liked physics (M = 2.83, SD = 2.91) had higher means than those who liked chemistry (M = 2.76, SD = 2.254) or biology (M = 2.62, SD = 2.64).

A one-way ANOVA test was performed to find out the effect of students' favorite science subjects on their conceptions of learning science. Based on the findings, any significant effect of students' favorite science subjects on testing (F[2, 581] = 1.96, p > .05, ηp^2 = 0.01), increasing one's knowledge (F[2, 581] = 0.06, p > .05, ηp^2 = 0.001), applying (F[2, 581] = 0.32, p > .05, ηp^2 = 0.001), or understanding (F[2, 581] = 0.51, p > .05, ηp^2 = 0.002) were not obtained. But, significant effect of students' favorite science subjects on memorizing (F[2, 581] = 3.07, p < .05, ηp^2 = 0.01) and calculating and practicing (F[2, 581] = 8.65, p < .01, ηp^2 = 0.03) were found in current research. It can be seen, based on the *post hoc* test provided in Appendix 2, that in memorizing, students who liked biology and chemistry were significantly higher (p < .05) than those who liked physics. In contrast, students who liked physics and chemistry were significantly higher on calculating and practicing than those who liked biology (p < .01).

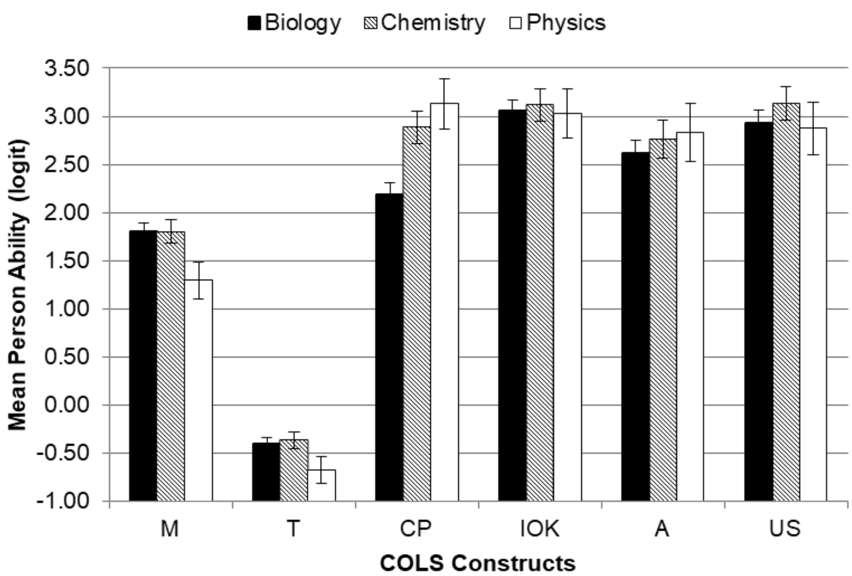

Figure 2: Students' favor science subject differences in COLS constructs.

Indonesian High-school Students' COLS based on Clustering Results

Based on results computed through *mclust*, Indonesian high-school students were clustered into three different groups. This three-class result was obtained based on the smallest BIC of the mclust model, provided in Appendix 3. The data were best fitted to the VVE model, which indicated an ellipsoidal and equal orientation data type (see Fraley & Raftery, 2002); the BIC value was –13851.5 and was considered to be the smallest value. Characterization and naming were done to every student's class by considering the highest three means of conceptions; the results are shown in Figure 3.

Class 1, which included 9.7% of the participants (59 students), had the highest mean for applying (M = 2.69, SD = 0.87), increasing one's knowledge (*M* = 2.34, SD = 0.52), and calculating and practicing (*M* = 2.26, SD = 0.68). Based on these characteristics, in this paper it is called as Transitional Constructivist (TC). Class 2, which had the most assigned members (67.7%, around 406 students) had its three highest means on increasing one's knowledge (*M* = 2.71, SD = 1.73), understanding (*M* = 2.46, SD = 1.67), and calculating and practicing (*M* = 2.27, SD = 2.02). This second class was named as Transitional Reproductive (TR). The Class 3 was named fully Constructivist (fC), because it had the two constructivist conceptions – understanding (*M* = 4.52, SD = 3.32) and applying (*M* = 4.31, SD = 3.57) – as its highest means and was also characterized by increasing one's knowledge (M = 4.30, SD = 3.02).

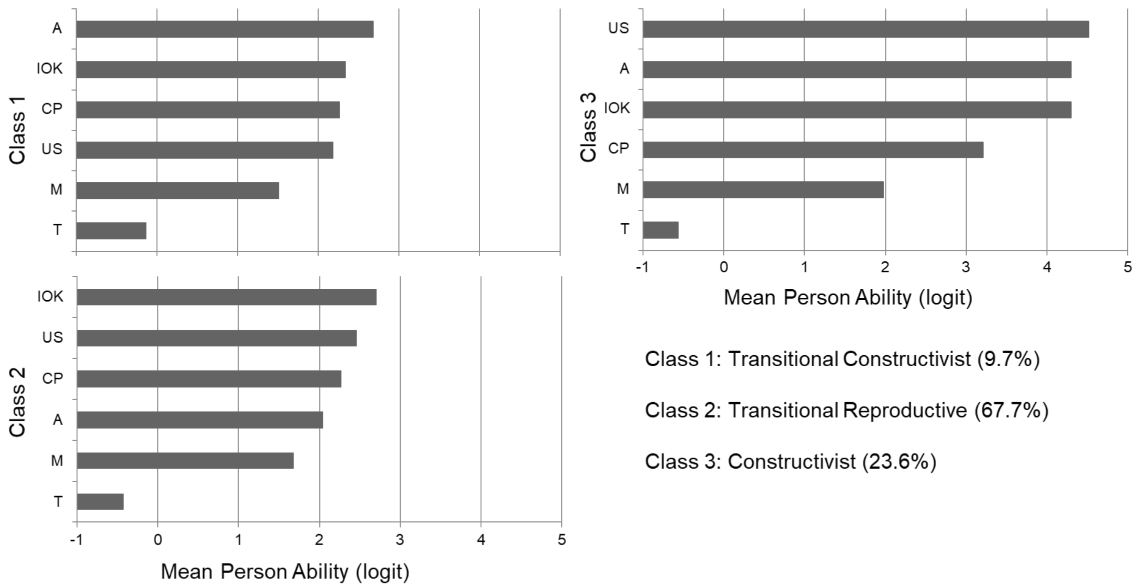

Figure 3: Results of cluster analysis (mclust).

In order to characterize every obtained cluster based on the students' demographics, chi-squared tests of interdependence were performed. The distribution of each group's members based on their demographics is shown in Table 4. The obtained groups of conceptions of learning science were not likely to be related to students' gender (χ^2 (4, 607) = 4.43, *p* > .05, Phi-Cramer's V = 0.09) or their favorite science subjects (χ^2 (4,584)= 8.27, *p* > .05, Phi-Cramer's V = 0.12). In contrast, it was found that the groups were significantly related to the school location (χ^2 (2, 609)= 17.54, *p* < .01, Phi-Cramer's V = 0.17), whereby the schools located inside the capital city of the province were dominant in the fC group (57.6%) and TC group (69.5%), but schools located outside the capital city were dominant in TR group (55.7%).

Table 4. Clusters distribution by gender, favorite science subjects and school location.

Group	Gender[a]		Favorite Science Subject[a]			School Location[b]	
	Male	Female	Biology	Chemistry	Physics	Inside	Outside
TC	15 (6.7%)	43 (11.3%)	40 (11.6%)	10 (5.9%)	4 (5.6%)	41 (69.5%)	18 (30.5%)
TR	150 (66.7%)	255 (66.8%)	219 (63.7%)	125 (74%)	48 (67.6%)	180 (44.3%)	226 (55.7%)
fC	60 (26.7%)	84 (22.0%)	85 (24.7%)	34 (20.1%)	19 (26.8)	83 (57.6%)	61 (42.4%)
Total	255	382	344	169	71	304	305

[a] *Percentage based on Independent variables (Gender and or Favorite Science Subjects)*
[b] *Percentage based on COLS Groups (because total were equal)*

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Discussion

The current research aimed to validate the COLS instrument by using Rasch analysis, to explore the influence of gender and favorite science subject, and to evaluate the new Indonesian science curriculum in terms of high-school students' conceptions of learning science.

COLS Construct Validity

Three types of analyses, namely, factor analysis, Rasch multidimensional analysis, and correlation tests, were performed to explore the constructs in the COLS instrument. By using the raw ordinal data, a factor analysis was performed and the results have shown that the COLS instrument based on Indonesian high-school students' responses consisted of five constructs whereby the two higher-level conceptions – applying (A) and understanding and seeing in a new way (US) – were loaded together in the same factor. In contrast, all the lower conceptions were loaded separately in the different factors, which implies that Indonesian high-school students did not see applying and US in learning science as different conceptions but as the same as being constructivist concepts. In addition, the different factors separated between the 'real' constructivist and 'transitional' constructivist conceptions, which is increasing of knowledge (IOK), obtained in current research has shown that IOK is not really a higher-level conception of learning science, as was suggested by Marton, Dall'Alba & Beaty (1993) and Säljö (1979), because they argued that IOK refers to the accumulation and acquisition of facts or correct knowledge, which tend to be more a part of a reproductive concept and use a surface approach. But because Tsai (2004) stated that IOK is correlated to students' personal desire to fulfill their development in learning, thus in the Rasch analysis, IOK was included in constructivist conception.

Because the factor analysis used the raw ordinal data that many have said might be biased, the confirmation test on dimensionality that Lee, Johanson & Tsai (2008) as the developers of COLS instrument suggested, using a Rasch analysis to confirm the validity of the instrument was done. Four COLS instrument models as mentioned above were compared. It can be seen in Table 1, the results suggested that the COLS instrument is best treated as being six-dimensional, as was originally suggested by Lee, Johanson & Tsai (2008), as is evident from the few missfitting items (exceeds 0.6 – 1.4) and better reliabilities shown in Table 2. For the two items that had an item-fit index of more than 1.4, the values are still below 1.5, which Wright & Linacre (1994) argued is still a reasonable fit of the data to the Rasch model. Moreover, Boone & Scantlebury (2006) said that Rasch analysis is sample independent, while factor analysis is sample dependent. Thus, Rasch, used to find out the validity of the instrument, can provide a consistent result from various types of samples and populations. That is why most science-education researchers are now attempting to use Rasch analysis to implement instrument development (e.g., Oon & Fan, 2017; Romine et al., 2017).

The Impact of Gender and Favorite Science Subject on Students' COLS

In terms of findings in gender difference only exhibited in memorizing, in which female students were higher than male students. This result aligns with the finding by Sadi & Lee (2017), who investigated Turkish and Taiwanese students' conceptions of learning science (biology) and found that in Taiwan, female students were higher in memorizing than male students. Moreover, many also have found that females use more memorization strategies when learning languages (e.g., Dale, 1970; Li & Chun, 2012), economics (e.g., Lumsden & Scott, 1987), and mathematics (e.g., Geist & King, 2008). The reason why females tend to conceive of science learning more in terms of memorizing than males do is discussed in the study by Herlitz & Rehnman (2008) on episodic memory, which is defined as the conscious regathering of particular terms of facts, such as what, when, and where (Tulving, 2001). One dimension of this memory is verbal-production abilities, which females are superior at. Since science subjects consist of many facts, theories, or even symbols that need to be memorized, when learning science females often use memorization strategies, which led to their conceptions of learning science. Herlitz & Rehnman (2008) added that males tend to use a higher level of memory than females, such as understanding and reasoning, which in this research were not examined. Furthermore, current finding supported an old hypothesis about how females tend to use rote learning strategies in science learning proposed by Ridley & Novak (1983), they suggested that females tend to use rote learning because they are prone to want to please teachers, partly because of the social stereotype of females as having lower attainment than male students do.

In consideration to gender stereotyping issue in science education, to date several recent researches are still reporting that female is still underrepresented in the field of science (e.g. Cheryan et al., 2017; Miller, Eagly & Linn, 2014; Wang & Degol, 2016). Consequently, many have argued that gender stereotyping is one of cognitive biases that hinders the current goals of global science education which is equity in science learning and science for all to be reached (Andre et al., 1999; Bianchini et al., 2015; Phillip & Azevedo, 2017; Renni, 1998; Rodriguez, 2015; Zeyer, 2017). By finding out the way to tackle this issue, it may lead to the decrease of female students on using rote learning in science subjects, because they are likely starting the effort not to please the teachers. Moreover, females may increase their level of conceiving science learning to the higher one and being able to have deeper understanding of science concepts that could increase their performance in science subjects. Thus, uncovering and developing program to decrease gender stereotyping in science are crucial.

As aforementioned, students' COLS are related to their favorite science subject. The significant differences in COLS as memorizing and as calculating and practicing were found in this research. Students who liked biology tend to conceive of learning science as memorizing. This corresponds to the fact that biology in schools is full of teaching materials that need to be memorized by students (Lin, Liang & Tsai, 2014). Especially in Indonesia, many teachers still use traditional teaching methods that explicitly ask students to memorize much content. Consequently, students who liked biology follow the methods and infer that science is memorizing facts. In addition, it was found that students who liked physics tend to conceive of learning science as calculating and practicing. This corresponds to the nature of teaching physics in Indonesia, which emphasizes practicing physics problems, which has more to do with mathematics than with theoretical issues in physics. Hence students who liked physics conceive of science more as calculating and practicing. Interestingly, students who liked chemistry tend to conceive of science learning as both memorizing and calculating and practicing. This indicates that the contents of chemistry are related to the things that need both memorization and calculation and practice. Current findings have empirically shown the nature of every science subject in the Indonesian school context.

Indonesian High-school Students' Conceptions of Learning Science

The third research question addresses what Indonesian high-school students' COLS are after the implementation of the new curriculum. Based on the findings described above, it was found that there were three types of student conceptions of learning science, namely, transitional constructivist, transitional reproductive, and constructivist. In addition, it was found that the types of students differed in gender and favorite science subject, but these differences were related to the school location, that is, to how long the new science curriculum had been implemented. The schools located inside the capital city of the province implemented the new curriculum around one year sooner than the schools located outside the capital. Thus, the findings may also show the impact of the new curriculum on how students conceive of their science learning.

The first group, which consisted of a tenth of the students and called as the 'transitional constructivist' group, because the students had high COLS in applying, increasing one's knowledge, and calculating and practicing. The highest conception was 'applying,' which is categorized as a constructivist conception, followed by IOK and CP. In the study of Lee, Johanson & Tsai (2008), IOK was indicated as a transitional conception, because it has no association with the intrinsic and extrinsic motivations and strategies to learn science. The group is predominantly students from the schools located in the capital city of the province. Conversely, in the second group, named 'transitional reproductive,' the highest concept was IOK and had CP as the third highest mean. This group was students who conceive of science learning as primarily increasing knowledge by calculating and practicing problems. It consisted mainly of students from schools located outside the capital city, made up more than half of total participants (68%), and can be assumed to represent most Indonesian high-school students. The last group, which was named as 'fully constructivist' had the highest hierarchy of COLS, which are US and A, placed in the highest rank of total mean. This group was about a fifth of the total participants, and most of them were students from schools inside the capital city.

The findings have shown that the new science curriculum influences how Indonesian high-school students conceive of their science learning. Even though most of them are still conceiving of science learning at the level of transitional reproductive, the impact of the science curriculum is clearly shown, because the number of students in the 'fully constructivist' group was higher for the schools that had been implementing the new curriculum longer. Hence more time is needed for this new curriculum to influence more Indonesian high-school students. Moreover, the new policy about the role of examinations in the school system within the new curriculum is also significantly impacting students' conceptions of learning science. It is shown by COLS, because 'testing' had the

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lowest mean for all the groups of students (Figure 3). As noted earlier in the literature review, this new policy is related to the deletion of the role of the national examination as the sole judgment for students graduating from high school and instead considering attitude as the highest factor for students graduating from high school. But more evidences and further studies are still needed to make sure that the Indonesian high-school students' COLS were really influenced by this new curriculum and whether the COLS were highly related to science literacy as was the main notion of the new science curriculum.

Conclusions and Implications

Current research has suggested that the conceptions of learning science instrument was a stable instrument with the confirmation through two methods, classical test theory (CTT) and item response theory (IRT) with Rasch model. In addition, current research has suggested that there are different conceptions of learning science between genders, in which females tend to use more memorization than male students in learning science. Finally, the research also suggested that the long period of curriculum with more emphasis on scientific literacy could change students' conceptions of learning science.

This research has both limitations and implications. What the claims established in current research regarding Indonesian high-school students points only to students from the metropolitan island, Java Island. Given that Indonesia consists of many islands, small and big, the results found in current research could not be generalized to students outside Java Island, particularly outside West Java province. Given the many different ethnicities and characteristics of culture and people in the other islands, it is believed that they may have different conceptions of learning science, even using the same new science curriculum. This may call for a new future study, such as comparing conceptions of learning science from different ethnicities in one nation. Furthermore, the implementation of the new Indonesian science curriculum that introduced attitude as the main notion has shown very promising results, given the existence of students in the fully constructivist group. When students already have a higher hierarchy of learning science, as mentioned previously, they may accept science more easily and apply science concepts more frequently in their daily life. This can lead to an increase in science literacy as proposed as the main notion of the new Indonesian science curriculum 2013.

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References

Adams, R., & Wu, M. (2010). *Notes and tutorial ConQuest: Multidimensional model*. Retrieved from https://www.acer.org/conquest/notes-tutorials. 25 May 2017.

Allan, B. (2003). Approaches to learning and academic achievement of Filipino students. *The Journal of Genetic Psychology*, *164*, 101-114.

Andre, T., Whigham, M., Hendrickson, A., & Chambers, S. (1999). Competency beliefs, positive affect, and gender stereotypes of elementary students and their parents about science versus other school subjects. *Journal of Research in Science Teaching*, *36* (6), 719-747.

Bianchini, J. A., Dwyer, H. A., Brenner, M. E., & Wearly, A. J. (2015). Facilitating science and mathematics teachers' talk about equity: What are the strengths and limitations of four strategies for professional learning? *Science Education*, *99* (3), 577-610.

Biggs, J. (1994). Approaches to learning: Nature and measurement of. In T. Husen & T. N. Postlethwaite (Eds.), *The international encyclopedia of education* (2nd ed., Vol. 1, pp. 319 – 322). Oxford, England: Pergamon.

Biggs, J. B., & Collins, K. (1982). *Evaluating the quality of learning: The SOLO taxonomy*. New York, NY: Academic Press.

Bond, T., & Fox, C. M. (2015). *Applying the Rasch model: Fundamental measurement in the human sciences*. Routledge.

Boone, W. J., & Scantlebury, K. (2006). The role of Rasch analysis when conducting science education research utilizing multiple-choice tests. *Science Education*, *90* (2), 253-269.

Boone, W. J., Townsend, J. S., & Staver, J. (2011). Using Rasch theory to guide the practice of survey development and survey data analysis in science education and to inform science reform efforts: An exemplar utilizing STEBI self- efficacy data. *Science Education*, *95* (2), 258–280.

Buehl, M. M., & Alexander, P. A. (2001). Beliefs about academic knowledge. *Educational Psychology Review*, *13* (4), 385-418.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, *143* (1), 1-36.

Chiou, G. L., Liang, J. C., & Tsai, C. C. (2012). Undergraduate students' conceptions of and approaches to learning in biology: A study of their structural models and gender differences. *International Journal of Science Education*, *34* (2), 167-195.

Dale, R. R. (1970). A comparison of the academic performance of male and female students in schools and universities. *Journal of Biosocial Science*, *2* (S2), 95-99.

Dart, B. C., Burnett, P. C., Purdie, N., Boulton-Lewis, G., Campbell, J., & Smith, D. (2000). Students' conceptions of learning, the classroom environment, and approaches to learning. *The Journal of Educational Research*, *93* (4), 262-270.

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, *37* (6), 582-601.

Den Brok, P., Telli, S., Cakiroglu, J., Taconis, R., & Tekkaya, C. (2010). Learning environment profiles of Turkish secondary biology classrooms. *Learning Environments Research*, *13* (3), 187-204.

DeVellis, R. F. (2003). *Scale development: Theory and applications* (2nd Ed.). Thousand Oaks, CA: Sage.

Entwistle, N., & Tait, H. (1990). Approaches to learning, evaluations of teaching, and preferences for contrasting academic environments. *Higher Education*, *19* (2), 169-194.

Fraley, C., & Raftery, A. E. (2002). Model-based clustering, discriminant analysis, and density estimation. *Journal of the American Statistical Association*, *97* (458), 611-631.

Geist, E. A., & King, M. (2008). Different, not better: Gender differences in mathematics learning and achievement. *Journal of Instructional Psychology*, *35* (1), 43-53.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching*, *46* (2), 127-146.

Gummer, E. S., & Shepardson, D. P. (2001). Facilitating change in classroom assessment practice: Issues for professional development. In *Assessment in Science* (pp. 53-66). Springer Netherlands.

Herlitz, A., & Rehnman, J. (2008). Sex differences in episodic memory. *Current Directions in Psychological Science*, *17* (1), 52-56.

Hong, Y. Y., & Salili, F. (2000). Challenges ahead for research on Chinese students' learning motivation in the new millennium. *Journal of Psychology in Chinese Societies*, *1* (2), 1-12.

Lai, P. Y., & Chan, K. W. (2005). A structural model of conceptions of learning, achievement motivation and learning strategies of Hong Kong teacher education students. *Australian Association of Research in Education Parramatta Conference*, Sydney, 28 November-2 December.

Lee, C. S., Hayes, K. N., Seitz, J., DiStefano, R., & O'Connor, D. (2016). Understanding motivational structures that differentially predict engagement and achievement in middle school science. *International Journal of Science Education*, *38* (2), 192-215.

Lee, M. H., Johanson, R. E., & Tsai, C. C. (2008). Exploring Taiwanese high school students' conceptions of and approaches to learning science through a structural equation modeling analysis. *Science Education*, *92* (2), 191-220.

Lee, M. H., Lin, T. J., & Tsai, C. C. (2013). Proving or improving science learning? Understanding high school students' conceptions of science assessment in Taiwan. *Science Education*, *97* (2), 244-270.

Li, J. & Chun, C. K. W. (2012). Effects of learning strategies on student reading literacy performance. *Reading*, *12*(1), 30-38.

Liang, J. C., & Tsai, C. C. (2010). Relational analysis of college science- major students' epistemological beliefs toward science and conceptions of learning science. *International Journal of Science Education*, *32* (17), 2273-2289.

Lin, T. C., Liang, J. C., & Tsai, C. C. (2015). Conceptions of memorizing and understanding in learning, and self-efficacy held by university biology majors. *International Journal of Science Education*, *37* (3), 446-468.

Lonka, K., & Lindblom-Ylänne, S. (1996). Epistemologies, conceptions of learning, and study practices in medicine and psychology. *Higher Education*, *31* (1), 5-24.

Lumsden, K. G., & Scott, A. (1987). The economics student reexamined: Male-female differences in comprehension. *The Journal of Economic Education*, *18* (4), 365-375.

Marshall, D., Summer, M., & Woolnough, B. (1999). Students' conceptions of learning in an engineering context. *Higher Education*, *38* (3), 291-309.

Marton, F., Dall'Alba, G., & Beaty, E. (1993). Conceptions of learning. *International Journal of Educational Research*, *19*, 277 – 299

Mendikbud [Indonesian Ministry of Education and Culture]. (2016). *Salinan Lampiran Permendikbud No.21 th 2016 tentang Standar Isi Pendidikan Dasar dan Menengah* [A copy of the additional documents of Indonesian ministry of education and culture regulation number 21 year 2016 on Content Standards for Primary and Secondary Education]. Jakarta: Mendikbud.

Miller, D. I., Eagly, A. H., & Linn, M. C. (2015). Women's representation in science predicts national gender-science stereotypes: Evidence from 66 nations. *Journal of Educational Psychology*, *107* (3), 631-635.

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2016). *TIMSS 2015 international results in science*. Retrieved from Boston College, TIMSS & PIRLS International Study. Center website: http://timssandpirls.bc.edu/timss2015/international-results/.

OECD. (2015). *OECD science, technology and industry scoreboard 2015: Innovation for growth and society*. OECD Publishing. Paris.

OECD. (2016). *PISA 2015 results (Volume I): Excellence and equity in education, PISA*. OECD Publishing, Paris.

Oon, P. T., & Fan, X. (2017). Rasch analysis for psychometric improvement of science attitude rating scales. *International Journal of Science Education*, *39* (6), 683-700.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25* (9), 1049-1079.

Perkins, K. K., Barbera, J., Adams, W. K., & Wieman, C. E. (2007, January). Chemistry vs. physics: A comparison of how biology majors view each discipline. In L. McCullough, L. Hsu & P. Heron (Eds.), *AIP conference proceedings*, *883* (1), 53-56. DOI: 10.1063/1.2508689.

Philip, T. M., & Azevedo, F. S. (2017). Everyday science learning and equity: Mapping the contested terrain. *Science Education*,

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ISSN 2538–7138 /Online/

1-7. DOI: 10.1002/sce.21286.

Pillay, H., Purdie, N. O. L. A., & Boulton-Lewis, G. (2000). Investigating cross-cultural variation in conceptions of learning and the use of self-regulated strategies. *Education Journal Hong Kong-Chinese University of Hong Kong*, *28* (1), 65-84.

Purdie, N., Hattie, J., & Douglas, G. (1996). Student conceptions of learning and their use of self-regulated learning strategies: A cross-cultural comparison. *Journal of Educational Psychology*, *88* (1), 87-100.

Rennie, L. J. (1998). Gender equity: Toward clarification and a research direction for science teacher education. *Journal of Research in Science Teaching*, *35* (8), 951-961.

Ridley, D. R., & Novak, J. D. (1983). Sex-related differences in high school science and mathematics enrollments: Do they give males a critical head start toward science-and math-related careers? *Alberta Journal of Educational Research*, *29* (4), 308-318.

Robnett, R. D., Chemers, M. M., & Zurbriggen, E. L. (2015). Longitudinal associations among undergraduates' research experience, self- efficacy, and identity. *Journal of Research in Science Teaching*, *52* (6), 847-867.

Rodriguez, A. J. (2015). What about a dimension of engagement, equity, and diversity practices? A critique of the next generation science standards. *Journal of Research in Science Teaching*, *52* (7), 1031-1051.

Romine, W. L., Walter, E. M., Bosse, E., & Todd, A. N. (2017). Understanding patterns of evolution acceptance - A new implementation of the measure of acceptance of the theory of evolution (MATE) with Midwestern university students. *Journal of Research in Science Teaching, 54* (5), 642-671.

Sadi, Ö., & Çevik, M. (2016, January). Investigating of conceptions of learning biology with respect to gender, grade level and school type. *In SHS web of conferences (Vol. 26)*. EDP Sciences. DOI: 10.1051/shsconf/20162601025.

Sadi, Ö., & Lee, M. H. (2017). Exploring Taiwanese and Turkish high school students' conceptions of learning biology. *Journal of Biological Education*, DOI: 10.1080/00219266.2017.1285799.

Sadi, O., & Uyar, M. (2013). The relationship between self-efficacy, self-regulated learning strategies and achievement: A path model. *Journal of Baltic Science Education*, *12* (1), 21-33.

Sadi, Ö. (2015). The Analysis of high school students' conceptions of learning in different domains. *International Journal of Environmental and Science Education*, *10* (6), 813-827.

Säljö, R. (1979). Learning about learning. *Higher Education*, *8* (4), 443-451.

Schumm, M. F., & Bogner, F. X. (2016). Measuring adolescent science motivation. *International Journal of Science Education*, *38* (3), 434-449.

Scrucca, L., Fop, M., Murphy, T. B., & Raftery, A. E. (2016). mclust 5: Clustering, classification and density estimation using gaussian finite mixture models. *The R Journal*, *8* (1), 289-317.

Severiens, S., & Dam, G. T. (1997). Gender and gender identity differences in learning styles. *Educational Psychology*, *17* (1-2), 79-93.

Sinatra, G. M. (2001). Knowledge, beliefs, and learning. *Educational Psychology Review*, *13* (4), 321-323.

Sondergeld, T. A., & Johnson, C. C. (2014). Using Rasch measurement for the development and use of affective assessments in science education research. *Science Education*, *98* (4), 581–613.

Thompson, T. L., & Mintzes, J. J. (2002). Cognitive structure and the affective domain: On knowing and feeling in biology. *International Journal of Science Education*, *24* (6), 645-660.

Tsai, C. C. (2004). Conceptions of learning science among high school students in Taiwan: A phenomenographic analysis. *International Journal of Science Education*, *26* (14), 1733-1750.

Tsai, C. C. (2006). Reinterpreting and reconstructing science: Teachers' view changes toward the nature of science by courses of science education. *Teaching and Teacher Education*, *22* (3), 363-375.

Tsai, C. C., Ho, H. N. J., Liang, J. C., & Lin, H. M. (2011). Scientific epistemic beliefs, conceptions of learning science and self-efficacy of learning science among high school students. *Learning and Instruction*, *21* (6), 757-769.

UNESCO. (2015). *A complex formula: Girls and women in science, technology, engineering and mathematics in Asia*. UNESCO: UNESCO Bangkok Office.

Vermunt, J. D., & Vermetten, Y. J. (2004). Patterns in student learning: Relationships between learning strategies, conceptions of learning, and learning orientations. *Educational Psychology Review*, *16* (4), 359-384.

Vermunt, J. D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: A phenomenographic analysis. *Higher Education*, *31* (1), 25-50.

Wang, M. T., & Degol, J. L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review*, *29* (1), 119-140.

Wang, Y. L., Tsai, C. C., & Wei, S. H. (2015). The sources of science teaching self-efficacy among elementary school teachers: A mediational model approach. *International Journal of Science Education*, *37* (14), 2264-2283.

Watts, M., & Alsop, S. (2000). The affective dimensions of learning science. *International Journal of Science Education*, *22* (12), 1219-1220.

Wright, B. D., & Linacre, J. M. (1994). Reasonable mean-square fit values. *Rasch Measurement Transactions*, *8* (3), 370.

Zeyer, A. (2017). Gender, complexity, and science for all: Systemizing and its impact on motivation to learn science for different science subjects. *Journal of Research in Science Teaching*, 1-25. DOI: 10.1002/tea.21413.

Appendixes

Appendix 1. Factor analysis of COLS.

Items	Factor 1 US & A	Factor 2 IOK	Factor 3 CP	Factor 4 T	Factor 5 M
US5	.747				
US6	.738				
US4	.715				
US3	.697				
US2	.696				
A4	.578				
A3	.556				
A2	.492				
US1	.490				
A1	.456	.436			
IK3		.674			
IK5		.669			
IK2		.667			
IK4		.637			
IK1		.601			
CP4			.754		
CP2			.711		
CP1			.703		
CP5			.698		
CP3			.687		
T4				.757	
T1				.714	
T6				.597	
T2				.590	
T3	–.402			.515	
T5				.468	
M2					.716
M3					.649
M1					.642
M4					.592
M5					.502

Appendix 2. Tuckey HSD pairwise comparison.

	(I) Favorite	(J) Favorite	Mean Difference (I–J)	Std. Error	p-value	95% Confidence Interval for Difference	
						Lower Bound	Upper Bound
Memorizing	Biology	Chemistry	0.003	0.152	1.000	–0.362	0.368
		Physics	0.509†	0.211	**.048**	0.002	1.016
	Chemistry	Physics	0.506	0.229	.082	–0.043	1.056
Calculating and Practicing	Biology	Chemistry	–0.696‡	0.210	**.003**	–1.200	–0.192
		Physics	–0.940‡	0.291	**.004**	–1.639	–0.241
	Chemistry	Physics	–0.244	0.316	1.000	–1.003	0.515

‡ $p < .01$, † $p < .05$

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Appendix 3. **Bayesian Information Criterion (BIC) values for deciding the number of group computed by mclust package.**

Number of Class	EII	VII	EEI	VEI	EVI	VVI	EEE	EVE	VEE	VVE	EEV	VEV	EVV	VVV
1	–15454.9	–15454.9	–14976.2	–14976.2	–14976.2	–14976.2	–14095.0	–14095.0	–14095.0	–14095.0	–14095.0	–14095.0	–14095.0	–14095.0
2	–14809.9	–14779.7	–14535.9	–14455.9	–14515.3	–14485.0	–14094.7	–14042.4	–13910.4	–13922.1	–14070.5	–13956.5	–14100.7	–13982.9
3	–14519.7	–14352.7	–14318.8	–14151.1	–14296.6	–14197.8	–14138.7	–14049.3	–13904.8	–13851.5	–14138.3	–13885.8	–14153.8	NA
4	–14440.4	–14287.2	–14285.1	–14076.1	–14196.4	–14130.0	–14130.4	–14043.3	–13904.9	–13900.2	–14210.0	–13928.6	–14192.0	NA
5	–14396.4	–14299.8	–14234.2	–14006.0	–14258.9	NA	–14144.9	–14058.2	–13933.4	–13875.3	–14253.8	–13919.5	–14284.5	NA
6	–14411.2	–14130.5	–14138.2	–13970.0	NA	NA	–14141.9	NA	–13942.1	NA	–14299.1	–13968.2	NA	NA
7	–14289.7	–14105.6	–14086.9	–13968.8	NA	NA	–14099.9	NA	NA	NA	–14390.5	–14057.3	NA	NA
8	–14241.0	NA	–14082.4	NA	NA	NA	–14134.4	NA	NA	NA	–14450.5	NA	NA	NA
9	–14330.9	NA	–14113.4	NA	NA	NA	–14174.6	NA	NA	NA	–14516.1	NA	NA	NA
10	–14352.4	NA	–14114.8	NA	NA	NA	–14170.7	NA	NA	NA	–14585.1	NA	NA	NA
11	–14388.7	NA	–14162.9	NA	NA	NA	–14186.9	NA	NA	NA	–14648.5	NA	NA	NA
12	–14419.4	NA	–14180.6	NA	NA	NA	–14221.0	NA	NA	NA	–14699.7	NA	NA	NA
13	–14352.7	NA	–14193.2	NA	NA	NA	–14197.0	NA	NA	NA	–14690.8	NA	NA	NA
14	–14408.5	NA	–14280.3	NA	NA	NA	–14236.8	NA	NA	NA	–14745.8	NA	NA	NA
15	–14425.0	NA	–14315.8	NA	NA	NA	–14267.1	NA	NA	NA	–14979.0	NA	NA	NA
16	–14393.0	NA	–14290.1	NA	NA	NA	–14317.1	NA	NA	NA	–14803.3	NA	NA	NA
17	–14436.1	NA	–14326.8	NA	NA	NA	–14380.3	NA	NA	NA	–14933.7	NA	NA	NA
18	–14465.1	NA	–14318.0	NA	NA	NA	–14403.6	NA	NA	NA	–14949.6	NA	NA	NA
19	–14487.3	NA	–14347.7	NA	NA	NA	–14428.1	NA	NA	NA	–14996.1	NA	NA	NA
20	–14442.8	NA	–14358.5	NA	NA	NA	–14378.7	NA	NA	NA	–15204.9	NA	NA	NA

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Arif Rachmatullah	S.Pd, Master Student, Division of Science Education, College of Education, Kangwon National University, 1 Kangwondaehak-gil, Chuncheon-si, Gangwon-do, 24341 Republic of Korea. E-mail: arifraach@gmail.com
Sariwulan Diana	Dr., Senior Lecturer, Department of Biology Education, FPMIPA Indonesia University of Education, Jl. Dr. Setiabudhi No. 229 Bandung 40154 Jawa Barat, Indonesia. E-mail: sariwulwul@yahoo.co.id
Minsu Ha *(Corresponding author)*	Ph.D, Assistant Professor, Division of Science Education, College of Education, Kangwon National University, 1 Kangwondaehak-gil, Chuncheon-si, Gangwon-do, 24341 Republic of Korea. E-mail: msha@kangwon.ac.kr