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Research Article

Effects of South Korean High School Students' Motivation to Learn Science and Technology on Their Concern Related to Engineering

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Abstract

This study investigated the gender difference among South Korean high school students in science learning motivation, technology learning motivation, and concern related engineering, as well as the correlation between these factors. It also verified effects of the sub-factors of science learning motivation and technology learning motivation on concern related to engineering. For this study, 745 students in grade 11th at six high schools in South Korea were involved as subjects in a survey conducted using instruments developed by Glynn et al. and Hall et al. In the results, a gender difference was observed in some sub-factors related to science learning motivation and technology learning motivation, and a positive correlation was found between most of the sub-factors of science learning motivation and technology learning motivation and concern related to engineering. Moreover, intrinsic motivation and personal relevance in technology were major factors that influenced students' concern related to engineering. Based on the findings, this study demonstrates the educational implications of including engineering in high school technology curriculums.

Keywords

Technology education • Technology learning motivation • Concern related to engineering • Science education • Science learning motivation

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Engineering has contributed to creating numerous artifacts that people use in everyday life today. The level of engineering has a major impact on national competitiveness, and therefore, many countries around the world are making substantial efforts to foster competent engineers. However, in recent years, countries like South Korea and the United States have faced the problem of a decreasing number of students who choose engineering as their future career, and this can lead to a decrease in the overall number of engineers in the country, thereby decreasing national competitiveness. For that reason, these countries have implemented policies to include engineering in secondary education, such as integrative Science, Technology, Engineering, Mathematics (STEM) education and the provision of engineering education to secondary school students.

Despite the attempts to allow secondary school students to approach engineering, it is debatable whether these policies actually help to provide in-depth engineering education because engineering education in secondary schools is still limited. For instance, among secondary schools in the United States, few offer engineering in their curriculum (Katehi, Pearson, & Feder, 2009), and as of 2013, only 23 high schools (1.47%) in South Korea ran engineering classes (Korean Educational Statistics Service, 2015). Part of the reason for this is that engineering is generally perceived as a discipline taught at tertiary educational institutions like universities. As a system or curriculum for engineering education at secondary schools has not been properly established, it is important to investigate secondary school students' perceptions of engineering and propose a direction for engineering education in the future.

In this study, secondary school students' perception of engineering was measured based on the students' concern related to this field, and the major factors influencing concern related to engineering were identified. In this study, the main variables that were seen as likely to influence concern related to engineering were science learning motivation and technology learning motivation, because many previous studies suggested correlation between engineering and science and engineering and technology (Apedoe, Reynolds, Ellefson, & Schunn, 2008; Klein & Sherwood, 2005; Lewis, 2004; Olds, Harrell, & Valente, 2006; Wicklein, 2006), as well as between science learning motivation and careers in science-related fields (Maltese & Tai, 2010; Tai, Liu, Maltese, & Fan, 2006). These findings imply that the science and technology learning motivation of secondary school students may have an effect on their concern related to engineering, so far, no research has demonstrated a direct correlation. In other words, previous studies simply explored ways to improve students' motivation to learn science or technology, but they did not examine the effects of learning motivation on students' perception of engineering.

On the other hand, many researchers were interested in gender differences in science, technology and engineering areas and presented desired educational methods accordingly. This is due not only to the low ratio of female students registering for such subjects in secondary schools but also the low ratio of women engaging in such areas in the society (Bryan, Glynn, & Kittleson, 2011; Mitts, 2008; Sander, 2001; Siebert, 2001; Simon, Aulls, Dedic, Hubbard, & Hall, 2015; Virtanen, Räikkönen, & Ikonen, 2015). In this situation, many researchers analyzed differences between male and female students in science, technology and engineering areas (Britner, 2008; Cavallo, Potter, & Rozman, 2004; Chatoney & Andreucci, 2009; McCarthy, 2009; Glynn, Taasoobshirazi, & Brickman, 2007; Zeyer, Bölsterli, Brovelli, & Odermatt, 2012). It is also expected in the present study that gender difference would exist in the motivation for science and technology study as well as concern related to engineering. However, few South Korean studies have examined such an aspect.

Therefore, this study attempted to investigate the relationship between the science and technology learning motivation of high school students and their concern related to engineering, as well as to discuss the relevant educational implications by gender. To accomplish this, the correlation between science and technology learning motivation and concern related to engineering was examined based on correlation analysis and the effect of science and technology learning motivation on the concern related to engineering based on regression analysis. The following research problems were set in this study:

1. Is there a gender difference in science learning motivation, technology learning motivation, and concern related to engineering among high school students?
2. What are the relationships between science learning motivation and technology learning motivation concern related to in engineering among high school students?
3. What effects do the science learning motivation and technology learning motivation of high school students have on their concern related to engineering?

Motivation

"Motivation is the internal state that arouses, directs, and sustains students' behavior toward achieving certain goals" (Glynn et al., 2007, p. 1089). As it encourages students to actively learn difficult concepts, motivation is considered the most important factor in self-directed learning (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). In addition, Druger (2006) suggested that the most important goal of an instructor is to establish students' motivation so that they can set and reach learning goals independently. Given the importance of motivation in learning, scholars concerned with science and technology education have conducted various studies related to learning motivation.

Motivation theory has been researched from diverse perspectives (Pintrich, 2004). In this study, the social cognitive theory was adopted. Social cognitive theory was developed by Bandura and extended by scholars such as Pajares, Schunk, and Pintrich (Bryan et al., 2011). The theory emphasized the importance of social influence on human behavior (Glynn et al., 2011). It posits that students' characteristics, behaviors, and learning environment mutually interact. In South Korea, the government oversees educational curriculum provided to students and the national college entrance examination plays an important role in determining students' social positions (Kwon, 2016a; Kwon & Chang, 2009; Seog, Hendricks, & González-Moreno, 2011). For such reasons, students' learning motivation is largely influenced by the social aspects. Accordingly, the social cognitive theory is considered appropriate for examining South Korean students' motivation.

The social cognitive theory describes that students' motivation is most effective when students are in the self-regulated status. In other words, students tend to have the strongest motivation when they understand, monitor and control their own motivation. In this sense, Druger (2006) said that the most important goal of a university in teaching science is to help students to motivate themselves for study. To this end, many science instructors commented that multiple elements of motivation should be considered (Glynn et al., 2011). Researchers who adopted the social cognitive theory in their studies commonly presented their view that learning motivation was not made up of one single element (Bryan et al., 2011; Duncan & McKeachie, 2005; Eccles & Wigfield, 2002; Glynn, Taasoobshirazi, & Brickman, 2009; Koballa & Glynn, 2007; Sanfeliz & Stalzer, 2003; Taasoobshirazi & Carr, 2009). They considered that learning motivation to have elements such as intrinsic motivation referring to the satisfaction with the study itself; self-determination, the belief of a student in his or her ability to control his or her own study; self-efficacy, the confidence to excel in science; grade motivation, desire to achieve a high score in science; and test anxiety felt by students when taking a test. This present study also bases on such sub-factors presented under the social cognitive theory.

Concern

The present study adopted "concerns" theory to investigate high school students' perceptions of engineering. Interest refers to emotion or ideas related to something new that will influence one's life as a result of change. High school students, who are engaged in a developmental process, are likely to have emotions or ideas about the discipline they will study in university, which can influence their future. Considering that almost all colleges of science and engineering require engineering as a mandatory course, it is reasonable to assume that high school students have emotions or ideas about engineering. In this study, concerns' theory was deemed suitable for examining such emotion and ideas.

The stage of concern, proposed by Hall, George, & Rutherford (1977), is one of the most well-known "interest" theories. These authors established a theory of interest by researching types of interest among teachers who do or are likely to practice a curriculum in an innovative way and classifying the level of interest into seven stages. The instrument proposed by Hall et al. (1977) has been used in many studies measuring teachers' level of interest in a new curriculum. It was also used for surveying levels of student's interest in different topics in studies that used the general population as subjects. The instrument has been used for examining interest in a certain subject, such as students' interest in the internet, the level of parents' interest, and family-centered early intervention in different studies (Bailey, Palsha, & Simeonsson, 1991; Daniel & King, 1997; Wells & Anderson, 1997). Although previous research used other instruments to measure students' perceptions of engineering (Fralick, Kearn, Thompson, & Lyons, 2009; Karatas, Micklos & Bodner, 2011; Thompson & Lyons, 2008), these instruments were employed to analyze qualitative data; therefore, they were unsuitable for this study. In addition, because no previous study made use of interest theory to measure students' perception of engineering, in this study, the level of high school students' concern related to engineering was examined based on the theory developed by Hall et al. (1977).

Relationship between Motivation and Concern

This study seeks to investigate the relationship between students' science and technology learning motivation and concern related to engineering, which is associated with their future career path. Such a relationship between them has been little researched to date. However, the learning motivation and concern have been considered important in multiple studies. For instance, Glynn et al. (2007), in their study, examined college students' science learning motivation by separating them according to their vocational areas of interest. Ha and Lee (2012) examined South Korean high school students and analyzed their science learning motivation structures according to their area of interest in terms of future career. Moreover, there are studies in which a positive correlation can be inferred between students' learning motivation and concern related to engineering. For instance, Kwon (2016b) reported in his study that middle school students' technology learning motivation had a positive correlation with attitude toward engineering. Studies by Aschbacher, Li, and Roth (2010) and DeWitt et al. (2011) reported that science learning motivation was a significant factor for students to choose an engineering-related career in the future.

As mentioned before, though the relationship between science and technology learning motivation and concern related to engineering has been scarcely investigated, many studies enable the inference that science and technology learning motivation may be related with engineering to be studied by students in the future. This study seeks to identify the causal relationships among the factors involved.

K-12 Science, Technology, and Engineering Education

In the past, engineering in K-12 education drew little attention from most countries Americans, including educators and policymakers (Katehi et al., 2009). However, many developed countries, such as the United States, began to recognize the decreasing number of engineers and students who wish to pursue a career in engineering as a serious social issue. Accordingly, the importance of engineering education for K-12 students has been increasingly emphasized. This is because engineering education at the K-12 level can improve students' academic performance in mathematics and science, as well as their awareness of engineering and engineers, and induce students' interest in becoming engineers in the future (Katehi et al., 2009).

Many attempts have been made to teach engineering to K-12 students, most notably by including engineering in K-12 science and technology curriculums. Several studies have discussed engineering in science curriculum. For instance, Olds et al. (2006) demonstrated that including an engineering design activity in science class can improve students' understanding of mechanical principles, while Apedoe et al. (2008) found that an engineering design activity in high school chemistry can help students to understand atoms and energy. Klein and Sherwood (2005) applied an engineering program designed for secondary schools in physics and advanced biology classes; as a result, students in the experimental group showed more competence in understanding scientific knowledge and concepts and applying them to problems. Cantrell, Pekcan, Itani, and Velasquez-Bryant (2006) also incorporated engineering design into a middle school science class; consequently, the difference in science achievement between students was reduced, while their knowledge of scientific concepts improved. Sadler, Coyle, and Schwartz (2000) suggested that engineering design activities helped middle school students to improve their awareness of scientific principles and develop logical thinking and communication skills. Schauble, Klopfer, and Raghavan (1991) applied a format that began with an engineering model/engineering problem and proceeded with science problems; as a result, students showed substantial improvement in the subject. In addition, science educators have made attempts to include engineering in the science curriculum standard (Moore et al., 2014; Moore, Tank, Glancy, & Kersten, 2015).

Multiple studies have also discussed engineering in relation to the subject of technology. Merrill, Custer, Daugherty, Westrick, and Zeng (2008) conducted classes for secondary school students by applying core engineering concepts. Here, the constraints, optimization, and predictive analysis (COPA) of the participants were significantly improved. In a study conducted by Mentzer and Becker (2009), engineering design tasks were proposed to high school students in a technology class; as a result, their learning motivation increased. Lawanto and Stewardson (2013) conducted two engineering design projects and found that they had a significant effect on improving internal motivation. In addition, many technology education scholars and teachers show highly positive perceptions concerning the inclusion of engineering in technology education. For instance, researchers found that engineering included in a technology subject can improve the technical literacy of students and help their future careers (Gorham, 2002; Gorham, Neberry, & Bickart, 2003; Pinelli & Haynie, 2010; Rogers & Rogers, 2005; Wicklein, 2006). Technology teachers or administrators who had experience with teaching engineering had a positive view of including engineering in technology education and perceived that engineering had a positive effect on secondary school students (Gattie & Wicklein, 2007; Rogers, 2005, 2007).

As such, the K-12 science and technology textbooks showed diverse efforts to include engineering. It was found that K-12 science and technology subjects were closely related with engineering. However, it is difficult to view that engineering education has been widely provided in K-12 teaching schools. For example, it was reported that few secondary schools in the US was providing the engineering subject (Katehi et al., 2009). The South Korean high schools analyzed in this research, show a particularly poor attempt overall to teach engineering. One example is the report that only 23 (1.47%) of the South Korean high schools were found to have the engineering subject and provide engineering education in 2013 (Korean Educational Statistics Service, 2015). As such, engineering education is very limited in South Korean high schools.

Meanwhile, traditionally, female students are reported to have a low level of interest in science, technology, and engineering; as a result, only a small number of female students are reported to intend to pursue a career in the relevant fields (Sadler, Sonnert, Hazari, & Tai, 2012). Some scholars have argued that female students have a gene that puts them at a disadvantage in these fields in relation to male students, while others suggest that a lack of social support discourages female students from pursuing interests in these fields (Schunk, Pintrich, & Meece, 2008).

Many researchers studying motivation have conducted research investigations to examine the cause of this gender difference, including suggesting that gender difference in these fields is formed as a result of students' perceptions concerning the level of their abilities. For instance, male students perceived their abilities in mathematics and physical education to be relatively high, while female students perceived that they had a higher level of ability in reading, English, and social studies than male students. The study suggested that this difference in self-perception creates gender differences in relevant fields (Eccles & Harold, 1991; Eccles, Wigfield, Harold, & Blumenfeld, 1993; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Watt, 2004). This finding was supported in studies that involved lower-grade elementary school students and as subjects (Entwisle & Baker, 1983; Frey & Ruble, 1987). Such gender differences can be also explained by the motivation theory of expectation–value theory. According to this theory, value is closely related to a choice. Therefore, this gender difference may have been created because female students do not value subjects like science and technology as much as male students do.

In studies on students' motivation under the social cognitive theory, gender difference was an important variable. Multiple studies have compared the gender difference, in particular, among the sub-factors of learning motivation under the social cognitive theory, and gained educational implications.

Glynn et al. (2011) studied college students' learning motivation for science and found higher self-determination in male students than female students in both an engineering student group and others. They also found higher self-efficacy in male students than female students. No gender difference was found in other elements: intrinsic motivation, career motivation, and grade motivation. Glynn et al. (2009) studied college students' learning motivation for science and found that the self-efficacy and assessment anxiety were higher in male students, whereas self-determination was higher among female students. Salta and Koulougliotis (2015), in their study on secondary school students' learning motivation for chemistry, found that lower secondary female students had higher self-determination, career motivation, and intrinsic motivation than their male counterparts. In addition, self-determination was higher among upper secondary female students than upper secondary male students. In the study by Bryan, Glynn, and Kittleson (2011) on 14-16-year-old students' motivation, it was found that only intrinsic motivation was higher in male students than in female students in the Advanced Placement non-takers group among the sub-elements of motivation, while other motivations such as self-efficacy and self-determination showed no gender-based difference. Britner (2008) studied high school students' motivation and found that self-efficacy was higher in female students than in male students in earth science classes. In life science classes, female students' science anxiety was found to be stronger than that of male students. In physical science classes, on the other hand, no gender difference was found in motivational elements such as self-efficacy and science anxiety. As such, multiple studies have been performed to investigate gender differences in sub-elements of motivation based on the social cognitive theory and their findings are not consistent.

Methods

Subjects

The subjects of this study were selected from high schools located in six regions in South Korea based on the convenience sampling method. From these schools, 774 grade 11th students were selected as subjects, and inadequate responses (29 students) were excluded from the final analysis. As a result, data collected from 745 students (male: 368, female: 377) were analyzed.

Instrument

Science Learning Motivation and Technology Learning Motivation scales. In this present study to measure the science learning motivation and technology learning motivation, Glynn et al.'s (2009) test instrument, the science motivation questionnaire (SMQ) was utilized. Glynn et al.'s (2009) test instrument is based on the social cognitive theory to measure and assess people's motivation. Many studies on students' learning motivation have employed the SMQ. The reason is that, while other motivation assessment instruments deal with some specific motivation elements such as efficacy or interest, the SMQ is capable of assessing many key components with just one single set (Zeyer et al., 2013). In addition, there are already many preceding studies employing SMQ (Bryan et al., 2011; Glynn et al., 2009, 2011; Ha & Lee, 2012; Salta & Koulougliotis, 2015; Tosun, 2013), to compare with this present study finding. Lastly, in Korea, test result-related aspects deeply affect students' learning motivation (Kwon, 2016a), and the SMQ also includes test questions assessing such an aspect. So, this study employed Glynn et al.'s (2009) SMQ.

In order to use the SMQ, the researcher requested relevant specialists to translate the questions, review them, and performed a preliminary test and confirmatory factor analysis (CFA). Specific processes thereof are as follows; first, by referring to the translation process presented in Hambleton's (2001) study, the SMQ questions were translated from English to Korean. The researcher requested translation by two Korean English teachers who each had a pedagogy doctorate. Both of them had lived in and English-speaking country (US, UK) for at least 4 years and had plenty of survey translation experiences. The researcher provided the 30 questions in Glynn et al.'s (2009) SMQ separately to each of them for translation. Then, their translation results were compared, and a review was requested for any question item with a difference. They consulted and provided the final translation outcome to the researcher.

Next, to test the validity of translated instrument, validity testing was performed by specialists. The involved specialists were one science education professor, one technology education professor, two teachers with doctorates in science education, two teachers with doctorates in technology education, and three researchers who had published dissertations in South Korea by using SMQ-related test instruments. The researcher of the present study provided the translated the SMQ and they reviewed the question items in a meeting. Two present instructors holding a doctorate in science education were requested to provide advice on instrumental validity. Glynn et al.'s (2009) test tool is consisted of 30 questions in 5 sub-dimensions: Intrinsic motivation and personal relevance (10 questions), self-efficacy and assessment anxiety (9 questions), self-determination (4 questions), career motivation (2 questions), and grade motivation (5 questions). The instrument was designed originally to assess science learning motivation. However in this study, science learning motivation and technology learning motivation were to be measured at the same time. To this end, 30 questions translated to be under science learning motivation were presented to experts for review along with other 30 questions where the word 'science' was replaced with "technology."

In the question review of this research, all 60 questions were reviewed. Experts first presented their opinion that it would be okay to use the questions on intrinsic motivation and personal relevance and self-determination in science learning motivation and technology learning motivation without a change. However, for other elements, they suggested removing some questions. For instance, it seemed difficult to measure career motivation since the original instrument had only two questions on career motivation. In the study by Glynn et al. (2009), the Cronbach's α of grade motivation was as low as 0.55. Even the developers of the instrument viewed question review as being necessary. Lastly, self-efficacy and assessment anxiety questions were reviewed. Experts advised that the questions in these elements could not assess accurately in the South Korean situation because the terms included in the original instrument became slightly ambiguous in the translation process into Korean, potentially confusing responding students. Thus, the experts suggested using only the questions on assessment anxiety among the self-efficacy and assessment anxiety aspects, which are capable of precise assessment.

This study accepted that experts' suggestion and finalized the items of four sub-constructs: intrinsic motivation and personal relevance, self-determination, and assessment anxiety. The complete instrument consisted of the items for the learning science subject and for the learning technology subject; the specific composition is presented in Table 1.

Table 1
Instruments for the Original Study (Glynn et al., 2009) and the Present Study

Original study(Glynn et al., 2009)			Present Study		
Factor	# of Items	Cronbach's α	Factor	# of Items	Cronbach's α
intrinsic motivation and personal relevance	10	0.91	science intrinsic motivation and personal relevance	10	0.92
			technology intrinsic motivation and personal relevance	10	0.93
self-efficacy and assessment anxiety	9	0.88	science assessment anxiety	4	0.82
			technology assessment anxiety	4	0.86
self-determination	4	0.74	science self-determination	4	0.86
			technology self-determination	4	0.85
career motivation	2	0.88	None	-	
grade motivation	5	0.55	None	-	

This study selected these items as the instrument for this study and conducted data collection for a pilot study from 138 high school students. In the pilot study, participants were asked to complete the instrument and write their feedback on administering the survey. The results of the Cronbach's α values turned out to be reliable as follows: Science intrinsic motivation and personal relevance (.90), science assessment anxiety (.81), science self-determination (.84), technology intrinsic motivation and personal relevance (.88), technology assessment anxiety (.85), and technology self-determination (.83). Moreover, this study completed the instrument considering participants' feedback about the instrument.

This present study used the instrument for high school students in 11th grade. The results of the Cronbach's α values turned out to be reliable as follows: Science intrinsic motivation and personal relevance (.92), science assessment anxiety (.82), science self-determination (.84), technology intrinsic motivation and personal relevance (.93), technology assessment anxiety (.86), and technology self-determination (.85).

Finally, this present study performed CFA on the instrument to assess the goodness of fit of the model. As a result, science learning motivation was determined to be a good model, with a comparative fit index (CFI) of .92, Tucker-Lewis index (TLI) of .91, and goodness of fit index (GFI) of .90. Technology learning motivation was a good model, with a CFI of .94, TLI of .93, and GFI. 92, which were all higher than .90. According to Byrne (2010) and Hu and Bentler (1999), the model can be interpreted as a mediocre fit when the values of CFI, TLI, and GFI are all higher than .90. Meanwhile, the root mean square error of approximation (RMSEA) values for science learning motivation and technology learning motivation were .87 and .076 respectively. According to Hu and Bentler (1999), the model was a reasonable fit for .08 and below and a mediocre fit for 1.00 and below. Therefore, the model for science learning motivation was a mediocre fit and the model for technology learning motivation was a reasonable fit. However, No (2014) indicated that the RMSEA was a proper value when it was between 0.05 and 0.1. Thus, two models in this study turned out to be all reasonable fit. Science learning motivation and technology learning motivation were all valid considering all the indexes of this present study.

Concerns related to engineering. This study used a modified version of the instrument that Hall et al. (1977) developed for measuring the stage of concern. This instrument aims to measure how much interest teachers have in adopting a new program or curriculum in seven stages (Stage 0: Awareness, Stage 1: Informational, Stage 2: Personal, Stage 3: Management, Stage 4: Consequence, Stage 5: Collaboration, and Stage 6: Refocusing), with five questions proposed in each stage. These stages were classified into internal concerns (awareness, informational, personal, and management) and external concerns (consequence, collaboration, and refocusing) (Kwon & Chang, 2009; Wells & Anderson, 1997).

This instrument had the same process as the science learning motivation and technology learning motivation with the following steps: Interpretation by an expert group, item selection by an expert group, and a pilot study.

In this study, 15 questions related to external concerns were modified as questions related to concern toward engineering, and the responses were based on a 5-point Likert scale (1 = Strongly disagree, 5 = Strongly agree). In a study that measured teachers' concerns about a curriculum, Hall et al.'s (1977) scale was used to show the stages of teachers' concerns based on a simple statistical method.

Data Analyses

For statistical analysis of the collected data in this study, SPSS 21.0 and AMOS 20.0 were used. First, to validate the instrument, reliability analyses were performed on factors related to science learning motivation, technology learning motivation, and concern related to engineering. In addition, CFA was performed on science learning motivation and technology learning motivation, as they included sub-factors. A T-test was performed to examine gender differences in science learning motivation, technology learning motivation, and concern related to engineering, and correlation analysis was conducted to verify the correlation between these factors. Finally, hierarchical regression analysis was conducted to examine the effects of science learning motivation and technology learning motivation on concern related to engineering.

Findings

The results of the comparison of science learning motivation, technology learning motivation, and concern related to engineering between the two genders are presented in Table 2. The table shows that male students had significantly higher science intrinsic motivation and personal relevance, science self-determination, technology intrinsic motivation and personal relevance, technology self-determination, and concern related to engineering than female students. However, no statistically significant difference in science anxiety or technology anxiety was found between male students and female students.

Table 2
Science Learning Motivation, Technology Learning Motivation, and Engineering Concern by Gender

Variables		Gender	N	*M*	*SD*	*T*	*p*
SLM	SIM	Male	368	3.34	1.00	10.862	.000
		Female	377	2.67	.63		
	SAA	Male	368	2.83	.98	1.123	.262
		Female	377	2.75	.87		
	SSM	Male	368	3.09	.91	5.846	.000
		Female	377	2.74	.70		
TLM	TIM	Male	368	2.98	.92	5.396	.000
		Female	377	2.66	.72		
	TAA	Male	368	3.20	.95	-1.320	.187
		Female	377	3.29	.84		
	TSM	Male	368	2.71	.83	2.200	.028
		Female	377	2.59	.70		
EC		Male	368	47.11	13.00	7.221	.000
		Female	377	40.88	10.33		

SLM: Science Learning Motivation, TLM: Technology Learning Motivation, SIM: Science Intrinsic Motivation and Personal Relevance, SAA: Science Assessment Anxiety, SSM: Science Self-determination Motivation, TIM: Technology Intrinsic Motivation and Personal Relevance, TAA: Technology Assessment Anxiety, TSM: Technology Self-determination Motivation, EC: Engineering Concern.

To examine the correlation of students' technology learning motivation, science learning motivation, and concern related to engineering, the Pearson correlation coefficient technique was used. Table 3 shows the coefficient of correlation for each gender. The results show that in male students, concern related to engineering had a statistically significant positive correlation with science intrinsic motivation and personal relevance, science self-determination, technology intrinsic motivation and personal relevance, and technology self-determination, while it had a significant negative correlation with science anxiety and technology anxiety. These correlations were also found in female students. Although both male students and female students showed negative correlations between science anxiety and technology anxiety and other factors, in male students, some correlations were not statistically significant.

Table 3
Correlation Among Technology Learning Motivation, Science Learning Motivation, Engineering Concern

Variables	1	2	3	4	5	6	7
1.SIM	1	-.164**	.564***	.492***	-.152**	.273***	.522***
2.SAA	-.204***	1	-.192***	-.253***	.600***	-.145**	-.209***
3.SSM	.719***	-.096	1	.345***	-.160**	.432***	.376***
4.TIM	.483***	-.154*	.364***	1	-.320***	.600***	.610***
5.TAA	-.098	.432***	-.098	-.288***	1	-.237***	-.235***
6.TSM	.364***	-.078	.447***	.680***	-.277***	1	.388***
7.EC	.624***	-.212***	.518***	.693***	-.203***	.488***	1

Male	Female
(below diagonal)	(above diagonal)

SIM: Science Intrinsic Motivation and Personal Relevance, SAA: Science Assessment Anxiety, SSM: Science Self-determination Motivation, TIM: Technology Intrinsic Motivation and Personal Relevance, TAA: Technology Assessment Anxiety, TSM: Technology Self-determination Motivation, EC: Engineering Concern.

*$p < .05$, **$p < .01$, ***$p < .001$.

A hierarchical regression analysis was conducted in order to determine which variables were effective in predicting engineering concern. Table 4 shows the results of analyzing the effects of science learning motivation and technology learning motivation on concern related to engineering in male students. Before regression analysis, assumptions were checked. Considering the Durbin Watson value used in testing autocorrelation in the model, it is observed that the value, which was expected to be between 1.5 and 2.5 (Kalaycı, 2006 as cited in Karatas, Arslan, & Karatas, 2014). In this regression model, the Durbin Watson value was 1.810, which was no autocorrelation in the model.

According to Table 4, the model is statistically significant ($p < .001$). In consideration of the explanatory power of the model, it was found that all independent variables explain 59.8% of the total variance ($R = 0.773$, $R^2 = 0.598$, $p < .001$) for concern related to engineering. Predictor variables were examined in accordance with the standardized regression coefficient of the variable (β) and it was determined that technology intrinsic were the most important predictor of concern related to engineering. This variable was followed by the variables of science intrinsic and science determination. The concern related to engineering was not significantly predicted by technology determination. When the levels of technology intrinsic, science intrinsic and science determination increased, the level of concern related to engineering increased and vice versa.

Table 4
Hierarchical Regression Analysis Results for the Variables of Science Learning Motivation and Technology Learning Motivation (Male)

Model	Variables	*B*	*SE B*	*β*	*t*	*R*	R^2	ΔR^2	*F*
1	(Constant)	17.859	1.668		10.708***	.693	.480	.480	336.583***
	Technology intrinsic	9.808	.535	.693	18.346***				
2	(Constant)	9.205	1.723		5.343***	.768	.590	.110	
	Technology intrinsic	7.226	.542	.510	13.321***				261.589***
	Science intrinsic	4.905	.497	.378	9.877***				
3	(Constant)	9.103	1.819		5.005***	.768	.590	.000	
	Technology intrinsic	7.151	.691	.505	10.350***				173.938***
	Science intrinsic	4.900	.498	.378	9.840***				
	Technology determination	.126	.716	.008	.176				
4	(Constant)	7.907	1.853		4.266***	.773	.598	.009	134.773***
	Technology intrinsic	7.536	.699	.532	10.787***				
	Science intrinsic	3.630	.673	.280	5.391***				
	Technology determination	-.590	.755	-.038	-.781				
	Science determination	2.014	.727	.141	2.771*				

*$p < .05$, ***$p < .001$.

Table 5 shows the results of analyzing the effects of science learning motivation and technology learning motivation on concern related to engineering among female students. Before regression analysis, assumptions were checked. In this regression model, the Durbin Watson value was 1.922, which was no autocorrelation in the model.

According to Table 5, the model is statistically significant ($p < .001$). In consideration of the explanatory power of the model, it was found that all independent variables explain 44.0% of the total variance ($R = .663$, $R^2 = .440$, $p < .001$) for concern related to engineering. Predictor variables were examined in accordance with the standardized regression coefficient of the variable (β) and it was determined that technology intrinsic were the most important predictor of concern related to engineering. This variable was followed by the variables of science. The concern related to engineering was not significantly predicted by technology determination and science determination. When the levels of technology intrinsic and science intrinsic increased, the level of concern related to engineering increased and vice versa.

Table 5
Hierarchical Regression Analysis Results for the Variables of Science Learning Motivation and Technology Learning Motivation (Female)

Model	Variables	B	$SE\ B$	β	t	R	R^2	ΔR^2	F
1	(Constant)	17.517	1.625		10.780***	.610	.372	.372	221.721***
	Technology intrinsic	8.794	.591	.610	14.890***				
2	(Constant)	10.293	1.902		5.412***	.660	.436	.064	144.141***
	Technology intrinsic	6.719	.645	.466	10.411***				
	Science intrinsic	4.770	.735	.291	6.493***				
3	(Constant)	9.580	2.058		4.654***	.661	.437	.001	96.323***
	Technology intrinsic	6.328	.776	.439	8.159***				
	Science intrinsic	4.791	.735	.292	6.517***				
	Technology determination	.655	.722	.044	.907				
4	(Constant)	9.007	2.097		4.294***	.663	.440	.003	72.889***
	Technology intrinsic	6.472	.782	.449	8.280***				
	Science intrinsic	4.179	.858	.255	4.868***				
	Technology determination	.271	.773	.018	.351				
	Science determination	1.028	.747	.070	1.376				

***$p < .001$.

Discussion

This study investigated the gender difference among South Korean high school students in science learning motivation, technology learning motivation, and concern related engineering, as well as the correlation between these factors. It also verified effects of the sub-factors of science learning motivation and technology learning motivation on concern related to engineering.

First, the results of this study showed a gender difference in science intrinsic motivation and personal relevance, science self-determination, technology motivation intrinsic and personal relevance, and technology self-determination. In other words, male students had higher motivation for these factors than female students did. This result is inconsistent with the study finding that intrinsic motivation showed no gender difference or higher intrinsic motivation in female students than male students in some groups (Glynn et al., 2011; Salta & Koulougliotis, 2015). However, Bryan et al. (2011) found higher intrinsic motivation in male students who had not completed the AP course than their female counterparts, consistent with this present study's findings. In addition, in their study, self-determination on science or technology was found to be higher in male students than in female students. This result was on the contrary to other study findings that self-determination was higher in female students than male students (Glynn et al., 2009, 2011; Salta & Koulougliotis, 2015). Scholars such as Glynn et al. (2011) and Bryan et al. (2011) estimated that such a gender difference was because of socialization involving parents, teachers, friends, media, etc., rather than being a fundamental difference. In other words, a partial explanation of this result is that individual students have internalized social stereotypes about their abilities (Eccles, Wigfield, & Schiefele, 1998). In previous research, male students perceived that they had a higher level of abilities in mathematics and physical education, which are traditionally associated with masculinity, than female students did; meanwhile, female students perceived that they had a higher level of abilities in reading, English, and social studies, which are traditionally associated with femininity, than male students did (Eccles & Harold, 1991; Eccles et al., 1993; Jacobs et al., 2002; Watt, 2004).

The findings in this study demonstrated that, in South Korea, female students still do not value science and technology highly, and that students have a gender-discriminatory stereotype to the effect that science and technology are male fields. It is indisputable that despite their low expectations in these fields, female students can be as competent as male students in science and technology. Therefore, it is necessary to improve female students' awareness of science and technology. To accomplish this, female students need to understand that science and technology can help in solving many problems in everyday life and that these subjects are important for a wide variety of professions, such as anchorperson or lawyer, as well as for scientists and engineers. In addition, it is important to eliminate gender-discriminatory stereotypes by creating a suitable environment. Today, the social role of women is becoming more important, and women's professional are expanding as well. Now, we can find female professionals working as astronauts, CEOs at science-related companies, engineers, doctors of medicine, and engineers. Science and technology teachers need to instruct female students in such a manner that they develop positive perceptions of science, technology, and engineering. Moreover, the social environment must be improved so that female students overcome the social prejudice that limits their careers in science, technology, and engineering fields.

Second, the results of this study suggested that in both male students and female students, the sub-factors of learning motivation, science intrinsic motivation and personal relevance, science self-determination, technology intrinsic motivation and personal relevance, and technology self-determination had positive correlations with each other. This finding is consistent with the research finding that intrinsic motivation and self-determination had a positive correlation (Glynn et al., 2009; Salta & Koulougliotis, 2015). In addition, the study has found negative correlations of technology assessment anxiety and science assessment anxiety with other motivational elements. The finding is consistent with the study finding that science assessment anxiety had a negative correlation with other motivational elements (Britner & Pajares, 2006). This indicates plenty of correlations of technology motivation with science motivation. Accordingly, it is necessary to form close cooperation between relevant teachers and instructors for educational curriculum or content organization to help enhance students' learning motivation.

Positive correlation was found between concern related to engineering and motivational elements such as science intrinsic motivation and personal relevance, science self-determination, technology intrinsic motivation and personal relevance, and technology self-determination. This finding is partially consistent with the study finding that students with stronger technology learning motivation showed a positive attitude to engineering (Kwon, 2016b). Based on the study findings, the concern related to engineering was found to have strong relationships with science learning motivation and technology learning motivation. It was found that motivation is necessary for subjects including science and technology in order to induce high school students' concern related to engineering. To enhance students' learning motivation, it is necessary to introduce not only the basic science but also related applied science while providing detailed information on related jobs (Ha & Lee, 2012). In addition, it is necessary to provide engineering as part of re-training programs for science and technology teachers and to include various engineering-related courses in curriculums designed to foster instructors' teaching of technology subjects.

Third, the results of this study suggested that the factors that had an effect on concern related to engineering, in both male students and female students, were intrinsic motivation and personal relevance in technology. In other words, improving intrinsic motivation in technology subjects can induce students' concern related to engineering.

These findings can be discussed in terms of improving intrinsic motivation, as proposed by scholars like Pintrich and Schunk (2002) and Alderman and Beyeler (2008). First, it is necessary to provide students with the freedom and opportunity to choose assignments. In technology subjects, generally, assignments are proposed according to the textbook or teacher. However, it is more helpful to allow students to choose the type and level of assignments. Even if multiple assignments are not available, it is at least necessary to enable them to choose the approach, order, or procedure used in an assignment. Second, it is necessary to provide specific and instructional feedback concerning the results of their performance. It is good to provide feedback as soon as possible, especially by informing them as to what aspects were of good or insufficient qualitatively rather than comparing their performance with that other students. Third, it is necessary to adjust the difficulty of assignments according to students' ability. For instance, in this study, a gender difference was found in the sub-factors of science learning motivation and technology learning motivation. Therefore, it is advisable to give assignments at an adequate level because assignments that are too easy can interfere with inducing curiosity in male students, for instance. In contrast, for female students, it is necessary to give them assignments of a lower level of difficulty so that they will have more opportunities to succeed.

This research is limited in generalizability of its findings for reasons as follows. The study investigated students in six high schools in large cities of South Korea. Korea has a unique situation in that a very large proportion of high school students enter colleges. Accordingly, the findings presented in this research could be different from the learning motivation status in students outside Korea. Moreover, in this study, students' learning motivation was measured according to the social cognitive theory. Therefore, the sub-elements of learning motivation may different from those under other motivation theories. In this sense, any related interpretation needs to be carefully implemented.

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