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Technology Teachers' Motivation toward Teaching Biotechnology

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<Abstract>

Due to the importance of biotechnological literacy, the educational community in fields such as technology education, science education, and agricultural education has acknowledged the importance of biotechnology instruction for secondary school. Although recognized as a content organizer in the field of technology education, the actual teaching of biotechnology has not been broadly implemented in technology education classes. In the perspective of expectancy-value theory, technology teachers' motivation is the key factor for affecting the biotechnology instruction. This study investigates Korean technology teachers' motivational beliefs toward biotechnology and its instruction and their perceived ability and value toward biotechnology learning contents. To measure their motivational beliefs and attitudes, a composite on-line survey (fifteen motivational beliefs items, eight biotechnology content items, and related demographic items) was developed. Based on 114 Korean technology teachers' responses the researcher performed a descriptive analysis, independent t-test, and factor analyses (exploratory and confirmatory factor analysis using M-plus 5.0 and SPSS 16.0). Korean technology teachers' abilities toward eight biotechnology contents indicated lowscores while their values were relatively high. Through the independent sample t-test by two demographic variables (gender and professional development), this study found several significant differences in the perceived value. As a preliminary finding of exploratory factor analysis, fifteen items was separated into two motivational constructs of expectancy (6 items) and value (8 items). One item (item #6) was eliminated due to the cross loading. The final findings of this study may have significant implications for professional development regarding biotechnology and its instruction (both in-service and pre-service training) of technology teachers. Also, the confirmatory facctor analysis supported the preliminary finding. Finally, this study recommends that a validity test for other population, investigation for motivational sub-constructs, and in-depth investigation toward biotechnology instruction.

Keywords : Biotechnology, Motivation, Factor Analysis, Expectancy-Value Theory

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I. Introduction

Modern biotechnology is central to human innovation and the future. The significance of biotechnology has caused society to focus on increasing public awareness about the benefits and impact of biotechnology through the educational process (Project 2061 Panel report, 1989; Wells, 1994). The educational community at large and specific fields of education such as technology education (Savage & Sterry, 1991; Wells, 1994; ITEA, 2000), science education (Leslie & Schibeci, 2003; Steele & Aubusson, 2004), and agriculture education (Wilson, Kirby, & Flower, 2000) have realized the importance of teaching about biotechnology at the secondary level. Initial efforts have focused on including biotechnology in the field of technology education suggested it be a fourth and equal content organizer alongside transportation, production, and communication as presented in *A Conceptual Framework for Technology Education*(Savage & Sterry, 1991). For nearly two decades, there have been continuous efforts by the Technology Education organization to establish a background for biotechnology education in technology education programs (Wells, 1994; ITEA, 1996; ITEA, 2000). However, compared to most content organizers for technology education, biotechnology is a relatively new (Russell, 2003; Wells & Kwon, 2008).

Although recognized as a content organizer in the field of technology education and included in the Standards for Technological Literacy (ITEA, 2000), the actual teaching of biotechnology has not been broadly implemented in technology education classes (Brown, Kemp, & Hall, 1998; Sanders, 2001; Russell, 2003). Although several studies emphasized a need for teacher professional development associated with biotechnology instruction at both the pre-service and in-service levels, reasons that biotechnology is not being taught to a greater extent than currently in technology education classes remain unclear (Brown, et al., 1998; Dunham, Wells, & White, 2002; Scott, Washer, & Wright, 2006). However, Brown, et al. (1998) did indicate that outside factors such as school setting, appropriate laboratories and related administrative support were probable factors. Furthermore Wells and Kwon (2008) pointed out teachers' misconceptions likely resulted from insufficient professional development necessary for teaching biotechnology content.

In response to its growing significance in society, biotechnology content recently became an accepted content organizer in technology education in South Korea (Korea Institute of Curriculum and Evaluation [KICE], 2002; Lee, 2008; Yi, Lee, Chang, & Kwon, 2006). Yet, in spite of continuous efforts to incorporate biotechnology in technology education programs and national curriculum emphasizing the instruction of biotechnology, it has not been broadly implemented in technology education classrooms (KICE, 2002). Identifying the reasons for this problem, the several studies alluded to insufficient opportunities for professional development of technology teachers, lack of school and administrative support systems, and teachers' many misconceptions related to biotechnology as possible factors (Lee, 2008; Yi & Kwon, 2008). Among these tentative factors affecting the implementation of biotechnology instruction, Korean technology teachers' motivation could be a key factor. This study was designed to investigate Korean technology teachers' motivation toward biotechnology and its instruction.

1. Research Questions

The purpose of this study was to investigate Korean technology teachers' motivation toward biotechnology teaching with a focus of motivation theory. More specifically, the study intended to answer the following research questions. Regarding research question 1, there were two research sub-questions to describe technology teachers' perceived ability and value toward biotechnology contents

1. What is the Korean technology teachers' perceived ability and value toward biotechnology contents for the secondary school level Technology Education?
   1) What is their overall perceived ability and value toward biotechnology contents?
   2) Are there statistically significant differences in two demographic categories (gender, years &participation of professional development related to biotechnology content)?
2. What is the number of underlying factors of Korean technology teachers' motivation related to the implementation of biotechnology instruction?
3. What are the identified factors for Korean technology teachers' motivation related to the implementation of biotechnology instruction?
4. How the identified factors of Korean technology teachers' motivation do match the expectancy-value theory?

2. Definition of Terminologies

1) Biotechnology

Confusion regarding the definition of biotechnology was addressed by the Office of Technology Assessment (OTA, 1988) and found to be the result of wide variations in definitions used by the many biotechnology industries. Reports by the OTA in both 1988 and 1991 emphasized the need for defining biotechnology and reached the following consensus: " any technique that uses living organisms (or parts of organisms) to make or modify products, improve plants or animals, or to develop micro-organisms for specific uses" (OTA, 1988/1991). General acceptance of this definition was demonstrated in the following studies (ITEA, 1996/2000; Stotter, 2004; Wells, 1992/1994/1995) regarding biotechnology instruction in Technology Education. The study documented in this paper employs the definition because it has widely been accepted by the profession of Technology Education.

2) Expectancy-Value

Wigfield, Tonks, and Eccles (2004) defined expectancy as "individual’s expected probability for success on a specific task" (p. 167). Individual’s expectations for success predict the educational, vocational, and other achievement related choices (Eccles, 2005; Wigfield et al., 2004). Graham and Taylor (2002) described an individual’s value as "attractiveness or usefulness" (p. 122) regarding a specific activity and Wigfield, Tonks, and Eccles (2004) defined values as "a set of stable, general beliefs about what is desirable" (p. 168) and "a class of motives that affect behavior by influencing the attractiveness of different possible goals and thus the motivation to attain the goals"(p. 168). The personal values directly influence performance, activity choice, and its participation (Eccles, 2005).

3. Limitation

The participants in this study were limited to three different regions. Even though a random sampling technique was conducted for Daejon region, Seoul and Gyeonggi regions employed a convenient sampling. Therefore, the generalization of the research results was considered with more critical viewpoint. With this in mind, a validity study for this scale should be done for using this instrument further.

II. Theoretical Background

1. Teachers’ Motivation

This study documented in this paper is framed by motivation theory in order to identify the motivations affecting technology teachers’ intent to teach biotechnology content in technology education. The study of motivation arose from two fundamental questions of "What causes behavior?" and "Why does behavior vary in its intensity?" (Reeve, 2005). These questions have led to theories of motivation that explain why people do what they do. Reeve (2005) categorizes behavioral expressions of motivation into effort, latency, persistence, choices, probability of response, facial expressions, and bodily gestures. He defined the study of motivation as "those processes that give behavior its energy and direction" (p. 6).

The exploration of factors influencing students' learning has a long history in education and psychology. Contrary to studies regarding students' motivation, Arami, Poulsen, and Chambers (2004) pointed out that there is a scarcity of studies documenting teachers' motivation. The conceptualization of expectancy-value theory developed as a product of the combined works of various theorists (Tolman, 1932; Atkinson, 1958; Vroom, 1964). Atkinson (1958) developed the expectancy value model to explain different kinds of behaviors such as striving for success, choice among tasks, and persistence. Since his study, various theorists have identified the impact of an individual's expectancy and value beliefs on performance, persistence, and choice through a number of validated real world studies (Eccles, 2005; Graham & Taylor, 2002; Wigfield, Tonks, & Eccles, 2004).

Abrami, Poulsen, and Chambers (2004) used the expectancy-value model to construct a model of the diverse issues that affect a teacher's decision to implement cooperative learning as an educational innovation. They concluded that education innovations are more likely to be implemented if teachers have a high value for and high expectancy for the innovation. In other words, the expectancy and value with which teachers perceive innovation affect teachers' decisions regarding the implementation of educational innovations. The personal value that the researchers measured included benefits to teachers (congruence with teaching philosophy and career advancement) and benefits to students (increased achievement, improved attitude, and enhanced interpersonal skills). They also measured internal factors such as teacher self-efficacy and skill and external factors such as student characteristics, classroom environment, and support. Based on their findings, they suggested that useful and successful educational innovation should be implemented in the relevant professional development. Wozney, Venkatesh, and Abrami (2006) accepted the Abrami et al. model in their study of teachers' decision to adopt computer technologies in their classroom. They identified three major factors: expectancy, value, and cost involving a decision to adopt computer technologies in the classroom.

Kay (2006) used expectancy-value theory as a frame for examine influential factors in teachers' classroom decision-making processes, especially in relation to their willingness to implement a contructivist based curriculum in their classroom. She concluded that teachers' expectancy-value beliefs were associated with their willingness to implement a constructivist based curriculum as well as to the level of implementation. For example, she believed that teachers who demonstrate lower levels of curriculum implementation had lower levels of expectancy and value to the curriculum. The studies applying the expectancy-value theory in an educational context demonstrated the power of this research framework (Abrami et al., 2004; Hancock, 1996). In particular, the studies (Abrami et al., 2004; Kay, 2006; Wozney et al., 2006) confirmed that a teacher's decision to implement a curriculum was strongly related to "how highly they value it", "how successful they expect to be", and "how high they perceive the cost of it".

Expectancy-value theory provides a framework to identify factors affecting the implementation of biotechnology instruction. In particular, this study documented in this paper investigates technology teachers' perceived expectation and value regarding the implementation of biotechnology instruction for secondary technology education classroom in South Korea. Also, the definitions of expectancy and value are used for a background for developing a measurement tool of technology teachers' motivation.

2. Biotechnology Contents for Technology Education

Savage and Sterry (1991) provided a theoretical framework for Technology Education by including technological systems as well as biotechnology content for technology education curricula. Wells (1992) created a taxonometric structure for the study of biotechnology. He pointed out that insufficient systematic studies exist regarding biotechnology and identified eight main biotechnology knowledge areas and eighty-four subdivisions, using a Delphi study, for biotechnology at the secondary school level. The eight categories were "biotechnology foundation, bioethics, environment, agriculture, bio-processing, genetic engineering, medicine, and biochemistry".

The most powerful inclusion of biotechnology content into Technology Education was in the works of ITEA (1996/2000). Scott (2005) validated biotechnology content for technology teacher education using an online Delphi study. He divided biotechnology content into eight categories of "biotechnology fundamentals, bioethics, environment, bioengineering, agriculture, medicine, industry, and bioinformatics".

In Korea, biotechnology content is a content organizer for the secondary school level Technology Education with four content organizers: manufacturing technology, construction technology, communication technology, and transportation technology (Yi et al., 2006; Yi & Kwon, 2008). Korea Institute of Curriculum and Evaluation (2002) suggested seven content standards for biotechnology content of Technology Education. The enduring categories of the seven content standards were "biotechnology concept and development, bio-process and application, agriculture, health, environment, bioethics, and career related to biotechnology". Lee (2008) identified key contents for biotechnology learning for secondary Technology Education courses synthesizing the previous major studies (KICE, 2002; Scott, 2005; Wells, 1994) related to biotechnology content. He established two broad areas: "understanding" and "utilization and practice" for biotechnology content. He subdivided biotechnology content into sixteen sub-categories.

III. Research Methodology

In this study, both exploratory and confirmatory factor analyses were conducted by a self-reported survey containing fifteen items of technology teachers' motivation. Also, this study identified technology teachers' self-perceived ability and value toward eight biotechnology contents by a self-reported survey. Several statistical analyses (descriptive statistics & independent sample t-test by two demographic data: gender & professional development related to biotechnology and its instruction) associated with the investigation of technology teachers' perceived ability and value toward biotechnology content were conducted.

1. Data Source and Description of the Dataset

1) **Instrumentation**

The researcher of this paper developed a survey based upon factors or variables related to the motivation of technology teachers. A fifteen-item instrument measuring teachers' motivation was created by the definitions of several motivation studies (Eccles, 2005; Graham & Taylor, 2002; Wigfi디d et al., 2004). The instrument consisted of three sections: 1) Technology teachers' perceived beliefs toward biotechnology teaching and their perceived ability and value for biotechnology content, 2) Technology teachers' intent to implement biotechnology teaching and perception of possible barriers to implement biotechnology teaching, and 3) Technology teachers' demographic information such as years of teaching technology, major, teachers' professional development (in-service teachers' training) related to biotechnology, and gender.

The researcher of this study used the first and third sections of the instrument because this study focused on the measurement issue of teachers' motivational constructs. It represents technology teachers' perceived beliefs (perception) toward biotechnology and its instruction. Major measurement in this study had two different sections: 1) Technology teachers' motivational beliefs toward biotechnology teaching and 2) Technology teachers' motivational attitudes (perceived ability and value) toward biotechnology content. In the first section, participants were asked to indicate the degree of agreement in terms of given sentence associated with biotechnology and its instrument by selecting one of the following responses for each item: "strongly disagree (1)", "disagree (2)", "neutral (3)", "agree (4)", and "strongly agree (5)". The instrument which was an online survey consisted of fifteen question items measuring two major constructs of teachers' expectancy and value in terms of biotechnology teaching. The survey items related to two motivational constructs were presented in <Table 1>.

<Table 1> **Items of Technology Teachers’ Motivation toward Biotechnology Teaching**

Survey Items	Constructs
I like to teach biotechnology content	Value
I believe that human life will be improved through biotechnology	Value
I am interested in learning new terminologies and concepts related to biotechnology	Value
I believe that all literate people should know biotechnology content	Value
I can teach biotechnology in a unique method different from that of biology and agriculture teachers.	Expectancy
I am interested in reading newspapers and books and watching TV programs related to biotechnology	Value
I believe that teaching biotechnology is valuable, considering the developmental trends of contemporary technology innovation.	Value
I can develop hands-on activities related to biotechnology for my technology class	Expectancy
I can implement problem-based learning in hands-on activities related to biotechnology	Expectancy
Considering students’ future life, learning biotechnology is essential	Value
I can evaluate/assess hands-on activities for biotechnology	Expectancy
I can manage materials, tools, equipment, and the laboratory for biotechnology hands-on activities	Expectancy
Biotechnology is one important content that should be taught in technology class	Value
I can employ the content or strategies of other subjects (e.g. biology, mathematics, etc)for teaching biotechnology in technology class	Expectancy
Considering students’ actual life, learning biotechnology is useful	Value

In the second section, instrument items for measuring technology teachers’ motivation toward biotechnology content were created. Through reviewing and synthesizing prior studies of biotechnology learning content for the secondary school level Technology Education, eight biotechnology learning content for the secondary school level Technology Education were identified. Participants were asked to indicate the degree of agreement in terms of their perceived 1) *ability* and 2) *value* toward eight different biotechnology learning contents: "strongly disagree (1)", "disagree (2)", "neutral (3)", "agree (4)", and "strongly agree (5)". The eight biotechnology contents were presented in <Table 2>.

The years of teaching technology were measured in 8 categories (1=less than 1 year; 2=1-3 years; 3=4-6 years; 4=7-10 years; 5=11-15 years; 6=16-20 years; 7=21-25; 8=over 26 years). The regional data were collected in 3 categories (1=Seoul; 2=Gyeonggi; 3=Daejon).

Also, this survey asked participants to present the hours of professional development (in-service teachers' training) related to biotechnology and its instruction, their gender, and their major.

Before data collection, this study was approved by *Virginia Tech School Institutional Review Board (IRB)* to ensure appropriate research procedures for relevant data collection. Also, this study used an online survey.

<Table 2> **Biotechnology Content for Secondary School Level Technology Education**

Eight Categories	Wells (1994)	KICE (2002)	Scott (2005)	Lee (2008)
Biotechnology Fundamentals	○	○	○	○
Bio-Processing	○	○		○
Agriculture	○	○	○	○
Environment	○	○	○	○
Bioethics	○	○	○	○
Health and Medicine	○	○	○	○
Genetic Engineering	○		○	○
Biochemistry	○			○

2) **Content/Face Validity**

The instrument was reviewed for content/face validity by a panel of experts made up of 1) two technology education scholars who had Ph.D in the field of technology education, 2) one education measurement professor, and 3) one educational psychologist. To overcome the possible translation problem, three Korean language high school teachers and two English language teachers in South Korea reviewed the survey items. Typographical errors were corrected. The instruments were then administered to twenty one pilot participants from ten technology middle school teachers who were not participated in the real survey and taught biotechnology over three years. The reliability of the instrument was 0.889 as measured by the *Cronbach's Alpha*. The syntactical corrections were made to the final instrument as suggested by pilot study.

3) **Data Collection**

The population of this study was Korean technology teachers who were currently teaching middle school '*Technology-Home Eonomics*" subject in Seoul special city, Daejon metropolitan city, and Gyeonggi province. In Daejon metropolitan city, there were 127 middle school technology teachers who taught technology in the spring of 2008. Using Cochran's formula for estimating sample size to determine the sample of a finite population (Cochran, 1977), 95 technology teachers needed to be surveyed to meet the minimum number of randomly sampled survey respondents. To obtain the representative sample of the population of Seoul special city and Gyeonggi province, the directories of technology teachers' association in several local districts were obtained. A convenient sample of 75 middle school technology teachers who taught technology in four districts of Seoul city and Gyeonggi province was obtained. In total, 114 Korean middle school technology teachers were participated in this survey (67.05 % response rate).

IV. Statistical Analyses and Findings

1. Descriptive Statistics

A total of 114 respondents (58.8% male and 41.2% female technology teachers) completed the instrument. The majority of respondents (n=101, 88.6%) were technology teachers majored in technology education. About 11.4 percent of respondents had other majors of "Home Economics", "Industrial subjects", and "Agricultural Science". This study also used two demographic data such as gender and professional development. SPSS 16.00 was used to conduct statistical analyses. The reliability of the fifteen items was 0.91 (*Cronbach's Alpha*). Also, items measuring technology teachers' perceived ability and value toward biotechnology content had the reliability coefficients of 0.884 and 0.812 respectively. The overall reliability scores indicate a high quality of instrument.

The means and SD (Standard Deviation) for the perceived ability and value toward biotechnology content were presented in <Table 3>.

<Table 3> **Technology Teachers' Perceived Ability and Value toward Biotechnology Content**

Eight Categories	Perceived Ability		Perceived Value	
	Mean	SD	Mean	SD
Biotechnology Fundamentals	3.46	0.755	3.64	0.718
Bio-Processing	2.88	0.874	3.44	0.652
Agriculture	3.03	0.917	3.60	0.725
Environment	3.03	0.897	3.97	0.697
Bioethics	3.16	0.868	3.89	0.784
Health and Medicine	2.71	0.957	3.75	0.782
Genetic Engineering	2.75	0.976	3.87	0.747
Biochemistry	2.58	0.808	3.36	0.693

The survey asked participants to their self-perceived ability and value toward eight biotechnology contents. In particular, the responses of their perceived value were greater than ones of their perceived ability. In their ability toward biotechnology content, the results indicate that technology teachers perceive their ability as low toward bio-processing, health and medicine, genetic engineering, and biochemistry. In their value toward biotechnology content, the results indicate that technology teachers perceive the value (importance) as high toward environment, bioethics, and genetic engineering.

The results should be identified by collected demographic data (gender: male/female; professional development related to biotechnology: None/Participation) as presented in <Table 4> and <Table 5>. The mean differences between demographic data were tested using independent sample t-test.

<Table 4> **Statistical Testing Results of Mean Differences by Gender**

Biotechnology Content	Gender	N (113)	Ability			Value		
			Mean	SD	t	Mean	SD	t
Biotechnology Fundamentals	Male	67	3.57	.743	.069	3.63	.775	.855
	Female	46	3.30	.756		3.65	.640	
Bio-Processing	Male	67	2.97	.953	.170	3.52	.660	.081
	Female	46	2.74	.743		3.30	.628	
Agriculture	Male	67	3.09	.949	.382	3.66	.750	.262
	Female	46	2.93	.879		3.50	.691	
Environment	Male	67	3.13	.983	.157	4.00	.739	.629
	Female	46	2.89	.737		3.93	.646	
Bioethics	Male	67	3.27	.863	.137	3.76	.818	**.043***
	Female	46	3.02	.856		4.07	.712	
Health and Medicine	Male	67	2.73	1.067	.847	3.61	.852	**.021***
	Female	46	2.70	.785		3.96	.631	
Genetic Engineering	Male	67	2.78	1.042	.755	3.82	.833	.430
	Female	46	2.72	.886		3.93	.611	
Biochemistry	Male	67	2.67	.894	.166	3.33	.746	.527
	Female	46	2.46	.657		3.41	.617	

*** p<0.05**

The independent sample t-test shows t-value scores above (p>.05), indicating that there is no significant difference between male and female in their perceived ability and value toward biotechnology content except two cases of "Bioethics" and "Health and Medicine". The mean scores of female technology teachers in their perceived value toward biotechnology content of "Bioethics" and "Health and Medicine" (mean=4.07 and 3.96 respectively) are significantly greater than ones of male technology teachers (mean=3.76 and 3.61 respectively).

In general, the mean scores of professional development participants are greater than ones of "no participation" group presented in <Table 5>. However, there are no statistically significant differences between two groups except one case. The independent t-test shows a t-value of .039 (p<.05), indicating that there is a statistically significant difference between participation and no-participation in the perceived value toward "Genetic Engineering". In other words, technology teachers who had professional development related to biotechnology perceived "Genetic Engineering" content as more important than no-participation group.

<Table 5> **Statistical Testing Results of Mean Differences by Professional Development (PD)**

Biotechnology Content	PD	N (112)	Ability			Value		
			Mean	SD	t	Mean	SD	t
Biotechnology Fundamentals	None	67	3.37	.832	.121	3.57	.763	.235
	PD	45	3.60	.618		3.73	.654	
Bio-Processing	None	67	2.87	.869	.790	3.43	.701	.790
	PD	45	2.91	.900		3.47	.588	
Agriculture	None	67	3.09	.866	.452	3.54	.703	.282
	PD	45	2.96	.999		3.69	.763	
Environment	None	67	3.01	.896	.767	3.93	.765	.295
	PD	45	3.07	.915		4.07	.580	
Bioethics	None	67	3.10	.873	.486	3.84	.709	.428
	PD	45	3.22	.876		3.96	.878	
Health and Medicine	None	67	2.69	.908	.538	3.66	.750	.127
	PD	45	2.80	1.014		3.89	.832	
Genetic Engineering	None	67	2.70	.921	.378	3.75	.725	**.039** *
	PD	45	2.87	1.036		4.04	.767	
Biochemistry	None	67	2.60	.740	.985	3.28	.647	.231
	PD	45	2.60	.889		3.44	.755	

*** p<0.05**

2. Factor Analysis

The factor analysis was performed by research procedure of two phases: (1) exploratory factor analysis phase, and (2) confirmatory factor analysis phase. At the exploratory factor analysis phase, this study explored latent factors included in the fifteen items. Also, confirmatory factor analysis provided a systematic verification for expectancy-value constructs.

1) Factor Analysis Model

The factor analysis model expresses the variance and covariance in a set of observed variables y (i=1 to 15). Figure 1 presents the path diagram for this *Exploratory Factor Analysis* model. In matrix form, the equation is,

$$y_i = \nu + \Lambda \eta_i + \varepsilon_i \text{, when}$$

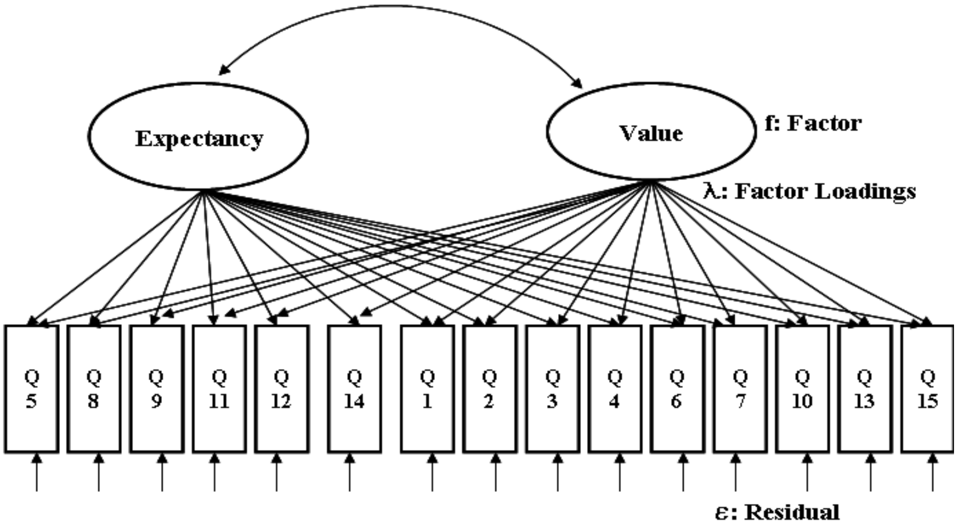
ν is thevector of intercepts (mean),

Λ is the matrix of factor loadings λ,

Ψ is the matrix of factor variances/covariances, and

Θ is the matrix of residual variances/covariances

$$\Sigma = \Lambda \Psi \Lambda' + \Theta$$



[Figure 1] Exploraty Factor Analysis Model

2) Preliminary Findings Exploratory Factor Analysis

Based on the findings of SPSS 16.0 (*Principal Component Analysis and Promax Rotated with Kaiser Normalization*) and M-plus 5.0 (*Maximum Likelihood Method and Promax Rotated*), this section provides a preliminary result and describes the procedure. A preliminary finding of SPSS factor analysis presents two factors (two motivational constructs) <Table 6> and one cross loading (Item # 6). The factor loadings of SPSS Principal Component Analyses (Component matrix and Rotated matrix) were presented in <Table 7>. There were no general rules for selecting good factor loadings but the criteria for reasonable factor loading was .30 in this study. The item that had a cross loading was eliminated. Researcher reviewed the sentence of the item 6 and found there was a translation problem.

<Table 6> **Principal Component Analysis from SPSS**

Factor	Eigen Value	Percent of Variance	Cumulative Percent
1	6.713	44.751	44.751
2	1.986	13.238	57.989
3	.933	6.219	64.207

The results are consistent with the structure of the intended factors (constructs). Also, the results of the M-plus were the same as the ones of SPSS. In other words, M-plus promax rotation also indicated two factors and one cross loading (item #6). M-plus results provide value of chi square, RMSEA, SMSR, and negative residual value as shown in <Table 8>. Considering the results of test of model fit, two factors model was chosen as the preliminary finding of SPSS factor analysis suggested. The chi square testing values were not significant but RMSR and RMSEA values were close to the criteria (.08) that Brown (2006) suggested and there were no negative residual values in this case. Therefore, the M-plus results support the finding of SPSS analysis.

<Table 7> **Component Matrix and Rotated Matrix from SPSS**

Items	Component Matrix		Rotated Matrix (Promax)	
	Factor 1	Factor 2	Factor 1	Factor 2
Item 1	.736	-.174	**.632**	.200
Item 2	.665	-.401	**.813**	-.075
Item 3	.685	-.266	**.692**	.077
Item 4	.633	-.275	**.668**	.041
Item 5	.641	.386	.018	**.739**
Item 6	.610	.073	.309	**.394**
Item 7	.639	-.458	**.853**	-.148
Item 8	.646	.510	-.108	**.866**
Item 9	.625	.565	-.170	**.919**
Item 10	.640	-.472	**.868**	-.162
Item 11	.741	.287	.178	**.687**
Item 12	.652	.385	.025	**.744**
Item 13	.752	-.221	**.688**	.160
Item 14	.683	.369	.061	**.743**
Item 15	.674	-.256	**.675**	.082

<Table 8> **EFA Test of Model Fit for all 16 items**

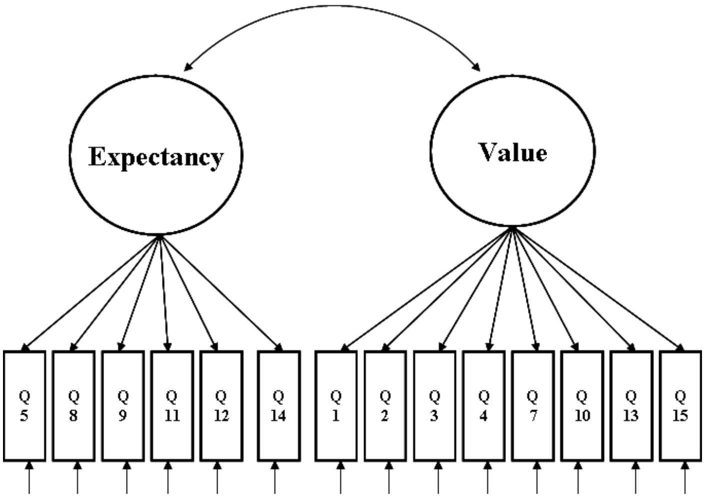
Factors	Chi Sauare Value (df) p	RMSEA	RMSR	Negative Res. Value
1	328.169 (90) 0.000	0.152	0.115	No
2	159.112 (76) 0.000	0.098	0.056	No
3	112.723 (63) 0.000	0.083	0.044	No
4	77.684 (51) 0.009	0.068	0.038	No

Based on the findings, two factors of "expectancy" and "value" were named. It was exact same structure of factors as this study designed at the initial stage. The final factor loadings (14 items) of EFA Promax Rotation were shown in <Table 9> and the final model also drawn as Figure 2. There are two factors for this survey, "Korean Technology Teachers' Motivation". The items of expectancy are item 5, item 8, item 9, item 11, item 12, and item 14. Also, the items of value are item 1, item 2, item 3, item 4, item 7, item 10, item 13, and item 15. The item 6 was eliminated due to a cross loading. The determinacies (presenting the quality of factors) in the findings of EFA (promax rotation) are 0.949

(expectancy) and 0.950 (value) presenting high quality of the two constructs

<Table 9> **Factor Loadings of Final Model (M-plus)**

Items	Value	Expectancy	Items	Value	Expectancy
Item 1	**0.581**	0.211	Item 5	0.075	**0.634**
Item 2	**0.759**	-0.060	Item 8	-0.115	**0.868**
Item 3	**0.616**	0.107	Item 9	-0.183	**0.934**
Item 4	**0.620**	0.030	Item 11	0.222	**0.600**
Item 7	**0.844**	-0.186	Item 12	0.106	**0.611**
Item 10	**0.819**	-0.141	Item 14	0.119	**0.639**
Item 13	**0.681**	0.133			
Item 15	**0.632**	0.001			



[Figure 2] Final Factor Model (EFA) - Expectancy and Value

3) Confirmatory Factor Analysis

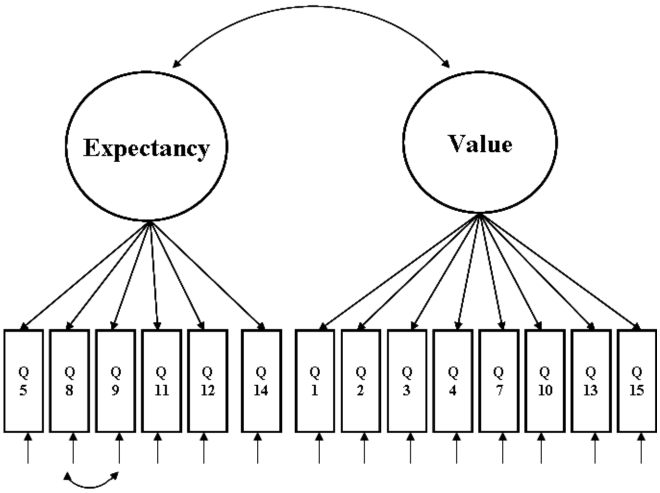
This section describes the results of Confirmatory Factory Analysis (CFA) using M-plus 5.0. The research conducted a CFA for the 14 variables with a two factor model depicted in Figure 3 without a correlated error between expectancy and value. Then, using modification index (M-plus produced) and Standardized Expected Parameter Change (StdYX E.P.C.), decision to add the correlated error was made.

In the original model (Figure 2), there are two factors (latent variables), expectancy (defined by Q5, Q8, Q9, Q11, & Q12) and value (defined by Q1, Q2, Q3, Q4, Q7, Q10, Q13, & Q15). The software used for this analysis is M-plus 5.0. The type of data/matrices is a variance/covariance and the estimator used is ML (Maximum Likelihood). At the first model, the overall goodness of fit is in <Table 10>. Although several indicators (Chi Square p-value, RMSEA, SRMR, & CFI/TLI) are not good enough for their cut off scores, R-square (reliability of the item) score ranges from 0.403 to 0.606. Also, the results recommend a model modification work for this factor model. The largest StdYX E.P.C. was 0.610 (Q9 with Q8). This value should be considered seriously if the absolute value of it is greater than 0.3.

<Table 10> **Overall goodness of fit in CFA**

Factors	Chi-Square Value/p value	RMSEA	SRMR	CFI/TLI
Original	152.136 / 0.0000	0.094	0.064	0.904/0.885
Model 1	131.506 / 0.0010	0.081	0.059	0.928/0.913

At the modified model, the action regarding the E.P.C. value is to add a correlated error between Q8 and Q9 due to the largest StdYX E. P. C. The modified model gave an improved quality of R[MSEA, SRMR, and CFI/TLI. The diagram of the modified model was presented in Figure 4. The determinacies which indicate the quality of the factors are 0.947 (value) and 0.933 (expectancy). This indicates a good quality as a measurement.



[Figure 4] A Modified CFA Model (Final)

V. Summary, Conclusion & Recommendations

1. Summary & Conclusion

Teaching biotechnology is like an innovation for technology education program.

Contrary to continuous efforts of technology education professions, the real implementation level of biotechnology instruction is not good. Therefore, identifying factors affecting the implementation of biotechnology instruction is significant. Prior studies emphasize that teachers' motivation can be an important factor for affecting their curriculum implementation. This study investigated technology teachers' motivation as a key factor affecting the biotechnology instruction. In other words, this study investigated Korean technology teachers' motivation as a function of expectancy and value toward biotechnology and its instruction. Based on the definition of motivational beliefs such as expectancy and value, fifteen items were developed and validated with a procedure of instrumentation. Also, technology teachers' perceived ability and value toward eight biotechnology contents were measured and several demographic data (gender, major, and professional development participation) were collected. Based on 114 Korea technology teachers' responses, a descriptive statistics, independent sample t-test, and factory analyses (both exploratory factory analysis and confirmatory factor analysis) were performed using SPSS 16 and M-plus 5.

The reliability coefficient (*Cronbach's Alpha*) of major measurement items turned out to be reliable (fifteen motivation scale: 0.91, Perceived ability and value: 0.884 & 0.812). Through reviewing and synthesizing prior studies regarding biotechnology contents (KICE, 2002; Lee, 2008; Scott, 2005; Wells, 1994), eight biotechnology contents ("*Biotechnology Fundamentals*", "*Bio-Processing*", "*Agriculture*", "*Environment*", "*Bioethics*", "*Health and Medicine*", "*Genetic Engineering*", *and* "*Biochemistry*") were identified. In particular, technology teachers perceived their ability as low toward bio-processing, health and medicine, genetic engineering, and biochemistry while they perceived the value (importance) as high toward environment, bioethics, and genetic engineering.

Based on the results of exploratory factor analysis, a preliminary finding of SPSS factor analysis indicated two factors (two motivational constructs: 6 expectancy items and 8 value items). Also, the item #6 that had a cross loading was eliminated. Researcher reviewed the sentence of the item 6 and found there was a translation problem. The results were consistent with the structure of the intended factors (constructs). Also, the results of the M-plus were the same as the ones of SPSS. The confirmatory factor analysis supported the preliminary finding.

2. Recommendations

This study gives several recommendations regarding further studies. First of all, this study suggests the needs to investigate sub-factors of the motivation construct. Although the indicators of the CFA model were near the cut off scores, two factors model had a need to improve the indicators. In other word, the insufficient cut-off scores suggest more delicate item development associated with the motivation constructs. In particular, the construct of value can frequently be categorized in the contemporary educational psychology. Eccles (2005) categorized subject task value into four components: "1) attainment value or the value an activity has, 2) intrinsic or interest value expected enjoyment of engaging in the task, 3) the utility value of the task for external rewards, and 4) the cost of engaging in the activity" (p. 109). As an effort to improve this instrument, constructing sub-factors of the value is necessary to measure teachers’ value construct properly.

Second, the studies targeted for other populations should be performed for a validity study. As the research limitation section in this study mentioned, this study needs a validity study. Educational measurement field requires the researcher to have more valid instrument conducting to other populations (Brown, 2006) (for instance, technology teachers in other regions, technology teachers in other cultural settings, and teachers in other disciplines such as agriculture teachers or biology teachers).

Third, the real instructional situation of teaching biotechnology may be more complicated than we expected. Also, there are many identified issues such as insufficient professional development, lack of curriculum materials, and insufficient supports related to biotechnology instruction (Brown et al., 1998; Dunham, et al., 2002; Lee, 2008). More concrete and systematic investigation for biotechnology instruction should be done for dealing with these identified issues.

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<국문초록>

생물기술교육에 대한 기술교사의 동기유발

권혁수*

생물기술의 중요성으로 인해 기술교육, 과학교육, 그리고 농업교육 분야에서는 중등교육에서 생물기술교육의 중요성을 인식해오고 있다. 기술교육에서 생물기술이 하나의 내용조직자로서 인식되어왔지만, 실제 생물기술의 교육은 폭넓게 실천되고 있지 않은 실정이다. 기대-가치 이론의 측면에서 기술교사의 동기유발은 생물기술을 가르치는 하나의 중요한 요인이 될 수 있다. 이 연구는 한국기술교사의 생물기술교육에 대한 동기유발과 생물기술 내용에 대한 그들의 스스로 인식하고 있는 능력과 가치를 연구하였다. 이런 동기유발의 측정을 위해, 하나의 온라인 설문지(15개의 생물기술관련 동기유발 문항, 8개의 생물기술내용에 대한 교사들 스스로 인식하고 있는 능력과 가치, 그리고 기타 정보)가 개발되었다. 114명의 한국기술교사의 반응에 의해, 이 연구는 기술통계, 독립표본 t-검증, 그리고 요인 분석들(SPSS와 M-plus를 사용하여 탐색적 그리고 확인적 요인 분석)을 수행하였다. 생물기술내용에 대한 한국 기술교사의 가치(중요성 평가)는 상대적으로 높은 점수를 나타내고 있는 반면 생물기술내용에 대한 그들의 능력은 낮은 점수를 나타내고 있다. 성별과 교사의 연수 여부에 따른 독립표본 t-검증 결과 교사들의 가치면에서 몇개의 의미있는 차이점을 찾았다. 탐색적 요인분석의 결과, 15개의 항목이 2개의 요인들(6개의 기대항목과 8개의 가치항목)로 나뉘었다. 한 항목 (6번) 은 교차로딩으로 제거되었다. 또한, 확인적 요인분석은 탐색적 요인분석의 결과를 지지하고 있다. 이 연구의 결과는 생물기술과 관련된 연수 프로그램에 대해 의미있는 함의를 가지고 있으며, 결론적으로 이 연구는 다른 교사들에 대한 타당성 평가, 동기유발 하위개념에 대한 연구, 그리고 생물기술교육에 대한 심화된 연구의 필요성에 대해 제언하고 있다.

주제어 : **생물기술, 동기유발, 요인분석, 기대-가치 이론**

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