Inclusion of Biotechnology in US Standards for Technology Literacy: Influence on South Korean Technology Education Curriculum

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Abstract For the past 10 years the national curriculum reform in South Korea has incorporated, to an ever increasing extent, technology education as a subject area for general education. This decade of national curriculum reform in Korea parallels the technology education curriculum reform movement in the United States, which culminated in the current *Standards for Technological Literacy* (STL). The US influence on Korea's development of a national technology education curriculum is apparent throughout, but more so in their move to include biotechnology as a content area of study. This influence is ultimately revealed in the most recent revision of their national curriculum where biotechnology has specifically been added as a fifth content organizer. At a finer level the influence is seen to go beyond the mere transition of terminology used for earlier content organizers, and has directly impacted the evolving degree of biotechnology content technology education teachers are responsible for covering. A close inspection of that content strongly mirrors the biotechnology content identified in the US *Standards for Technological Literacy*. Yet to be developed in South Korea is the curriculum necessary for guiding instruction of biotechnology, and indications are that US curricula stand ready to play a prominent role.

Keywords Biotechnology • Standards for Technological Literacy • South Korea • Curriculum

Rationale

The impact of the *Standards for Technological Literacy* (STL) (ITEA, 2000) on curricular development outside of the United States is believed to be fairly significant. Yet, to date few investigations have been published that document the pathways and impacts of such influence (Yi, 2001; Choi, 2001; KICE, 2002), and fewer still on how it affects the extent to which specific US content areas are incorporated into international curricula. This latter influence currently presents itself as a unique research opportunity given that in the United States the formal inclusion of one such content area, biotechnology, is a relatively recent occurrence. As a new content area for Technology Education in the United States with a compelling presence in the STL, we are afforded an opportunity to investigate the influence of US incorporation of biotechnology content in those curricular development initiatives occurring in other countries. Influenced largely by those members serving on the development teams, curriculum decisions of this order carry implications for continuing to promote positive student attitudes toward technology in general, and biotechnology literacy in particular. This article focuses on the influence US Standards for Technological Literacy have had on South Korea's inclusion of biotechnology as part of Technology Education programs within their National Curriculum. Over the past three decades South Korea has transitioned through seven versions of their National Curricula (Yi, et al, 2006), and is currently in the process of developing their eighth. The sixth revision in 2000 was the first version to specifically incorporate biotechnology as a new content area for technology education. This revision followed close on the point in time (late 1990s) when biotechnology was first being considered as content necessary for inclusion in the US Standards for Technological Literacy. This parallel in evolving standards and curriculum between the United States and South Korea provides a clear case for exploring the influence of US developed STL on curricular decisions toward inclusion of biotechnology in the Korean National Technology Education Curriculum, and for offering recommendations to these current efforts.

Global significance and sociocultural impact of biotechnology

The revolution in modern biotechnology that began sweeping the US only a few decades ago continues today at an ever increasing pace, permeating nearly every aspect of human social and cultural activity. From the foods that sustain us and fuels that drive our technological systems, to the molecular probes that target diseased cells and genetic engineering that can affect physical characteristics, biotechnology plays an increasingly important role in society. Biotechnology, a technology fundamentally based on cellular and molecular processes, includes both old and new techniques developed to harness the properties of living things. Etymologically, biotechnology translates into "the study of tools from living things" and in its broadest sense is a term that encompasses a mixture of both new and old technologies. Today across the major science disciplines the most widely recognized, accepted, and useful operational definition of biotechnology is:

"….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, 1984/1988/1991; NAP, 1992; FECCSET, 1992/1993; Wells, 1994/1995; ITEA-STL, 2000/2001; Eichelbaum, 2001; Fernandez, 2001)

Though this definition was developed to reflect current (modern) applications, biotechnology is not at all new. For thousands of years in many parts of the world humankind has made use of living organisms (or parts of organisms) for a broad range of applications from curing illness to exploiting microorganisms for making foods such as bread, cheese, wine, and vinegar. These applications of microbial biotechnology employed fermentation as a method for converting one food source into another. Examples of such early biotechnology techniques are termed "traditional" because the knowledge used was based on methods and processes passed down through generations without any real understanding of the science involved (Wells, 1994). In truth it wasn't until Luis Pasteur completed his work in 1857 that the science behind the fermentation process would be fully understood. Even the term biotechnology was not coined until 1917 by the Hungarian agricultural economist Karl Erchy who envisioned the merging of biology with technology. Despite being an integral part of human societies, biotechnology methods were used for quite some time before knowledge of cellular and molecular processes progressed far enough to allow scientists to move us beyond tradition.

Modern biotechnology, as reflected in the current definition, would not take hold until the work of James Watson and Francis Crick (1953) had unraveled the molecular structure of deoxyribonucleic acid (DNA), giving way to the understanding of biological processes at the molecular level of the cell. This elucidation of the molecular structure of DNA provided the necessary springboard for developing techniques to manipulate the genetic material of an organism. Today these biotechnology techniques affect industries from medicine to metallurgy and bioinformatics to bioremediation, offering potential benefits to human life limited only by the extent of human imagination

The steady growth and awareness of modern biotechnology has been stimulated by past, present, and potential future crises affecting humankind in all corners of the globe. Crises such as the 1970s international confrontations in response to oil shortages raised the issue of limited fossil fuels and the need for developing cheaper, more secure forms of renewable energy sources. Now, more than thirty years since that first fuel crisis, that future need is a reality and biotechnology is playing a pivotal role in the development of alternative energy sources. Throughout those past decades research and development in the field continued, providing modern biotechnology with more sophisticated methods of utilizing an increasingly broad spectrum of raw materials to alleviate not only energy resource concerns, but also the growing demands for basic human needs (food/water/health care) and escalating requirements of environmental sustainability (Australian Biotechnology Association, 2000; Rifkin, 1999; Roa, 1986). Today's advancements in medical diagnoses and disease prevention and treatment are resulting in powerful vaccines to protect against major viral diseases, in-home test kits for genetic disorders, and in-home food safety tests to guard consumers against contamination. These and a great many more advances have led to a steady rise in civic awareness of the potential economic and social impacts biotechnology will undoubtedly have on individuals and the peoples across our globe (Project 2061 Panel Report, 1989; Smith, 1988; Plein, 1991; Prentis, 1984). The primary vehicle used for dissemination of knowledge to the public is the educational enterprise. Therefore a natural accompaniment to this growing social awareness was the gradual incorporation of biotechnology content within new curricular development efforts across grade levels and disciplines. Technology education, a discipline predicated on promoting technological literacy, was among those disciplines, and biotechnology literacy for all K-12 students gradually became recognized as a required component of the technology education curriculum.

Incorporation of Biotechnology Content in Technology Education

Any meaningful comparison of curricular influences between the United States and South Korea calls for due attention to the historical backdrop of curriculum movements in the respective countries. The purpose of this study was limited to identifying significant points of curricular influence relative to biotechnology, and therefore an extensive historical treatment was unwarranted. The result is a historical overview sufficiently detailed to demonstrate progressions between the major changes to content addressed by the technology education field, beginning from a point of relative curricular stability observed in the 1960s. The overview reveals the integration points of biotechnology content into the TE curriculum over the past two decades.

Evolving Content for US Technology Education

For the first half of the 20th century K-12 Industrial Arts (IA) was a relatively well accepted subject area in the US school curriculum, focusing primarily on content drawn from the industry of the day (Householder, 1979). In the late 1950s however, sparked by the launch of Sputnik and the cold war, the United States fell into a period of political, economic, and social dissonance. American education was viewed to be largely responsible for the US falling behind as the world leader in science and technology (Bestor, 1953; Lynd, 1950). To reestablish that leadership position would require greater academic rigor. The passage of the National Defense Education Act (NDEA) in 1958 addressed this by focusing education on curriculum reform in mathematics and science, prompting a national shift in pedagogical perspectives from student-centered to teacher-centered (Kliebard, 1986, p.267). Ultimately this would have significant impact on the longstanding Industrial Arts curriculum.

In his 1979 examination of curriculum movements during the 1960s, Householder paints the Sputnik era as a period in which for the first time IA became open to changes in the traditional curricula. At the onset of these pedagogical changes the traditional subject areas in IA were organized around seven broad categories: Woodworking, Drawing, Metalworking, Electricity/Electronics, Graphic Arts, Industrial Crafts, and Power Technology (Wilber & Pendered, 1973 p 52-55). Towers, Lux, and Ray (1966), capitalizing on this climate of educational change, as well as NDEA funding earmarked for curriculum development, launched their Industrial Arts Curriculum Project (IACP) to analyze and organize content in these broad categories to be reflective of the body of industrial knowledge. Their efforts resulted in what is arguably the most outstanding curriculum developed for IA in the 1970s, and set a president for future curriculum initiatives. Unfortunately this curriculum did not continue to reflect the changing face of modern technology, or parallel the direction of curriculum reform that was occurring in both science and mathematics education.

In the early 1980s IA curriculum, and associated content organizers, would undergo further changes as the profession wrestled with developing an appropriate technology-based curriculum and aligning those teaching/learning processes needed for delivering such programs. The *Jackson's Mill Industrial Arts Curriculum Theory* (Snyder & Hale, 1981) was a significant effort by leaders in the field to restructure content in a manner intended to bridge the gap between knowledge domains and the teaching/learning processes. This new curriculum theory drew the content for IA from knowledge of systems related to human adaptive behaviors and technical endeavors. This systems knowledge was organized around four content organizers: communications, construction, manufacturing, and transportation (p 23). It is of note that up to this point no attempts were being made in this ongoing curricular reform to include any of the newly emerging technology fields such as biotechnology. However, this was not to last.

In 1985 the profession officially changed its name to Technology Education, and with that came continued curricular reform that was increasingly more inclusive of the broadening scope of modern technology. At the turn of the decade a very new perspective of the profession was presented in a pivotal document titled *Conceptual Framework for Technology Education* (Savage & Sterry, 1990) which recognized technology as human endeavor in its broadest sense, and as an integral element of all societies and cultures (p 7). Building from the earlier Jackson's Mill curriculum theory (Snyder & Hale, 1981), the Conceptual Framework document expanded the construct of human endeavors to include all technological processes, and categorized them under the following four content organizers: bio-related, communication, production, and transportation (p 17). For the first time in the history of the field, the profession broadened the content to include those technologies related to biology. This was a turning point in defining the discipline and the breadth of content it would be responsible for teaching. That responsibility precipitated the Technology for All Americans (TfAA, 1996) project, a momentous effort by the profession to

develop a set of national standards that would establish guidelines for specific content to be taught and articulated across grade levels from K-12.
The initial work by the SfAA project produced *A Rationale and Structure for the Study of Technology* (1996). This document presented technology from a systems perspective and sought to organize technology content around three main systems: informational, physical, and biological (p 31). In the four years following the development of the Rationale and Structure (1996 – 2000), the systems perspective lost favor and content organizers were once more modified as follows: information technologies, physical technologies, and biological/chemical technologies (1998). During this time eight drafts would be required before the final *Standards for Technological Literacy: Content for the Study of Technology* (STL) would be published in 2000. The organization of content ultimately presented in the STL was a dramatic shift in perspective from earlier thought, with purposeful intent toward alignment with the content structure followed in the *Benchmarks for Scientific Literacy* (AAAS, 1989). The STL used seven categories of standards to structure the study of technology: The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World. Of the 20 standards developed across these categories, the content pertaining to biotechnology was housed in The Designed World in Standard 15: Agricultural & Related Biotechnologies.
In retrospect, the pathway of biotechnology into the US content organizers in Technology Education became visible to the profession in 1990 and continued into the current STL. The evolution of content organizers in technology education was accompanied by key manuscripts from the profession, providing the rationale and a timeline documenting its inclusion (Table 1). As revealed in the table, biotechnology is a relatively new content area identified for inclusion in technology education, and with little obvious connection to traditional content areas held by the field.

Table 1 Evolution of Content Organizers 1990 – 2000

Year	Key Publication	Content Organizers
1990	Conceptual Framework	Bio-related, Communication, Production, Transportation
1996	Rationale and Structure	Informational Systems, Physical Systems, Biological Systems
1998	Early draft STL	Information Technologies, Physical Technologies, Biological/Chemical Technologies
2000	STL	The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, The Designed World

Specific biotechnology content suggested in the STL is at best vague. However, certain portions of Standard 15 included in the STL document do provide some general indicators of broad enduring concepts that progress across grade levels (Table 2). Needed still is a well developed curriculum that identifies what content should be covered and a pedagogical basis for implementing it in the technology education classroom.

Table 2 Enduring Biotechnology Concepts Embedded in STL Standard 15

Grade Progression	Biotechnology Enduring Concept
Grades K-2	▪ Living things depend on air ▪ Ecosystems are collections of organisms
Grades 3-5	▪ Artificial ecosystems are human-made environments ▪ Bio-fuels can be made from recycled wastes
Grades 6-8	▪ Living things are manipulated to make/improve products ▪ Biological principals are used to create products/processes
Grades 9-12	▪ Applications in most fields (agriculture, food, medicine, energy, etc.) ▪ Design waste management systems using microorganisms ▪ Environmental/Societal impacts of artificial ecosystems

Biotechnology content in US Technology Education

In the time following Savage and Sterry (1990) identifying biotechnology as a viable subject area for technology education, only a few efforts to identify specific content and/or develop curricula have been published by those in the field. The first to conduct research in this area was Wells, who's 1994 research resulted in a detailed taxonometric structure and associated content for teaching biotechnology in technology education (Table 3). Not until late 1998 did Brown, Kemp, and Hall report on a second effort to identify biotechnology content, though limited in addressing curricular needs for Kentucky technology education. Nearly 10 years would pass before Scott, Washer, and Wright (2006), in response to a charge by the Council for Technology Teacher Education to the Undergraduate Studies Committee, would publish their research to identify biotechnology competencies for first year/initially certified technology teachers. In the later two studies, the biotechnology content areas presented were for all practical purposes the same as those identified by Wells in 1994 (Wells, 1999). However, in the 14 years since the initial research on biotechnology content, there has yet to be a fully recognized, supported, and well defined national curriculum that identifies the content to be addressed and provides sound instructional strategies for incorporating this content area into the technology education classroom. Arguably the most robust curriculum currently available that does identify the content and provides the pedagogical approach is the *Biotechnology Teaching Guide* (Biosens, 2000) produced by the Technology Education Biotechnology Curriculum (TEBC) project. Based on the 1994 biotechnology taxonometric structure identified by Wells, the content covered in the Teaching Guide is divided into the following eight Knowledge Areas, each of which are further divided into five content sub-categories (Table 3).

Table 3 Biotechnology Knowledge Areas and Content Sub-Categories

Foundations of Biotechnology	Genetic Engineering
▪ Defining biotechnology	▪ Probing Techniques
▪ Historical Background	▪ Genetic Engineering Applications
▪ Relevant Terms	▪ Genetic Code
▪ Career Information	▪ Molecular Biological Techniques
▪ Social Impact	▪ Analysis of DNA

Table 3 (cont.) Biotechnology Knowledge Areas and Content Sub-Categories

Environment ▪ Bioremediation ▪ Biological Controls ▪ Biotreatment Systems ▪ Biorestoration ▪ Environmental Safety	Biochemistry ▪ Enzymology ▪ Control and Regulation ▪ Proteins ▪ Methods of Analysis ▪ Carbohydrates
Agriculture ▪ Tissue Culturing ▪ Plant/Animal Applications ▪ Agrichemicals ▪ Aquaculture ▪ Plant Science	Medicine ▪ Molecular Medicine ▪ Immunology ▪ Genetic Therapeutics ▪ Health Care ▪ Social Impact
Bioprocessing ▪ Fermentation ▪ Bio-products ▪ Microbial Applications ▪ Separation/Purification ▪ Processing Design	Bioethics ▪ Principles of Ethics ▪ Impacts of Biotechnology ▪ Potentials of Genetics ▪ Patenting of Life ▪ Forensics

The incorporation of biotechnology content into technology education began more than a decade ago as the profession transitioned from Industrial Arts to Technology Education. The identified biotechnology content for technology education has changed little throughout this time period, with only a few curricula available to guide practitioners in method and strategies appropriate for teaching it in the technology classroom. The US Standards for Technological Literacy have been dissmeniated globally stimulating broad interest from technology education programs in many other countries. The document has been translated for use in a number of countries, and therefore some degree of influence on their own curricular efforts is a logical assumption. In light of this, what influence can be found in recent curriculum development initiatives by those countries considering the inclusion of biotechnology content in their technology education programs? Observation of such an influence is possible for the recent curriculum development initiatives of South Korea.

South Korean Technology Education Curricular Initiatives

As a part of general education, Technology Education (TE) was first offered to secondary students in South Korea in 1970 which was the second revised curriculum. Through the 37 year history of technology education, there have been innovations and challenges in curriculum, instruction, and teacher education. Even though technology education in South Korea has a short history, goals, curriculum, subject name and target students of technology education have been changed in response to technological change. With these changes, the current technology education in South Korea faces and prepares for a new effort to improve the status of technology education. The preeminent effort to boost the status of technology education in South Korea can be found in the transitions of the National Curriculum. Since technology education was introduced as a general integration subject in 1970, the curriculum has been revised five times.

The school system in South Korea is a single track of 6-3-3-4 pattern under a strong National Curriculum. Education is compulsory for all students from 6 to 15 years of age (from the first grade to the tenth grade). Elementary school lasts for six years and secondary education includes three years in middle school and three years in high school.

At the initiatial stage of technology education in South Korea, there were no licensed technology teachers (technology teachers' education program), background research of TE, and educational facility for technology education. Due to the unidentified goals and contents of technology education, the fundamental study associated with K-12 technology education has been a top priority in the research of Korean technology education. There were several research findings to identify the characteristics of Korean technology education. Lee (1986) identified four major characteristics of technology education through historical reviews of technology curricula. He concluded that the technology education community should establish a theoretical background. He suggested that technology in the national curriculum should be 1) an independent subject with a unique knowledge system, 2) production technology rather than life technology, 3) taught as a general education subject, and 4) presented as a subject to meet the human manual skill needs through productive learning activities. Kim (1988) mentioned several transitions in the characteristics of technology education. The initial stage of technology education emphasized fundamental knowledge and industrial skills. While technology education stressed technology required for human existence in the early 1980s, technology education in the late 1980s focused on technological knowledge and industrial knowledge. He also concluded that Korean technology education focused on a unique technological knowledge system. Ryu (2000) presented five major characteristics of technology education: 1) a subject based on a technological knowledge system, 2) a subject aimed at the development of technological literacy, 3) a subject applying scientific knowledge to real life situations, 4) a subject to build knowledge through practical activities, and 5) a subject to increase opportunities for career exploration. Many scholars in Korean Technology Education have stressed the theoretical research in the rationale and practice of technology education (Lee, 1986; Kim, 1988; Ryu, 2000). In spite of the short history of Korean Technology Education, technology education has been one of the national curriculum subjects since 1970. Currently, technology education is one of the ten common subjects in the seventh national curriculum. The curriculum transitions in Korean technology education represent the transitions of the characteristics from vocational education to general education, indicating frequent additions or changes in learning goals/contents and subject name as shown in Table 4. There were many learning goals and contents for Korean technology education in the elementary school. The diverse contents were argued by many scholars in the field of technology education. Choi (2001) established a content model for technology subject in the elementary school for his content analysis of Korean practical arts textbooks. In his model, he categorized the contents of technological literacy into five : bio-related technology, manufacturing technology, construction technology, transportation technology, and information communication technology. Chang et al. (2000) analyzed the goals and objectives of secondary school technology education in the national technology curriculum in three categories: knowledge, attitude, and competence. According to their analysis, technological competence increased, while technological knowledge and attitude decreased in middle school. Likewise, technological knowledge increased, while technological attitude and competence decreased in high school.

Table 4 *Curriculum Transitions in Korean Technology Education*

Period	Elementary School (Practical Arts)	Middle School	High School
2nd Curriculum	Four major contents *(agriculture, industry, commerce, home economics)* Agricultural area emphasis	Technology (boys) Seperate textbook for girls No discipline system *(Drafting, woodworking, machinery, electricity, metal working, occupation)*	Technology (boys) No discipline system Vocational education
3rd Curriculum		Technology(only boys) Industry contents emphasis Adding *Cultivation* area	Technology (only boys) Adding *ComputerEducation*

Table 4 (cont.) *Curriculum Transitions in Korean Technology Education*

Period	Elementary School (Practical Arts)	Middle School	High School
4th Curriculum	Addding *Career content*	Life Technology Real life emphasis *Manufacturing Tech.*	Industiral Technology Adding *Energy & Power, Manufacturing, Construction*
5th Curriculum	Adding *Computer Education*	Technology Technology & Home Economics (partial) Adding *Communication Tech.*	Technology Emphasis on disciplines (*Energy & Power, Communication, Manufacturing, Construction, Occupation & Career*)
6th Curriculum	Starting from 3rd grade Behavioral description (making, manipulating, rearing, managing, cultivating)	Technolgy & Industry (For boys and girls) Adding *Industry contents & Construction Tech.*	Technology
7th Curriculum	Starting from 5th grade Adding *Environment* contents Life Technology (making, manipulating, cultivating)	Technology & Home Economics Sequential structure from 7th grade to 10th grade. (*Communication Tech, Manufacturing Tech*)	Technology & Home Economics

Note: Underlining indicates subject name and *the italic* refers to major learning contents

Through a triangulation of research findings related to K-12 technology curriculum revision, Yi(1998) pointed out the major problems of Korean technology education: uncertainty of curriculum, poor instruction, and quality of technology teachers. Korean technology education has continued to attempt to overcome these problems. Recently, a new curriculum revision of technology education is being prepared (Yi, Chang, Yi, & Kwon, 2006).

Biotechnology Content in Curriculum Development Study and National Curriculum

Biotechnology content in South Korean Technology Education

Several studies in biotechnology have focused on contents related to biotechnology. Rho (1983) suggested a model for technology curriculum content organizers. The model contained agriculture, industry, commerce, and trade and fisheries. During the early 1980's, there was no recognition of biotechnology as a part of Korean technology education. Historically, the agricultural contents were really pervasive. However, the research to make a systematic model for technology curriculum content emerged from synthetic literature reviews (Lee, 1986). It gave

Korean technology educators great motivation to approach technology as a system. Lee (1986) suggested three major factors in his content organization model: the human social/productive effort factor (manufacturing technology systems, construction technology systems, energy and power systems, communication technology systems, and cultivation and farming technology systems), social and cultural development factors (past, present, and future), and system factors (input, process, and output). Also, he noted that cultivation and farming technology systems should be one of the curriculum content organizers for technology education. He argued that biotechnology should be included as a component of productive technology.
Kim (1994) stressed the significance of theoretical background through literature associated with technology education. In other words, he indicated that technology education in South Korea needed to incorporate a theoretical approach regarding technology curriculum development. Especially, he pointed out a major problem in content organization and suggested five major contents: manufacturing technology, construction technology, transportation technology, and bio-related technology. In the model of technology curriculum, biological technology systems were included with systems of manufacture, construction, transportation, and communication. In his survey to develop a technology curriculum content, the validity of cultivation and farming technology content was very high. Most of the survey participants (technology educators) agreed to the inclusion of cultivation and farming technology. Also, he suggested sub-categories of bio-related technology such as 'cultivation and farming technology', 'gene manipulation' and the sequential teaching of bio-related technology such as 'exploration stage for middle school' and 'in-depth exploration stage for high school'. The study on biotechnology in the 1990s advanced in more theoretical approach indicating the sub-contents and sequential structure of biotechnology. Korean technology education scholars have recognized that teaching biotechnology as a simple agricultural discipline was a problem. They suggested that technology educators needed to identify the contents of biotechnology.

Biotechnology content in the National Curriculum

Biotechnology contents in the national curriculum were initiated from agricultural contents in the elementary school (boys and girls) and middle school (girls). Considering the social needs of the 1970s, the agricultural contents had a significant portion in technology education starting from the 2nd curriculum revision. As shown in Table 5, the agricultural contents' inclusion in Korean technology education continued to add more technical knowledge and skills. After the 5th Curriculum, the content in the elementary school was converted from technical contents related to agriculture into the activity based contents of the students' real life. Since the sixth curriculum revision, the terminology of biotechnology has been taught in the secondary school technology education. According to the formal documents in national curriculum,

Table 5 *Biotechnology Contents in the National curriculum*

Curriculum	Elementary School	Middle School	High School
2nd Curriculum	Cultivation/Breeding	Technolog (for girls) Cultivating flower Cultivating vegetable Vegetable Management	
3rd Curriculum	Cultivation/Breeding	Crops Machine/facility to cultivate Cultivation of major crops Special cultivation Harvesting and process	
4th Curriculum	Cultivation and breeding	Cultivation and life Cultivation and environment Cultivation management	Environmental protection Agriculture and food Agriculture technology Process and utilization of agricultural products
5th Curriculum	Cultivating/Rearing	Cultivation environment Cultivation planning Envrionmental control for Cultivation	Agriculture technology Environmental protection
6th Curriculum	Cultivation/Rearing	Utilization of biotechnology Resources and environment Agriculture technology	Biotechnology Environmental protection
7th Curriculum	Cultivating/Rearing pets	Biotechnology and cultivation	

Biotechnology standards and new curriculum

The initial studies on biotechnology were started from the emphasis of the agricultural contents. However, there were continuous studies to develop a variety of learning contents for biotechnology. As an exemplary study, the Korea Institute of Curriculum and Evaluation (KICE) which is a representative of Korean educational research center investigated the goals and contents of biotechnology from 2000 to 2002.
KICE's study was initiated from probing a question of "How should we set forth the educational goals and curriculum contents of Practical Arts and Technology & Home Economics for a knowledge-based society?" To progressively cope with the transitions of the environment and society, there was a need to clarify and verify demanding educational goals and curriculum contents of Practical Arts and Technology & Home Economics. The study aims to systematize the objectives and contents in practical arts education, technology education, and home economics education in school. From the three round Delphi survey, conclusions on the nature

and characteristics of structural framework of curriculum contents, and literacy through Practical Arts education, Technology education, and Home Economics education were drawn. A further study was conducted to develop the objectives and contents based on the results of a needs assessment of current curriculum (KICE, 2002).

The standards movement was pervasive through all subjects of national curriculum and had two types of standards. One is the achievement standard defined as expected national achievement levels. The achievement standards have been developed for presenting the minimum standards based on the national curriculum. The biotechnology instruction in current technology curriculum was presented by a middle learning unit of “biotechnology and cultivation” under a large learning unit of “future technology”. The other is the content standard, an outcome of the KICE’s study. According to KICE’s study, the content standards for technology education were developed from a triangulated synthesis of setting goals, objectives, and large learning units, assessing the needs of students, technology educators, and parents, and referring to international and historical technology curriculum documents. In Practical Arts, the general objectives, subj-objectives and thirty-six contents standards were each created. The content standards related to biotechnology in the elementary school could be described as in Table 6. The objectives of biotechnology in the elementary school emphasized on knowledge, competence, and attitude about cultivation and rearing. Also, the objectives for cultivation and rearing were described in the sub-objectives of separate sentences.

Table 6 *Content Standards related to Biotechnology in Practical Arts (Elementary School)*

[Objective] Students are able to develop their understanding on the fundamental knowledge related to "cultivation (plant) and rearing (animal)" and competence and attitude on "cultivation and rearing".

[Sub-Objective 1: [A] Cultivation] Students are able to understand the knowledge necessary to
cultivate plants and cultivate simple plant.

[Sub-Objective 2: [B] rearing] Students are able to understand the knowledge necessary to rear animals and rea animal in their lives.

Content Standards	Content components
A.1. Understand growing process of vegetable and cultivate several vegetables	- Process of vegetable growth - Germinating - Cultivating leaf, fruit, root vegetables
A.2. Understand cultivated process of flower and cultivate several flowers	- Process of flower cultivation - Seeding and planting - Managing seeding - Cultivating various flowers
A.3. Understand growing process of tree, plant, and manage tree	- Process of tree growth - Selecting and planting tree - Manage tree
B.1. Understand type, feature, and growth process of pet and rear selected pet	- Type and feature of pet - Growth process of pet - Rearing fish - Rearing pet (puppy, bird, etc)
B.2. Understand rearing and distributed process of the animals.	- Growing process of economical animals - Distribution process of economical animals

Compared to biotechnology contents in the elementary school, biotechnology contents in the secondary school focused on the biotechnological literacy. In other words, the objectives related to biotechnology were described by three categories of "knowledge, competence, and attitude". The technological literacy associated with biotechnology were 1) [knowledge] understanding concept and principles related to biotechnology, characteristics and significance of biotechnology, and historical development and transition of biotechnology, 2) [competence] ability to solve the problem related to biotechnology in real life and ability to apply knowledge related to biotechnology, and 3) [attitude] sound attitude related to biotechnology and attitude to evaluate and analyze the impact of biotechnology to human and environment. The content standards for the secondary school includes one general objective, three sub-objectives, seven content standards, and eighteen content components as listed in Table 7.

Table 7 *Content standards related to biotechnology in the secondary school*

[Objective] Students are able to understand functions and process of biotechnology in real life and develop competence to utilize a variety of biotechnology product reasonably.
[Sub-Objective 1: [A]] Students are able to understand basic knowledge and function related to biotechnology and apply know-how of biotechnology to real life.
[Sub-Objective 2: [B]] Students are able to understand process and methodology to employ biotechnology in many industrial fields.
[Sub-Objective 3: [C]] Students are able to analyze social impacts and ethical problems in the process to utilize biotechnology and explore careers related to biotechnology.

Content Standards	Content components
A.1. Understand concept and transition process of biotechnology	- Significance and conceptions of biotechnology - Utilized field of biotechnology - Transitions of biotechnology
A.2. Understand basic principle and methodology of biotechnology	- Principles of biological process - Utilized methodologyof biological objects
B.1. Understand application ways of biotechnology in agricultural industry	- Plan cultivation and breeding - Animal rearing and reproduction - Food process and fermentation
B.2. Understand application ways of biotechnology in medical industry	- Characteristics of gene and heredity disease - Development of medicines and application of micro-organism.
B.3. Understand applicative ways of biotechnology in environmental industry	- Waste disposal and biotechnology - Environmental protection and biotechnology - Resources recycling and biotechnology
C.1. Judge ethical problems related to biotechnology and understand their social impact	- Issue of animal reproduction - Issue of genetic modified organism and safety - Innovation of biotechnology and its social impact
C.2. Explore careers related to biotechnology	- Occupations related to biotechnology - Career exploration and tentative selection related to biotechnology.

Based on curriculum research, new Korean technology education curriculum is constructed with five curriculum content organizers: manufacturing technology, construction technology, communication technology, transportation technology, and biotechnology. Most significant in this newest technology education curriculum is the inclusion of biotechnology as a major curriculum content organizer. Biotechnology has been a small learning topic in Korean technology education since 1970. However, new technology curriculum places biotechnology as a major learning content as Table 8. Biotechnology has two sub-learning contents of ‘biotechnology in our lives’ and ‘application of biotechnology’. It is very silimar to biotechnology contents in Korean contents standards.

Table 8 *Learning contents in new technology curriculum*

Grade	7th grade	8th grade	9th grade	10th grade
Learning contents	Technological Development and Future Society Technology and Invention	Information and Communication Technology Manufacturing Technology	Electronics and Machine Technology Construction Technology Biotechnology	Vocation and Career Design Transportation Technology

Current Issues related to the Inclusion of Biotechnology into South Korea TE Curricula

Inconsistencies in terminology

The initial stage of Korean technology education emphasized the goals and contents of vocational education. Agriculture was a major learnig topic but contemporary technology education has taken efforts avoiding from vocational education. Traditional agriculture contents has transformed into biotechnology. The first emergence of biotechnology terminology was at the sixth revised technology curriculum. Although the biotechnology had emerged as a learning topic of 'utilization of biotechnology', the contents were still agricultural learning contents. Due to the shortage of curriculum research related to biotechnology, many curriculum researchers cited biotechnology contents in the publication of *Standards for Technological Literacy* (STL). Also, there are several problematic issues related to interpretation and translation of biotechnology terminology. Biotechnology, life-technology, life-engineering, bioengineering, and agriculture technology, and bio-related technology presented in literature, theses and dissertations, curriculum development research, many inconsistent terminologies gave Korean students and technology teachers disordered impressions of biotechnology. Therefore, study to delve into biotechnology terminology is needed for stable establishment of biotechnology in Korean technology education.

Technology teacher education and biotechnology

In South Korea there are three teachers' colleges that prepare licensed technology education teachers for secondary schools. These institutes are Chungnam National University (since 1985), Korea National University of Education (since 1996), and Daebul University (since 2005), all having technology education departments. A review of the curriculum used by these institutes suggests that courses related to biotechnology are scarce (Table 9). Considering the significance of biotechnology as a content organizer within the new technology curriculum, the design and development of biotechnology courses for pre-service technology education teachers should be made a priority.

Table 9 *Courses related to biotechnology in technology education department*

Institute Name	CNU	KNUE	DU
Course Name	Cultivation Technology	Agricultural Science and Technology Agricultural Biotechnology Food Science and Technology Environmental Engineering	Breeding and Cultivation Technology Technology of Nature and Environment

Biotechnology in SK Technology Education Curriculum: Observations and Recommendations

The recent curriculum reform initiatives in Korean Technology Education were innovative in terms of establishing goals and content for the national Technology Education curriculum. Despite the low number of qualified technology teachers and technology teacher educators, and the lack of public awareness of technology education since 1970, technology education in South Korea has continued to make great strides in establishing itself as an integral component of the national curriculum reform movement. As well, research results from several Korean studies on South Korean technology education are providing guidance for continuing these efforts by contemporary and future Korean technology educators (KICE, 2002; Yi, et al, 2006). It is of significance to note that this Korean research continually draws on the US *Standards for Technological Literacy* as a conceptual model when promoting technological literacy through technology education curriculum initiatives in South Korean. As a result the new Korean national technology education curriculum content organizers (manufacturing, construction, information and communication technology, transportation, and biotechnology) are more closely reflecting those presented in the US *Standards for Technological Literacy*.

The emergence of biotechnology was inevitable and acceptable to Korean technology education. The biotechnology contents is that all Korean middle school students should learn through technology education. However, the biotechnology contents had several challenges for futher biotechnology instruction: the needs of research related to biotechnology, lack of technology teachers' education related to biotechnology, and needs of research related to instructional strategies in biotechnology instruction. Even though new Korean technology edcuation curriculum is constructed by five major content organizers including biotechnology, instructional topics and methodology associated with biotechnology should be developed in accordance wtih Korean cultural/educational circumstance. Compared to other content organizers, supplementary studies related to biotechnology are needed. Due to many biological terminologies and inconsistent usages, technology teachers and students might get confused and frustrated with biotechnology contents.Therefore, the study on the terminology related to biotechnology is the top priority as a research topic. The history of Korean biotechnology instruction indicates an emphasis on agricultural contents. As the studies of Korean technology education intiatives

(KICE, 2002, Yi, et al, 2006) suggested, other contents such as environment, medical technology, biotechnological ethics, and etc should be studied systematically.

In the level of technology teachers' education, biotechnology courses was limited in the agricultural related courses. As the framework of content organizer in national technology education curriculum represents the inclusion of biotechnology, biotechnology related courses should be added or its contents should be reinforced correspondingly in the curriculum of preservice technology teachers. Korean technology teachers should concentrate on the strategies for biotechnology instruction.

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