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RESEARCH ARTICLE

Comparison of semantic networks for biotechnology unit in Korean and Iranian textbooks

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ABSTRACT

Textbooks are compiled based on the curriculum and are tools for implementing the curriculum, and they are the central teaching materials that teachers use to implement the curriculum in the field when teaching. In particular, science subjects have a high level of conceptual hierarchy, so science textbooks must secure connectivity for learners' smooth understanding. It is necessary to compare Korean textbooks with foreign textbooks to understand how the structure of scientific concepts is described. In the 21st century, biotechnology has been attracting attention as an industry with global economic value, and as many biotechnology technologies have been commercialized, they have become closely related to our daily lives. Accordingly, the importance of biotechnology is being emphasized. Therefore, this study compared how biotechnology concepts are described in Korean and Iranian life science textbooks. The biotechnology unit was analyzed by dividing it into the 'Genetic and bioengineering' and 'Uses of Biotechnology' domain. To compare the textbooks, three Korean approved textbooks and one Iranian national textbook were selected. The concept network was analyzed as a concept network and a connected concept network using the NetMiner 4.0 program. When comparing and analyzing the concept network and the main concept network as a result of the study, it was found that the Korean textbook had more concepts and a more complex network than the Iranian textbook. In addition, through the analysis of the connected concept network, it was found that many concepts were commonly used in both Korea and Iran. Based on this study, additional research should be conducted to compare concept networks described in textbooks with student concept networks.

Key words: Textbook, biotechnology, semantic network, international comparison of textbooks, genetic and bioengineering, uses of biotechnology

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Introduction

Textbooks are compiled based on the curriculum and are tools for implementing the curriculum (Choi & Park, 2010; Song & Shim, 2019), and are the central teaching materials that teachers use to implement the curriculum in the field when teaching.. Textbooks are a medium that help students acquire knowledge in various ways by including explanations of knowledge and theories as well as illustrations and materials to help with understanding (Kang, 2013).

Teachers use textbooks as the main teaching materials for teaching and learning activities and set the standards for educational activities (Angus, 2004), so textbooks play an important role in the classroom. Textbooks are a very important educational medium for students as well as teachers who conduct classes, as they function to present learning content, arrange learning sequences, guide inquiry content, and induce motivation (Priya & Yadava, 2017), and check learning achievement (Lee & Bae, 2010).

In particular, science is a subject with a high conceptual hierarchy, so connectivity must be secured for learners' smooth understanding (Brophy & McCaslin, 1992; Staver & Bay, 1989). If the content of science textbooks is not conceptually connected, learners will have difficulty structuring and comprehensively understanding scientific knowledge (Brophy & McCaslin, 1992; Staver & Bay, 1989). Science textbooks are positioned as an essential medium for teachers to conduct classes, with the function of presenting subject standards being emphasized more than in other subjects (Kesidou & Roseman, 2000).

Textbook research has been conducted on vertical connectivity between grades (Joo & Kim, 2002; Kim, 2023; Seo et al., 2020), illustrations (Kim, 2023; Lee, & Gen, 2022), teachers' use of textbooks (Kim, & Kim, 2023), textbook sentences or texts (Kwon et al., 2018; Park & Kwon, 2024), and comparisons with North Korea (Kim, 2020). In addition, comparisons with foreign textbooks have been studied.

Cases comparing domestic textbooks with foreign textbooks in science subjects were mainly conducted in East Asian countries such as Japan and China (Lee & Choi, 2013; Shim & Choe, 2005; Park & Park, 2006), the United States, Singapore, and Finland (Choi & Park, 2010; Kwon & Cho, 2011; Yang, 2016), and European countries (Lee, 2013). These previous studies were limited to the composition of textbook units, the content of textbooks, and the system. In other words, they did not analyze the conceptual structure described in textbooks. In addition, there were few comparisons with countries that use national textbooks, such as Iran.

Meanwhile, biotechnology is receiving attention as an industry with global economic value, and has become closely related to our daily lives. As members of society living in modern society, students must have scientific literacy through understanding biotechnology and be able to adapt to and cope with a rapidly changing society due to the development of science and technology (Jeong et al., 2015; Nordqvist & Aronsson, 2019). Accordingly, the importance of biotechnology-related topics is increasingly emphasized.

The field of biotechnology is broad and is divided into genetic engineering, protein engineering, and tissue engineering, and is developed based on various disciplines such as physics, mathematics, chemistry, and engineering as well as life science (Eskandari & Kim, 2022). In order to understand biotechnology, it is necessary to understand the overall content of life science and be able to integrate and apply various principles (Dawson, 2003; Lock, & Miles, 1993).

Although the importance of developing biotechnology curriculum and content has been confirmed (Chen et al., 2016), most science textbook studies have focused on the entire textbook or comprehensive studies such as inquiry activities or illustrations (Kim et al., 2017; Lee & Kim, 2016). Textbook studies on biotechnology units are insufficient (Han & Shim, 2024), and there is no international comparison. Therefore, this study analyzed the concept network of life science units in Korean and Iranian textbooks. Through this, we can understand the direction of guidance in other countries regarding biotechnology, and it will provide basic data for the description of biotechnology units in the future.

Research Methodology

Subjects

As the research subjects, three textbooks used in the field were selected from among the Korean life science II textbooks including the biotechnology unit. One life science textbook used in Iran was the Grade 12 life science textbook. Among the various parts of the textbook, only the text corresponding to the main text was analyzed.

Table 1. Units of the analyzed textbook

Textbook		Unit and sub-unit
Korea	A	Ⅵ. Biotechnology and human life
		1. Principles of genetic recombination technology
		2. Biotechnology related to cloning
		3 Treatment of incurable diseases using biotechnology
		4. Impact of biotechnology
		5. Present and future of biotechnology
	B	Ⅵ. Biotechnology and human life
		1. Biotechnology
		2. Human Life and the Use of Biotechnology
	C	Ⅵ. Biotechnology and human life
		1. Principles and Applications of Biotechnology
		2. Bioethics of Biotechnology
Iran		Ⅶ. New biotechnologies
		1. Genetic Engineering
		2. Protein and tissue engineering technology
		3. Uses of biotechnology
		4. Biotechnology and ethics

Data Collection and Data Analysis

In order to extract concepts from the biotechnology-related units of the selected textbooks, the text of the textbook was transcribed into a text file without modification. During the transcription process, words were separated by spaces, sentences were marked with periods, and paragraphs were marked with line breaks. The introduction of each unit, life science stories, research activities, reading material, experiments, and concept check included in the textbook were excluded from the analysis. The Iranian textbook used materials translated from Persian into English and was transcribed in the same way as the Korean textbook.

The transcribed text was divided into the 'Genetic and bioengineering' domain and the 'Uses of biotechnology' domain, and was divided into a biotechnology unit that included both domains and created as a text file. The transcribed text file was input into the NetMiner 4.0 program and the concept extraction process was performed.

During the concept extraction process, Korean particles and predicates were excluded, and English words were extracted. A thesaurus was created using the text file so that synonyms used with similar meanings were processed as one concept. A definition dictionary was created for concepts that consisted of multiple words but should be processed as one concept. For words that were too general or scientifically insignificant, an exclusion dictionary was created and went through a primary refinement process.

A refined concept extraction list was created using three dictionaries: a definition dictionary, a synonym dictionary, and an exclusion dictionary. In order to study Korean and Iranian textbooks together, the concept list was translated into English. Words extracted from Korean textbooks were translated into English using dictionary definitions and the English used in biology textbooks. The number of concepts initially extracted was 123 for Korean textbooks and 131 for Iranian textbooks, and 202 concepts were extracted through the preprocessing process.

The extracted concepts were requested to five biology education majors to select the final concepts. These majors consisted of four biology teachers (one master's and three doctoral degree) and one biology education expert. They were asked to indicate concepts that were scientifically insignificant among the concepts in the extracted concept list. Based on the five requests collected, words that were indicated three or more times were excluded from the list to complete the final concept list. The final number of selected concepts was 69. The number of concepts in the 'Genetic and bioengineering' domain was 45, and the number of concepts in the 'Uses of biotechnology' domain was 64.

The selected concepts were visualized as networks between concepts using the NetMiner 4.0 program. In network structure, the size of nodes (proportional to occurrence frequency), the thickness of links between nodes (based on co-occurrence and co-occurrence frequency), and closeness centrality were used to analyze the relationships between concepts. The main concept network was analyzed using only the top 30% of concepts in terms of frequency of appearance. It was visualized as a concept network using 1-mode in the NetMiner 4.0 program, and as a connected concept network using 2-mode.

Results

Concept network

'Genetic and Bioengineering' Domain

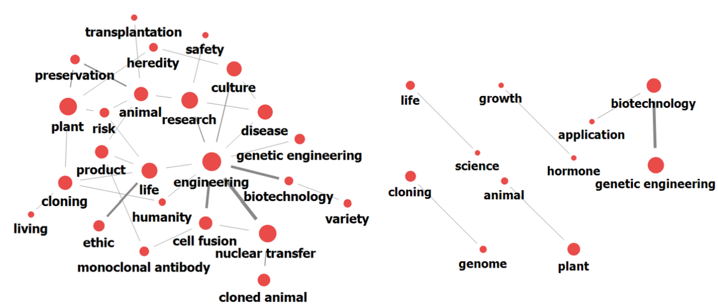
Fig. 1 shows the concept network of the 'Genetic and Bioengineering' domain in Korean and Iranian life science textbooks. Looking at the Korean textbook, the network consists of a total of 22 concepts (Fig. 1a). The frequency was high in the order of plant (18 times), nuclear transfer (18 times), research (15 times), life (14 times), and culture (13 times). The Eisenvector centrality was high in the order of life, ethic, preservation, and animal.

The network is located at the center with plant, cloning, life, and animal showing connections with four or more concepts. 'Plant' is connected to preservation, heredity, cloning, and risk, and 'animal' is connected to research, culture, product, preservation, and transplantation. Korean textbooks present key concepts as being organically interconnected, forming a large conceptual network.

The total number of concepts shown in the concept network of the Iranian textbook is 13, and the frequency of use of the concepts is biotechnology (16 times), genetic engineering (13 times), circular DNA (13 times), and engineering (12 times), and the other concepts were used 1 to 6 times. The Eisenvector centrality was high in the order of biotechnology, genetic engineering, application, and engineering.

The concept network image of the Iranian textbook formed a total of five concept networks, and all of them consist of 2 to 4 concepts. The network composed of 4 concepts is centered around biotechnology, and genetic engineering, application, and engineering are connected. Since all of these concepts have high Eisenvector centrality, it can be seen that this network shows the tightest connection.

The Korean textbook shows a network structure in which the concepts are connected to each other, but the Iranian textbook does not have the concepts connected to each other. In addition, the Korean textbook describes more concepts than the Iranian textbook.

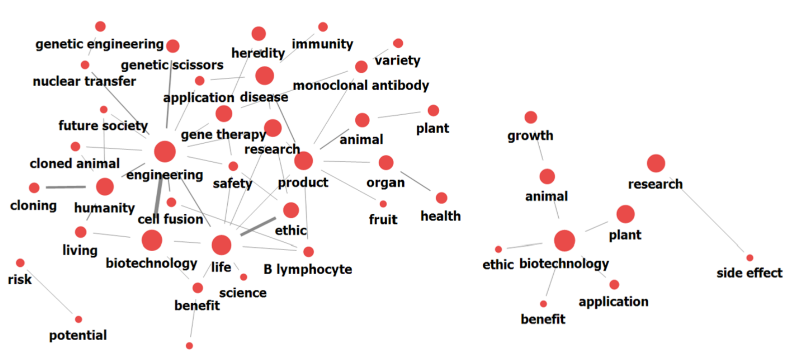


a. Korea b. Iran

Fig. 1. Concept network in the 'genetic and bioengineering' domain.

'Uses of Biotechnology' Domain

Fig. 2 shows the concept network of the 'Uses of biotechnology' domain. Looking at Korean textbooks, the network consists of a total of 32 concepts (Fig. 2a). The frequencies were high for biotechnology (50 times), life (30 times), product (22 times), and disease (22 times), while the rest all had frequencies of 15 or less. Eisenvector centrality was high for life and ethic.



a. Korea b. Iran

Fig. 2. Comparison of concept networks in the 'Uses of biotechnology' domain.

The concept network was formed around humanity, life, product, and disease. ‘Humanity’ is connected to cloning, living, and cloned animal, future society, and ‘life’ is connected to benefit, biotechnology, product, research, safety, ethic, science, and B lymphocyte. ‘Product’ is connected to organ, fruit, monoclonal antibody, animal research, life, B lymphocyte, and disease, and ‘disease’ is connected to application, heredity, research, and immunity. On the other hand, the concepts of genetic engineering, nuclear transfer, risk, and potential were not connected to other concept networks.

There are 9 concepts in the concept network for the 'Uses of biotechnology' domain of the Iranian textbook (Fig. 2b), and the frequency of use of the concepts was biotechnology (14 times), plant/research (8 times), and animal (5 times), while the other concepts showed a frequency of 1 to 3 times. Biotechnology had the highest eigenvector centrality, and animal, application, benefit, ethic, and plant had similar values. The concept network was formed around biotechnology. ‘Biotechnology’ is connected to animal ethic, benefit, and application. On the other hand, research and side effect were not connected to other concepts in the network.

Biotechnology Unit

Fig. 3 is the concept network of the Biotechnology unit,, which combines the ‘Genetic and Bioengineering’ domain and the 'Uses of biotechnology' domain. Looking at the Korean textbook, the network consists of a total of 34 concepts (Fig. 3a). The frequency was in the order of biotechnology (57 times), life (51 times), disease (43 times), product (35 times), and research (31 times). The Eisenvector centrality was high in the order of life, ethic, preservation, and animal.

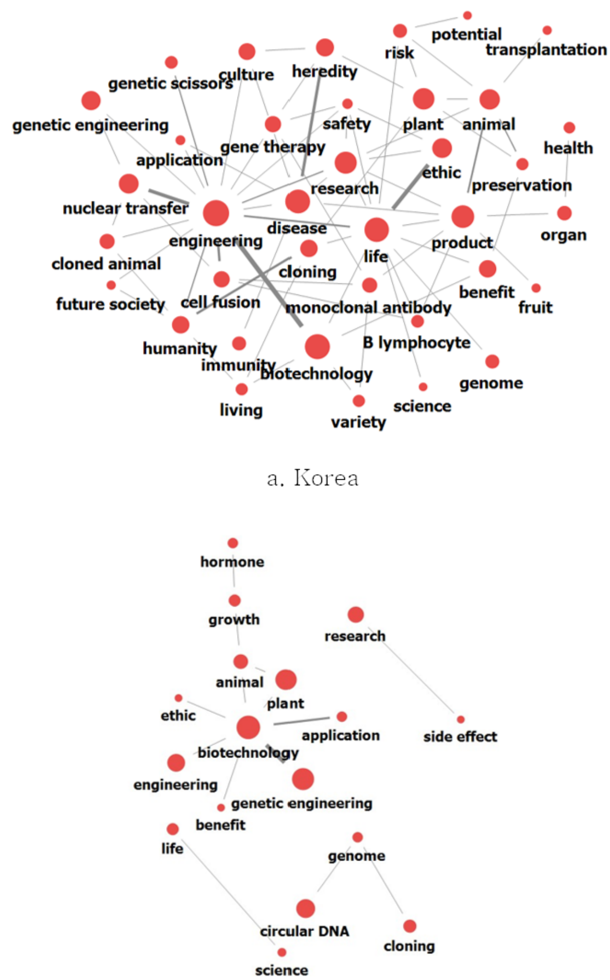
The concept network is centered around life, product, disease, and biotechnology. ‘Life’ is connected to risk, cloning, benefit, biotechnology, science, ethic, and product, and ‘Product’ is connected to fruit, organ, disease, B lymphocyte, and life. ‘Disease’ is connected to application, immunity, heredity, culture, research, and product, and ‘Biotechnology’ is connected to life, benefit, living, and variety.

The concept network for the Biotechnology unit, of the Iranian textbook consists of 17 concepts (Fig. 3b). The frequency of concept usage was high in the order of biotechnology (30 times), genetic engineering (16 times), plant (14 times), circular DNA (13 times), and engineering (11 times), and the other words showed frequencies of 1 to 8 times. Eigenvector centrality was also high in the order of biotechnology, genetic engineering, application, and animal, and the values of other concepts were similar. The concept network was described with biotechnology as the center. Biotechnology is connected to plant, animal, ethic, engineering, benefit, and genetic engineering. Unlike Korean textbooks, there were concepts that were disconnected.

Key Concepts Network Analysis

‘Genetic and Bioengineering’ Domain

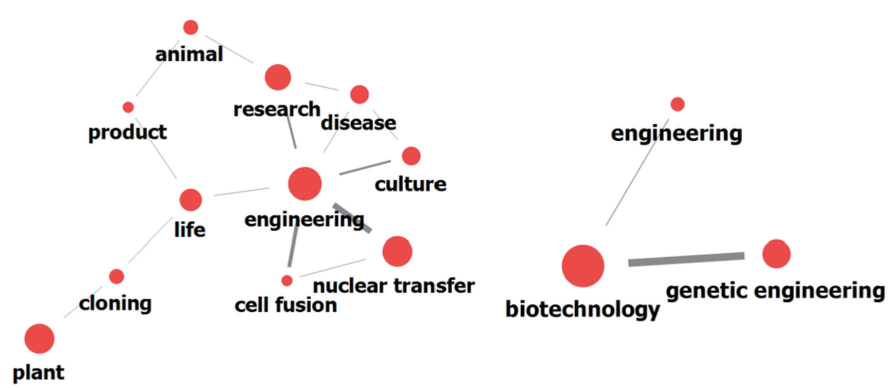
Fig. 4 shows the main concept networks described in Korean and Iranian textbooks in the 'Genetic and bioengineering' domain. Looking at the Korean textbook, the network consists of a total of 14 concepts (Fig. 4a). The main concept network is centered around nuclear transfer, life, plant, and research. ‘Nuclear transfer’ is connected to cloned animal and cell fusion, and ‘life’ is connected to product, animal, and life. ‘Plant’ is connected to cloning, risk, and preservation, and ‘research’ is connected to disease and animal. The Iranian textbook consists of three concepts, and genetic engineering and engineering are connected centered around biotechnology (Fig. 4b).



a. Korea

b. Iran

Fig. 3. Comparison of concept networks in the biotechnology unit.



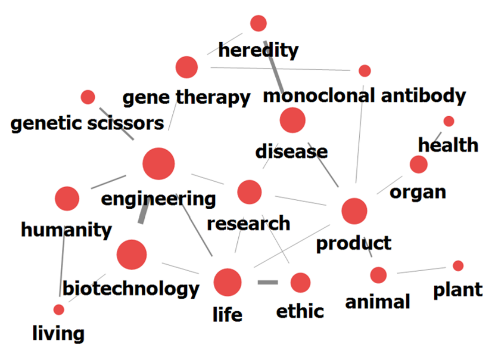
a. Korea b. Iran

Fig. 4. Comparison of key concept networks in the ‘genetic and bioengineering’ domain.

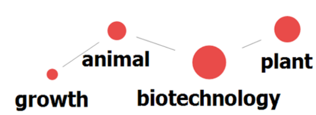
When comparing the number of concepts that make up the networks of Korean and Iranian textbooks, the Korean textbook has 11 concepts and the Iranian textbook has 3 concepts, with the Korean textbook having 8 more concepts. The network is also complexly formed due to the large number of concepts that make up the networks.

'Uses of Biotechnology' Domain

Fig. 5 compares the main concept networks of Korean and Iranian textbooks in the 'Uses of biotechnology' domain. Looking at the Korean textbook, the network consists of a total of 17 concepts (Fig. 5a). The network is centered around engineering, life, and product. 'Engineering' is connected to genetic scissors, gene therapy, humanity, research, and biotechnology, 'life' is connected to research, ethics, and biotechnology, and 'product' is connected to life, disease, organ, and animal. The Iranian textbook is centered around biotechnology, and biotechnology is connected to animal and plant. When comparing the Korean and Iranian textbooks, the number of concepts in the Korean textbook is 11 more than that in the Iranian textbook. While all concepts in the Iranian textbook's concept network are connected in a straight line, the Korean textbook's concept network has four concepts with three or more connections: disease, product, research, and life.



a. Korea



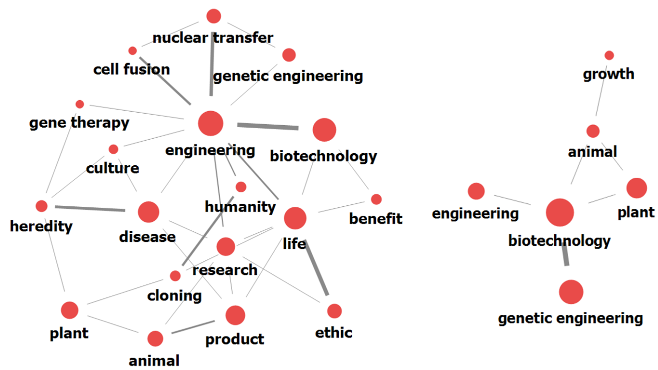
b. Iran

Fig. 5. Comparison of key concept networks in the 'Uses of biotechnology' domain.

Biotechnology Unit

Fig. 6 compares the main concept networks described in Korean and Iranian textbooks for the biotechnology unit. Looking at the Korean textbook, the network consists of a total of 17 concepts and is centered around engineering and life. 'Engineering' is connected to gene therapy, humanity, cell fusion, nuclear transfer, biotechnology, life, etc., and 'life' is connected to 'engineering, disease, animal, etc.' The Iranian textbook is centered around biotechnology, and 'biotechnology' is connected to engineering, genetic engineering, plant, and animal.

When comparing the Korean and Iranian textbooks, the number of concepts that make up the Korean textbook is greater than that of the Iranian textbook. The concept network of the Korean textbook consists of two networks, while the Iranian textbook consists of one network. The concepts that show more than four connections are five in Korea: research, animal, life, disease, and heredity, while in Iran, there is one: biotechnology.



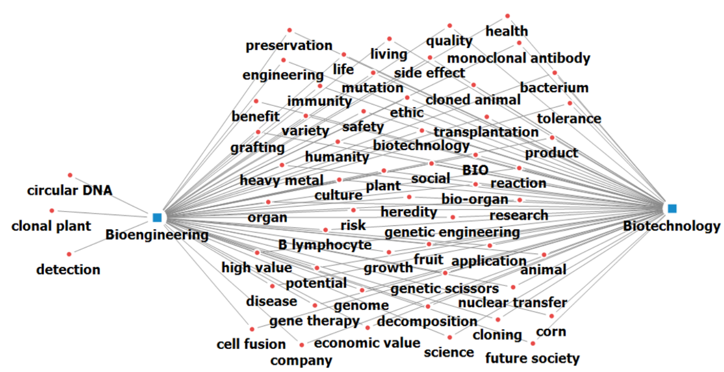
a. Korea b. Iran

Fig. 6. Comparison of key concept networks in the biotechnology unit

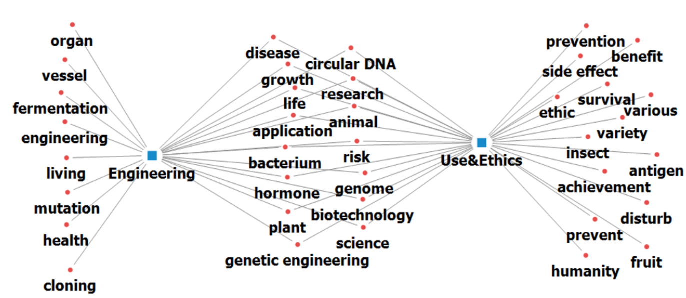
Connection Network

Between Domain

Fig. 7 analyzes the concepts connecting the 'Genetic and bioengineering' and 'Uses of biotechnology' domains of Korean and Iranian life science textbooks. The Korean life science textbook included a total of 57 concepts, and 54 concepts were common in both domains(Fig. 7a). The concepts that existed only in the 'Genetic and bioengineering'



a. Korea



b. Iran

Fig. 7. Comparison of the between domain connection networks in Korean and Iranian textbooks

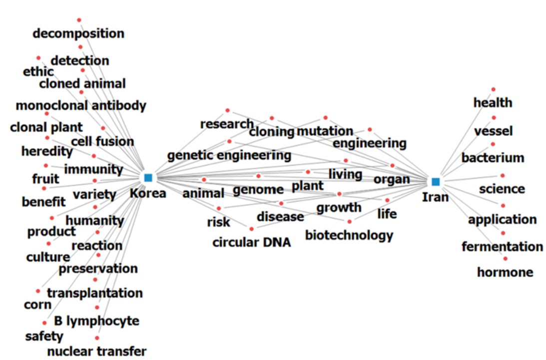
domain were circular, conal plant, and detection.

The Iranian textbook presented a total of 37 concepts, and the concepts that were commonly used were 15 concepts, including biotechnology, genetic engineering, circular DNA, hormone, and application(Fig. 7b). The concepts that were used only in the 'Genetic and bioengineering' domain were 8 concepts, including health, mutation, organ, vessel, and engineering. The concepts that were used only in the 'Uses of biotechnology' domain were 14 concepts, including humanity, benefit, ethic, insect, and side effect.

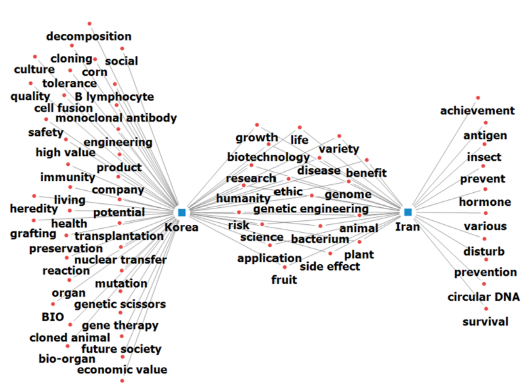
Compared to Iranian textbooks, Korean textbooks use many concepts to explain concepts, but they tend to make connections between the two domains. While Korean textbooks have three concepts that exist only in one domain, Iranian textbooks have eight and 14 concepts that exist only in one domain, respectively, which is more than Korean textbooks.

Between Countries

Fig. 8 is a network of connected concepts between Korea and Iran in the domains of 'Genetic and bioengineering' and 'Uses of biotechnology'. In the network of connected concepts in the domain of 'Genetic and bioengineering' (Fig. 8a), there were six concepts that were commonly described in Korean and Iranian textbooks, including genome, circular DNA, engineering, and biotechnology. In this domain, there were 22 concepts that existed only in Korean textbooks, including cloned animal and product, and seven concepts in Iranian textbooks, including bacterium. In the domain of 'Uses of biotechnology' (Fig. 8b), there were 19 concepts that were commonly described in Korean and Iranian



a. Genetic and bioengineering



b. Uses of biotechnology

Fig. 8. Comparison of the network of connected concepts in Korean and Iranian textbooks by domain

textbooks, including genome, ethics, and genetic engineering. There were 35 concepts that were described only in Korean textbooks, including cell fusion, company, and social, and 10 concepts in Iranian textbooks, including insect and hormone.

Discussion

So far, we have analyzed the concept networks of biotechnology units in Korean and Iranian life science textbooks. It was found that Korean textbooks state more concepts than Iranian textbooks. Korean textbooks presented concepts by connecting the two domains with many concepts. Iranian textbooks explain the concept of genetic engineering, which is the main concept of this unit, by repeatedly using concepts related to genetics or the cell cycle (Eskandari & Kim, 2022; Fathi-Azar, 1981). On the other hand, Korean textbooks use many concepts and explain them in connection with various related fields. This is thought to be based on the curricula of the two countries. In the case of Iran, genetic engineering, protein and tissue engineering, stem cells, and the application of biotechnology in agriculture and medicine are explained. Finally, biotechnology ethics are discussed (Eskandari & Kim, 2022). Korea requires that students research and present cases of biotechnology as well as biotechnology, and discuss the positive and negative effects of biotechnology. Finally, they understand the ethical, legal, and social issues that arise in the development process of biotechnology (MOE, 2015). In other words, Iran focuses on understanding and utilizing biotechnology, but Korea discusses the understanding and utilization of biotechnology, as well as ethical and social issues that should be considered when developing and utilizing biotechnology.

Some concepts are not connected to related concepts and are separated, making it difficult for students to understand the concepts. In the Korean textbook, risk and potential were not connected to other concepts. In the Iranian textbook, concepts such as 'culture', 'vaccine', 'biosafety', and 'genetic engineering' are not connected to other concepts. If concepts are not connected to other concepts, it becomes difficult for students to understand the relationships between related concepts (Brophy & McCaslin, 1992; Staver & Bay, 1989).

In the top 30% of key concepts presented in the textbook, the number of concepts or frequency of those concepts was higher in the Korean textbook. This is thought to be because the key concepts in the Iranian textbook are not explained in connection with related concepts. In the case of Korea, key concepts cover a lot of the content of the domain or unit, but there was no analysis on whether it was sufficient.

Conclusion

This study compared and analyzed the concept networks of biotechnology units in Korean and Iranian life science textbooks. To this end, the concept networks of the textbook text, main concept networks, and connected concept networks were examined. In the process, concepts were selected from three textbooks published by Korean publishers and one Iranian textbook, and networks were created using these concepts and then analyzed. The conclusions of the study are as follows.

First, Korean textbooks showed a larger number of concepts and a more complex and close network than Iranian textbooks. In addition, through the network analysis of connected concepts, it was found that many concepts were commonly used in both Korea and Iran. This can be seen as a result of the international nature of biotechnology units in life science textbooks.

Korean textbooks explained the application and value of biotechnology using many concepts. On the other hand, Iran tends to repeatedly describe biotechnology to facilitate understanding. In the case of Iranian textbooks, biotechnology was the main concept in both domains, but in the case of Korean textbooks, there were multiple main concepts, and other related concepts rather than biotechnology were at the center of the network.

Second, Korean and Iranian textbooks showed differences in describing biotechnology units. While Korea presents and states many related concepts, Iran explains them by using concepts repeatedly, focusing on the concept of genetic engineering. In addition to understanding and applying biotechnology, Korea also describes socio-cultural issues and future research directions. However, Iranian textbooks appear to focus on understanding and applying biotechnology.

Third, most of the concepts were commonly used in the network of concepts connecting the 'Genetic and bioengineering' domain and the Use of Biotechnology domain, which is a characteristic that appears in both Korean and Iranian textbooks. Through this, it can be inferred that Korean and Iranian textbooks have secured the connection between the two domains well in the textbooks, and that the expansion of textbook contents was also sequentially carried out according to the development of each unit.

Based on this study, additional research should be conducted to compare the concept networks described in textbooks with the student concept networks. Based on additional research, it is expected that the concept networks in textbooks and the student concept networks can become similar. In addition, it is expected that research will be conducted on what differences in the number of concepts presented in textbooks have on students' achievements.

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