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Effect of Middle School Students' Motivation to Learn Technology on Their Attitudes toward Engineering

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The purpose of this study was to investigate the effect of motivation to learn technology, as perceived by South Korean middle school students, on their attitudes toward engineering. Using the instruments of Glynn et al. (2011) and Lee (2008), the study focused on eighth and ninth grade students in four middle schools located in South Korea's larger cities. The study identified a positive correlation between middle school students' motivation to learn technology and their attitudes toward engineering. Also, the engineering interest was found to be mostly affected by motivation to learn technology; and the engineering curriculum and engineering consequence, by career motivation. Based on the educational implications of these study findings, this essay discusses the implementation of engineering in the middle school technology curriculum.

Keywords: motivation, technology education, k-12 engineering education, Republic of Korea

INTRODUCTION

In general, the motivation to learn, coupled with sufficient interest in the study contents, drives students to continue engaging with the learning process in order to achieve their study goals (Autio, Hietanoro & Ruismäki, 2011). Each subject contains diverse elements that can help motivate students to study it further.

Technology as a subject is no exception, and one of the ways it can enhance students' motivation to learn is through the incorporation of engineering in the technology curriculum. This is primarily a function of the global educational trend to teach engineering as part of the middle school curriculum (Katehi, Pearson, & Feder, 2009). Also, the inclusion of more detail in technology courses has led to a new emphasis on engineering in the technology curriculum (Clark & Ernst, 2008; Lewis, 2004; Wicklein, 2006). It is hoped that if the social status of technology as a subject improves in line with other major study subjects or if there is greater awareness that technology is helpful for students wishing to study natural sciences and

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engineering, students' motivation to learn technology will be enhanced.

A number of attempts have already been made to incorporate engineering into South Korean technology educational programs, and this has certainly led to more positive attitudes toward engineering. For example, Sung and Na (2012) conducted a technology education program for high school students featuring engineering content, while Moon (2009) and Jung (2012) offered similar initiatives for elementary school students. Furthermore, Kim et al. (2013) taught middle school students technology by connecting the contents with engineering. These attempts to integrate engineering with technology were found to have brought about a positive change in students' attitudes toward engineering.

As mentioned above, there has been a significant drive in recent times to reinforce engineering in the technology education curriculum with a view to improving students' learning motivation. It was found that when engineering was reflected more in the technology curriculum, students' attitudes toward engineering changed positively. Based on this finding, it can be deduced that the motivation to learn technology is closely linked with students' attitudes toward engineering. However, no academic study has yet been carried out on the relationship between students' motivation to learn technology and their attitudes toward engineering.

If the relationship between technology-learning motivation and attitudes toward engineering is successfully identified, it can be utilized to bring about a positive change in students' attitudes toward engineering. This is why we need to identify the motivational technology-learning factors that have a positive effect on students' attitudes to engineering and explore ways to increase them. To this end, the current study seeks to examine the relationship between technology-learning motivation and attitudes to engineering, as well as the effect of technology-learning motivation on attitudes toward engineering. To achieve these study objectives, the following research topics were established:

First, what is the relationship between middle school students' technology-learning motivation and attitudes toward engineering?

Second, what is the effect of middle school students' technology-learning motivation on attitudes toward engineering?

State of the literature

- Diversified research on learning motivation has been pursued for every study subject
- Diverse studies have also been carried out on the subject of technology in an attempt to understand students' learning motivation.
- The motivation to learn in a specific study subject is known to be linked with attitudes toward the corresponding subject area

Contribution of this paper to the literature

- Attempts have made in South Korea to incorporate engineering for K-12 students as part of the technology subject
- In South Korea, diverse research experiments have been conducted on attitudes toward engineering because a study tool exists for this purpose
- To facilitate a more meaningful educational discussion on the incorporation of engineering in technology education, a study is necessary to investigate the causal relationship between technology-learning motivation and attitudes toward engineering

THEORETICAL BACKGROUND

Technology-learning motivation

Learning motivation refers to "the enduring disposition of students to enjoy the process of learning and take pride in the outcomes of experience involving knowledge acquisition or skill development." (Brophy, 1983, p. 200). Learning motivation is known to exert a positive influence on learning behavior and academic achievement by supporting learners to continue their learning process and strengthen their interest in the subject contents in order to achieve their set study goals (Mitchell, 1992; Pajares, 2001, 2002). For this reason, diversified research on learning motivation has been pursued for every study subject (Bryan, Glynn, & Kittleson, 2011; Halat, Jakubowski, & Aydin, 2008; Glynn, Taasoobshirazi, & Brickman 2007, 2009; Shihusa & Keraro, 2009; Singh, Granville, & Dika, 2002; Tuan, Chin, & Shieh, 2005; Ulusoy & Onen, 2014; Zusho, Pintrich, & Coppola, 2003).

Diverse studies have also been carried out on the subject of technology in an attempt to understand students' learning motivation. Rasinen et al. (2009) explored ways to improve the interest and motivation of female elementary school students in the subject of technology. In that study, the researchers suggested the need to develop various kinds of educational programs for the technology curriculum that would take gender-based differences into consideration. Chatoney and Andreucci (2009) also proposed the need for a teaching approach reflecting female students' individual characteristics and supporting their learning processes in order to motivate them to study technology. Autio, Hietanoro, and Ruismäki (2011) conducted a qualitative case study and established that freedom of choice was the most important factor affecting students' motivation to choose technology as an area of study. In another study, Campbell and Jane (2010) evaluated children's language during their designing activity in the technology class to analyze the students' motivation to participate in the class. The results showed that the satisfaction of engaging in activity and completing the work was the most important motivational factor. Similarly, Lawanto and Stewardson (2013) investigated students performing two engineering design projects in order to ascertain the factors that made them interested (intrinsic goal orientation, extrinsic goal orientation, and task value) and the factors relating to success expectancy (control of learning beliefs, and self-efficacy for learning and performance). The study found that intrinsic goal orientation and task value were the major predictors influencing the success expectancy of the students performing the engineering design projects. Moreover, the researchers found that such engineering activities could help to enhance student motivation. Weber (2012) studied middle school students' STEM-related activities and found that diverse, engineering-related activity could elevate students' motivation to engage in the subject of technology. Additional studies have also been carried out on similar topics, including one reporting that students were motivated by engineering design projects at the middle/high school level (Fantz & Grant, 2013) and another stating that the achievement of high school students during their engineering tasks was a factor that predicted their technology-learning motivation (Mentzer & Becker, 2009).

One of the implications of the above studies is that engineering should be incorporated in technology education to achieve enhanced student motivation for technology learning. This is important because the technology curriculum is helpful for students who wish to study engineering, and it may also motivate more students to take up the study of technology (Wicklein, 2006).

Attitudes toward engineering

In general, attitude can be defined as "a summary evaluation of a psychological object captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likable-dislikable." (Ajzen, 2001, p. 28). Attitude is stable and difficult to change once formed, particularly when it relates to a specific context such as sustainable energy or nuclear energy plants (van Aalderen-Smeets, Walma van der Molen, J. H., & Asma, 2012). This study defines attitudes toward engineering as attribute dimensions including good-bad, harmful-beneficial, pleasant-unpleasant, and likable-dislikable, and how they relate to K-12 students engaged in engineering studies.

Globally, there have been few studies on K-12 students' attitudes toward engineering, mainly because engineering is primarily a subject at the university level and because no instrument has been available to measure attitudes toward the subject. While instruments have been developed more recently to measure attitudes toward engineering (Han & Carpenter, 2014; Guzey, Harwell, & Moore, 2014; Unfried, Faber, Stanhope, & Wiebe, 2005), their main focus is not on engineering itself but on attitudes to various subjects including science, math, technology, and engineering. Thus, there has been no in-depth discussion on engineering itself, and no study has utilized such tools to examine engineering attitudes.

In contrast, attempts have been made in South Korea to incorporate engineering for K-12 students as part of the technology subject. Also, experimental studies have been carried out to investigate changes in students' attitudes toward engineering. For instance, Jung (2012) developed and applied a Capstone design-based engineering program for elementary school students, and tested the program's effectiveness. In this research, the experimental group showed a significant increase in attitudes toward engineering compared to the control group. Moreover, Moon (2009) conducted a research experiment on elementary school students based on the theme, "My own humidifier," where students learned about the engineering principles used in humidifiers and developed their own prototype. This experiment brought about a positive change in the students' attitudes to engineering. Kim et al. (2013) conducted an engineering activity for middle school students where they photographed the earth using a successful case of earth photography via digital camera and mobile phone as a reference. Those researchers also found a significant positive increase in students' attitudes to engineering. In a study by Sung and Na (2012), the researchers experimented with the application of engineering-reinforced educational programs in the high-school technology curriculum, and the results showed a significant increase in students' positive attitudes to engineering.

As shown above, several research experiments have been conducted in South Korea on attitudes toward engineering. These studies all relate to technology education. In other words, they were all conducted by technology education researchers and published in South Korean technology education journals. What the studies had in common was that students' attitudes toward engineering was changed as a result of the incorporation of engineering in technology education. Specifically, the study findings showed a positive change in attitudes toward engineering.

In South Korea, diverse research experiments have been conducted on attitudes toward engineering because a study tool exists for this purpose. The tool in question is Lee's (1999, 2008) examination tool, which was modified to assess attitudes to engineering. His study tool is a Korean version of the tool used in the Pupils' Attitudes Towards Technology (PATT) project (Ardies, De Maeyer, & Gijbe, 2014; Van Rensburg, Ankiewicz, & Myburgh, 1999; Volk & Yip, 1999; Yu, Lin, Han, & Hsu, 2012) that has already been conducted several times internationally. Researchers investigating attitudes toward engineering in South Korea typically replaced "technology" with "engineering" in Lee's (1999, 2008) survey questions to assess attitudes toward engineering.

Relationship between technology-learning motivation and attitudes toward engineering

In general, the motivation to learn in a specific study subject is known to be linked with attitudes toward the corresponding subject area. For instance, Gardner (1975), in his meta-analysis of attitudes toward science, suggested a relationship between the motivation to accomplish in science and attitudes toward science. In their study of sixth to tenth grade elementary students, Simpson and Oliver (1985) found that the students' motivation to achieve in science decreased and their attitudes toward science disimproved as the school year advanced, which indicated a strong correlation between motivation to achieve and attitudes toward science. Mata, Monteiro, & Peixoto (2012) suggested that motivation-related variables were the prediction variables needed to estimate attitudes toward mathematics. Also, Singh et al. (2002) found that students' motivation affected their attitudes toward math and science, while Cavas (2011) found that students with a strong motivation for science study showed more positive attitudes toward science than those without. Gungor, Eryılmaz, & Fakıoglu (2007) found that students' attitudes toward science affected their motivation to study science.

Given that technology for K-12 students largely relates to engineering (Fantz & katsioloudis, 2011; Gattie & Wicklein, 2007), it can be assumed that technology-learning motivation is positively linked with attitudes toward engineering. However, no study has been conducted to look directly at the relationship between technology-learning motivation and attitudes toward engineering, although some studies have reported a positive change in attitudes to engineering arising from engineering-related activity in the study of technology (Fantz & Grant, 2013; Lawanto & Stewardson, 2013). In view of this, the most we can do is infer a possible positive effect of technology-learning motivation on engineering attitudes based on such studies (Jung, 2012; Kim et al., 2013; Moon, 2009; Sung & Na, 2012). In this case, to facilitate a more meaningful educational discussion on the incorporation of engineering in technology education, a study is necessary to investigate the causal relationship between technology-learning motivation and attitudes toward engineering.

METHOD

Study subjects

To investigate the relationship between middle school students' technology-learning motivation and their attitudes toward engineering, the present study surveyed 370 middle school students in four regions of large cities in South Korea between December 10 and December 31, 2014. Of the collected survey questionnaires, 334 were utilized for the research analysis, excluding 36 with poor or omitted answers. In relation to the gender distribution of the research subjects, 149 students (44.6%) were male and 185 (55.4%) were female. Regarding school years, 141 (42.2%) were eighth graders and 193 (57.8%) were ninth graders.

Instrument

Technology-learning motivation

The instrument used to assess technology-learning motivation in the current study was the tool designed by Glynn, Brickman, Armstrong, & Taasoobshirazi (2011). This instrument consists of five sub-dimensional motivational factors, namely, intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation. Each factor has five questions, giving a total of 25 questions. This instrument was originally produced to assess university students' motivation for science, but it has been utilized in a number of studies to assess middle and high school students' learning motivation (Salta & Koulougliotis, 2015; Tosun, 2013). The developers of the instrument specified that it could be applied to other disciplines, and in fact, one such study experiment used the instrument by replacing science with chemistry in order to assess chemistry-learning motivation (Salta & Koulougliotis, 2015; Tosun, 2013). Based on these precedents, it was deemed valid to assess technology-learning motivation using the above instrument. Thus, "science" was replaced with "technology" in the questionnaire and the questions were rephrased to fit with the middle school level. Each question was to be answered on a 5-point Likert scale (score 1: not at all ~ score 5: very much so). For instrument validation, the number of components was set at five here, and exploratory factor analysis (EFA) was then conducted by utilizing principal axis factoring analysis and the varimax method. As a result, six questions were excluded due to overlap, with 19 items remaining. The number of extracted questions and the variance were grade motivation (five items, 19.67%); career motivation (five items, 18.10%); self-determination (three items, 12.37%); intrinsic motivation (three items, 11.85%); and self-efficacy (three items, 10.00%). Also, the total variance was 71.99%. For grade motivation, the factor reliability (Cronbach's alpha) was .90; for career motivation, it was .88; for self-determination, it was .81; for intrinsic motivation, it was .83; and for self-efficacy, it was .77. These factors all recorded high values. Lastly, confirmatory factor analysis (CFA) was conducted for the instrument to assess model fitness. As a result, x^2/df was 2.492, was less than 3, and represented a good fitness level (Kline, 2011). Also, the comparative fit index (CFI) and goodness-of-fit (GFI) value were each higher than .90, at .939 and .906, respectively, which indicated good fitness levels (Byrne, 2010; Hu & Bentler, 1999). The root mean square error of approximation (RMSEA) value was under .08, at .067, showing a reasonable fit level (Hu & Bentler, 1999). Based on the above findings, the instrument for assessing technology-learning motivation was found to be valid.

Attitudes toward engineering

In this study, the instrument used to assess attitudes toward engineering was Lee's (2008) instrument, for which the US version of the PATT (Pupils' Attitudes Toward Technology) was adapted. This instrument was used to measure attitudes toward technology among K-12 students and consisted of 58 questions in six sub-factors. It has already been adapted for multiple South Korean studies through the replacement of technology with engineering, and used to assess students' attitudes toward engineering (Jung, 2012; Kim et al., 2013; Moon, 2009; Sung & Na, 2012). The researcher of the present study requested advice on changing Lee's (2008) instrument to an attitudinal one from five experts including a technology education professor, an engineering education professor, and three current in-service technology teachers with at least ten years of education experience and a master's degree or higher. Originally, Lee's (2008) instrument consisted of six sub-factors, but any factors that were difficult to view as general attitudes toward engineering or that overlapped with technology-learning motivation were excluded. As a result, three sub-factors in terms of engineering attitudes were chosen, namely, engineering interest, engineering consequences and engineering curriculum. Subsequently, the details of each remaining question were checked, and sentences with errors due to the replacement of technology with engineering were removed. Following these actions, the questions finally selected consisted of engineering interest questions (five items); engineering consequence questions (seven items); and engineering curriculum questions (five items). This led to a total of 17 items. Each item was to be answered on a 5-point Likert scale (score 1: not at all ~ score 5: very much so).

The researcher set the factor number to three for instrument validation and conducted EFA based on the principal axis factor analysis method and the varimax method. As a result, three questions were removed due to cross-loading, which left 14 questions in the final setup. Concerning the extracted question numbers and variance, the final instrument comprised the following items: engineering interest (four items, 20.41%); engineering consequence (six items, 23.68%); and engineering curriculum (four items, 16.11%). The total variance was 60.20%. The factor reliability (Cronbach's alpha) for engineering interest was .83; for consequences of engineering, it was .80; and for engineering curriculum, it was .78, indicating reliable levels. CFA was conducted on the instrument to evaluate model fitness. As a result, x^2/df was 2.764, was lower than 3, and showed good fitness (Kline, 2011). The CFI and GFI values were higher than .90, at .926, and .916, respectively, representing good fitness (Byrne, 2010; Hu & Bentler, 1999). In addition, the RMSEA value was under .08, at .073, showing a reasonable fit level (Hu & Bentler, 1999). These results indicated the validity of the instrument for assessing attitudes toward engineering.

Data analysis method

The data collected for this study were processed with the SPSS 21.0 program for frequency analysis, EFA, reliability analysis, correlation analysis, and multiple regression analysis. The AMOS 20.0 program was employed to perform CFA. The two major analysis methods used in this study were Pearson correlation analysis to investigate the relationship between middle school students' technology-learning motivation and attitudes toward engineering, and stepwise multiple regression analysis to examine the effect of technology-learning motivation on attitudes toward engineering.

STUDY RESULTS

Relationship between middle school students' technology-learning motivation and attitudes toward engineering

To identify the relationship between technology-learning motivation, as perceived by middle school students, and their attitudes toward engineering, Pearson correlation analysis was conducted. The results (see Table 1) indicate a significant correlation between the sub-factors of technology-learning motivation and the sub-factors of attitudes to engineering in middle school students. Specifically, at the significance level $p<.01$, a positive correlation (.42~.63) was observed between the technology-learning motivation sub-factors; a positive correlation (.38~.62) was observed between the attitude to engineering sub-factors; and a positive correlation (.26~.65) was observed between technology-learning motivation sub-factors and the sub-factors of attitudes to engineering. As such, the correlation values among all factors were smaller than .08, proving that there was no problem in terms of multicollinearity.

Effect of middle school students' technology-learning motivation on attitudes toward engineering

Effect of technology-learning motivation on interest in engineering

Table 2 shows the effect on engineering interest—the sub-factor of engineering attitude—of the sub-factors of technology-learning motivation (intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation). The

Table 1 Correlation between technology learning motivation and engineering attitude

	1	2	3	4	5	6	7	8
1. Self-efficacy	1							
2. Self-determination	.63**	1						
3. Intrinsic motivation	.62**	.55**	1					
4. Grade motivation	.63**	.55**	.42**	1				
5. Career motivation	.59**	.42**	.63**	.43**	1			
6. Engineering interest	.47**	.42**	.65**	.26**	.56**	1		
7. Engineering curriculum	.42**	.41**	.50**	.30**	.48**	.62**	1	
8. Engineering consequence	.37**	.38**	.34**	.35**	.40**	.38**	.55**	1
M	9.35	9.50	9.37	17.01	15.78	11.01	12.19	21.12
SD	2.23	2.29	2.52	4.00	3.78	2.83	2.52	3.46

$^{**}p<.01$

analysis results showed that the sub-factors of technology-learning motivation could explain about 45.9% (R^2=.459) of interest in engineering. Of that percentage, intrinsic motivation had the largest explanatory power, at 42.2%. When career motivation was added, this rose by 3.7% to reach 45.9% of the total. In other words, in terms of the relative explanatory power of interest in engineering, intrinsic motivation was found to be the strongest influence, followed by career motivation. For the F value, 22.660 was found to be significant, at p<.001, indicating the validity of this regression model. The tolerance limits of the independent variables were higher than .1, at .603 and .603 for each, which indicates no problem in multicollinearity. The Durbin-Watson value of 2.094 was closer to 2, showing no correlation among the residuals in support of regression model validity.

Effect of technology-learning motivation on the engineering curriculum

Table 3 shows the effects of the technology-learning motivation sub-factors on the engineering curriculum, which was a sub-factor of attitudes to engineering. Here, the technology-learning motivation sub-factors were found to explain 31.6% (R^2=.316) of the engineering curriculum. Of this percentage, career motivation was 25.0%, the highest explanatory power of the engineering curriculum. When self-determination was added, this rose by 4.7% to give an explanatory power of 29.7%. Also, when grade motivation was added, this rose by a further 1.9% to yield a 31.6% explanatory power for the engineering curriculum. In other words, regarding the relative explanatory power of the independent variables affecting the engineering curriculum, career motivation, self-determination, and grade motivation in this order were found to affect it most. In addition, an F value of 8.896 was found to be significant at p<.01, supporting the validity of the regression model. The tolerance limits of the independent variables were .504, .596, and .692, which were higher than .1 and therefore presented no problem in multicollinearity. The Durbin-Watson value was 2.087, which was closer to 2, showing no correlation among the residuals. Thus, the regression model was deemed valid.

Effect of technology-learning motivation on consequences of engineering

Table 4 shows the effect of the technology-learning motivation sub-factors on engineering consequences, a sub-factor of attitude to engineering. It was found that the technology-learning motivation sub-factors had 22.8% (R^2=.228) of the

Table 2. Regression analysis of engineering interest about technology learning motivation

Dependent variable	Independent variable	B	β	t	ΔR2	Multicollinearity	
						Tolerance	VIF
Engineering interest	(constant)	2.898		5.610***			
	Intrinsic motivation	.554	.493	9.478***	.422	.603	1.659
	Career motivation	.186	.248	4.760***	.037	.603	1.659
R=.678, R^2=.459, adjusted R^2=.456, F=22.660, p=.000, Duribin-Wastson=2.094							

****p<.001*

Table 3. Regression analysis of engineering curriculum about technology learning motivation

Dependent variable	Independent variable	*B*	*β*	*t*	*ΔR²*	Multicollinearity	
						Tolerance	VIF
Engineering curriculum	(constant)	5.425		9.333***			
	Career motivation	.246	.246	3.830***	.250	.504	1.982
	Self-determination	.175	.261	4.429***	.047	.596	1.679
	Grade motivation	.180	.163	2.983*	.019	.692	1.446
R=.562, R^2=.316, adjusted R^2=.309, F=8.896, p=.003, Duribin-Wastson=2.087							

**p<.05 ***p<.001*

Table 4 Regression analysis of engineering consequence about technology learning motivation

Dependent variable	Independent variable	*B*	*β*	*t*	*ΔR²*	Multicollinearity	
						Tolerance	VIF
Engineering consequence	(constant)	12.538		14.060***			
	Career motivation	.240	.262	4.752***	.161	.768	1.302
	Self-determination	.308	.204	3.415***	.056	.658	1.519
	Grade motivation	.109	.127	2.108*	.011	.648	1.543
R=.477, R^2=.228, adjusted R^2=.221, F=4.442, p=.036, Duribin-Wastson=1.721							

**p<.05 ***p<.001*

explanatory power for engineering consequences. Of this percentage, career motivation had 16.1% of the explanatory power, which was the highest value. Also, when self-determination was added, this rose by 5.6% to reach 21.7%. When grade motivation was added, this went up by 1.1% to 22.8%. In other words, in terms of the relative explanatory power of the independent variables affecting engineering consequences, career motivation, self-determination, and grade motivation in that order were found to affect it most. The F value of 4.442 was found to be significant at $p<.05$, supporting the validity of this regression model. The tolerance limits of the independent variables were higher than .1, at .768, .658, and .648, indicating no problem in multicollinearity. The Durbin-Watson value was closer to 2, at 1.721, representing no correlation among the residuals. Thus, the regression model was deemed valid.

CONCLUSION AND DISCUSSION

This study sought to identify the relationship between middle school students' motivation to learn technology and their attitudes toward engineering. It also aimed to examine the effects of technology-learning motivation on attitudes toward engineering. The main study findings are as discussed below.

First, the correlation between middle school students' technology-learning motivation and their attitudes toward engineering was investigated, and a positive correlation was found between technology-learning motivation and attitudes toward engineering. This is because the study of technology is closely related to the study of engineering, and technology typically deals with engineering-related content (International Technology Education Association, 2000). For that reason, the higher the technology-learning motivation, the more positive the attitudes toward engineering. In South Korea middle school, in particular, technology features engineering content in the form of construction technology, information and communication technology, manufacturing technology, transportation technology, and biotechnology (National Curriculum Information Center, 2015). For this reason, it was found that the higher the students' motivation to learn technology, the more positive their attitudes toward engineering. Prior studies attempted to reinforce engineering programs in the subject of technology to stimulate technology-learning motivation (Fantz & Grant, 2013; Lawanto & Stewardson, 2013). These studies show that it is necessary to provide diversified programs with engineering factors incorporated in technology in order to change students' attitudes toward engineering.

Second, this study also investigated the effect of middle school students' technology-learning motivation on interest in engineering, which was a sub-factor of engineering attitude. Intrinsic motivation was found to have the greatest effect. This finding indicates that the motivation to like learning technology in nature had the greatest effect on interest in engineering. In this sense, to improve middle school students' interest in engineering, the intrinsic motivation to study technology needs to be strengthened. Other literature reported that an enthusiastic attitude on the part of teachers helped improve students' intrinsic motivation (Cecchini et al., 2001; Patrick, Hisley, & Kempler, 2000). Therefore, teachers need to develop enthusiasm in order to identify individual students' characteristics and provide appropriate learning accordingly. Moreover, in South Korea, as part of efforts to enhance students' intrinsic motivation, problem-solving activities were introduced in 2013 to each unit of the technology subject in middle school (National Curriculum Information Center, 2015). Solving such activities enables students to gain firsthand experience of problem solving. Also, since this hands-on experience of activities can show individual differences to a large extent, diversified problems need to be introduced according to different student levels. A further aspect of these activities is that they should feature teamwork based on cooperation. Thus, in order to elevate intrinsic student motivation, teaching-learning methods should focus on team features.

Third, middle school students' technology-learning motivation was investigated here to look at its effect on engineering and the school engineering curriculum. The results indicated that career motivation was found to have the greatest effect of the engineering curriculum. Career motivation, in turn, was found to have the strongest effect on engineering consequences. This finding indicates that technology-related career motivation has the greatest effect on attitude factors such as positive engineering consequences and demand for engineering in the curriculum. Therefore, to enhance the attitudinal factors relating to engineering, such as positive engineering consequences or the engineering curriculum of middle school students, technology-related career motivation needs to be reinforced. The most basic method for reinforcing students' career motivation is to include details of technology-related jobs in the curriculum. Traditionally, one of the most important functions of technology has been career exploration (Zuga, 1989). Presently, the school technology curriculums for seventh to ninth graders in South Korea explore relevant careers in each subject area as part of its achievement standard (National Curriculum Information Center, 2015). However, due to textbook space limitations, only certain career details can be offered. Thus, it is up to individual teachers in schools to introduce information on more diverse and relevant professions to students. To this end, additional career-related educational data materials or technology curriculum-related career experience programs should be developed.

Based on the above study findings, it is evident that middle school students' attitudes toward engineering relate to their motivation to learn technology. Specifically, intrinsic motivation was found to affect students' interest in engineering, while career motivation was found to affect the engineering curriculum or engineering consequences. Therefore, to bring about a positive change in middle school students' attitudes toward engineering, methods for improving technology-learning motivation or methods that are relevant to the curriculum need to be considered here.

The researcher's recommendations for further study are as follows: First, this study investigated eighth and ninth graders in middle school, but subsequent studies will need to focus on high school students, who tend to have more specific career plans. In other words, since the connection of technology as a subject with engineering has recently been reinforced in South Korea through the inclusion of more engineering-based content such as creative engineering, high school students will need to be investigated to assess the relationship between their technology-learning motivation and their attitudes toward engineering so that appropriate teaching-learning strategies can be devised to suit their circumstances. Second, the present study did not assess differences in this subject area according to student gender or students' desired study areas. Thus, subsequent studies need to examine group-specific characteristics because, for example, student participation differs according to gender (Chatoney & Andreucci, 2009; McCarthy, 2009; Mitts, 2008; Sanders, 2001) and student achievement differs according to the students' desired study areas (Lawanto & Stewardson, 2013). Based on subsequent studies considering students' gender or desired careers, more appropriate ways to improve technology-learning motivation and attitudes to engineering can be explored.

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