Proceeding Paper

Patent Statistics and Analysis of Development Trends of Technology-Assisted Instruction [†]

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Abstract: Patents and related statistics are the indicators of technological progress. There have been controversial discussions about the value of patents as an indicator of technological advancement. Patent research has been conducted for research and development to develop the core framework of the United States Patent and Trademark Office. This study was conducted to classify the patents in terms of technology-assisted instruction using the Patent Co-citation Analysis (PCA) method and factor analysis. For the analysis, education, demonstration, rendition, instructional aids, instructional equipment, teaching aids, and didactic materials were chosen as keywords to construct a citation relationship network of patents and to classify core patent issues. The study results showed that 225 patents were cited more than 25 times. They were classified into 11 categories. The result provided information on the development and application of technology-assisted education to develop teaching tools further.

Keywords: patent statistics; citation analysis; patent co-citation analysis; technology-assisted instruction

1. Introduction

Teaching aids, classroom digitization equipment, and technology have continued to be improved over the past two decades. Recently, educational technology, including auxiliary teaching of textbooks and teaching aids, has become an issue for educational changes and the integration of classroom teaching. Combining traditional education with teaching aids improves the interest and quality of students in classroom learning [1]. In traditional teaching methods, adding devices to teaching materials devices assists classroom instruction and supports classroom learning and teaching process with tools, technologies, equipment, software environment, and information-based resources. It helps students overcome their learning difficulties with interesting topics and comfortable feelings. With the development of teaching aids, researchers pay attention to intellectual property rights which are key in many fields of business. Learning for development is conclusive for the education system in the era of modern technology. Due to the increasing importance of knowledge, private companies, research institutes, and colleges have found that protecting intellectual property rights is critical. These previous works led us to find the best way for intellectual property rights such as patents [2].

The OECD Patent Statistics Manual (OECD, 2009) gives a detailed list of patents as statistical indicators of inventive activity and covers the advantages and disadvantages of the indicators of patent statistics in depth. Patent analysis has been regarded as a tool for the techno-economic analysis of R&D management and productivity of enterprises, as well as

international innovation performance. Therefore, patents are considered a sufficient source of technical and commercial knowledge about the progress of technology, market trends, and ownership [3]. It is used as bibliometric data with various techniques to manipulate and analyze them. Patent citation analysis is the most widely used [4,5]. The patent citation analysis provides technical indicators such as patent citations, the cycle time of technology, and the impact index of technology. These indices have been used as indicators of the quality of technological assets, the economic value of innovation output in the market value equation, and technological coupling and knowledge flows within borders. Patent documents contain important research findings for educational, industrial, commercial, legal, and policy-makers [6]. Therefore, this research aims to study the development trends in technologies using patent information.

2. Literature Review

2.1. Teaching Aids

Teachers are presenters and players to encourage students to participate in learning and keep them vigilant and efficient in class [7]. In traditional teaching methods, adding devices to teaching materials assists classroom instruction and supports learning and teaching with tools, equipment, software, and information-based resources. It helps students overcome learning difficulties, makes the textbook interesting, and makes students feel competent [8].

2.2. Patent Analysis

The patent analysis requires bibliometric data with various techniques to manipulate and analyze it. Among them, patent citation analysis is the most adopted tool. It has been used to evaluate the competitiveness of firms [9], develop technology plans [10], prioritize R&D investment [11], or monitor technological change in firms [12]. Patent citation analysis is related to the bibliometric analysis of patent documents. Essentially, the methodology is citation-based to integrate patents precisely from the scientific paper databases [13]. Co-citation refers to different scientific mappings involving two processes: the cluster structure of co-cited documents and co-citation analysis. The result of co-citation clustering is to assign research papers to a co-citation cluster [14]. Recent studies have compared five citation-based approaches, including cross-reference, bibliographic coupling, co-citation, and text-based methods [15].

The co-citation analysis calculates the frequency of co-referenced documents to prove their similarity. The number of times co-referenced is not limited because new documents may reference A and B simultaneously. Therefore, the frequency at which documents are commonly cited is used effectively to evaluate their similarity and determine the literature and its evolution. The co-cited situation is presented in Figure 1.
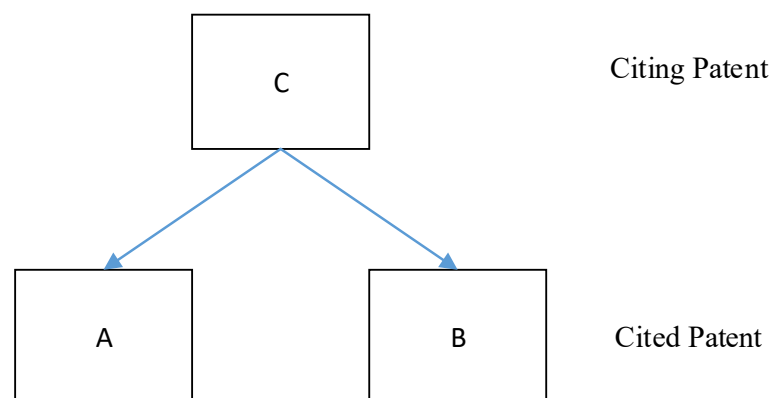

Figure 1. Relationship of co-citation.

3. Methodology

Co-cited analysis was originally used to measure the relationship between two publications. A common citation model can be constructed using co-cited analysis to determine the similarity between patents. We examined the development of technology-assisted instruction by employing the concept of co-citation and established citation relationships of technology-assisted instructions. We classified the technology-assisted instruction to identify the issues involved in patents.

3.1. Research Flow

3.1.1. Phase One: Establishing a Patent Citation Matrix

Confirming keywords for patent data retrieval, creating technology-assisted instruction patent and cited patent database, and establishing a patent citation matrix.

3.1.2. Phase Two: Technology-Assisted Instruction Clustering

Patent co-citation approach, factor analysis, and naming of specification factors.

3.2. Confirming Keywords

To retrieve technology-assisted instruction patents effectively, "education", "demonstration", "rendition", "Instructional Aids", "Instructional Equipment", "teaching aids", and "didactic materials" were set as keywords for subsequent search.

3.3. Sample and Data Collection

This study aimed to investigate the major trends of technology-assisted instruction technologies and to develop the framework using USPTO patent information. The search yielded 2225 technology-assisted instructions issued by the USPTO.

3.4. Measurement

The concept of co-citation in bibliometrics was employed to classify the patent specifications. The design concept was to select the most frequently cited specifications and use them as the specifications for classification. Subsequently, co-citation frequencies were used to evaluate the similarities between the patent specifications. Finally, the patent specifications were classified based on their similarities.

3.5. Similarities between Cited Specifications

Pearson's correlation coefficient was employed to investigate the similarities between pairs of cited specifications. This process consisted of three steps. In Step 1, we calculated the frequency with which the cited specification pairs were cited. In Step 2, the link strength within the cited specification pairs was calculated, and in Step 3, Pearson's correlation coefficients were calculated.

3.6. Factor Analysis for Specification Classification

In bibliometrics, the three most commonly used methods for co-citation analysis are factor analysis, cluster analysis, and multidimensional scaling analysis. This study employed factor analysis to obtain reduced and induction variables.

4. Results

The subjects of this study were 2225 technology-assisted instructions issued by the USPTO. The concept of co-citation classification in citation analysis was employed to develop a patent specification co-citation method for exploring the relationship between citing and cited specifications. In addition, factor analysis was used for specification classification, following which the categories were named based on their characteristics. This allowed us to determine whether the specification categories that were identified and summarized using bibliometrics resemble. Consequently, the correctness of this concept was established.

4.1. Specification Collection

The patent database was used as the source for obtaining specifications and selecting those issued by the USPTO. Full-text searches were conducted using "education, demonstration, instructional aids, instructional equipment, teaching aids, didactic materials" as keywords. From the 2225 specifications used as the citing specifications in this study, we obtained 76,298 cited specifications.

4.2. Selection of Cited Specifications

After combining repetitive citations and removing cited specifications with few citations, we obtained 206 cited specifications cited more than 30 times (including 1154 citations). In this study, we defined c as 30. Therefore, the citation relationship between cited specifications and citing specifications resulted in a new citation relationship matrix.

4.3. Similarity Evaluation of the Cited Specifications

To obtain Pearson's correlation coefficients for the cited specifications, three steps were taken between cited specifications and citing specifications.

4.3.1. Step 1: Calculating the Co-Citation Frequencies of Cited Specification Pairs

After obtaining the co-citation matrix consisting of cited specifications and cited specification pairs, the cited relationship matrix was integrated. The relationship matrix for cited specification pairs was transposed and multiplied to yield a symmetric cited specification co-citation matrix. An examination was conducted to check whether the co-citation matrix contained cited specification pairs with an excessively low co-citation frequency. However, no cited specifications were found to have been co-cited only once or not at all. Therefore, all of the cited specifications were retained.

4.3.2. Step 2: Calculating the Link Strength of Cited Specification Pairs

The co-citation matrix for cited specification pairs was integrated to yield a link strength matrix for cited specification pairs.

4.3.3. Step 3: Calculating Pearson's Correlation Coefficients

The link strength matrix for cited specification pairs was used to create a Pearson's correlation coefficient matrix for cited specification pairs using SPSS.

4.4. Specification Factors

In factor analysis, the specifications were classified into 14 categories. However, Categories 12 to 14 were removed because they contained a comparatively smaller number of specifications. Subsequently, we extracted the most frequently cited specifications in each category, identified the commonalities of the specification claims, and named each category based on their claims. The names of the categories were as follows: test system, test generating and formatting system, blended learning educational system, remote teaching system, computer-aided instruction, game-aided instruction, training system and method, internet-based education support, early childhood education aids system, technology-assisted learning, and cognitive ability training system. Table 1 shows the detailed bases for the naming and the commonalities.

Table 1. Bases for Factor Naming and Results.

	Basis for Naming	**Name**
Factor 1	US5321611A US4978305A US5466159A	test system

Table 1. *Cont.*

	Basis for Naming	Name
Factor 2	US6370355B1 US6470171B1 US6162060A	blended learning educational system
Factor 3	US5303042A US5437555A US6064856A	remote teaching system
Factor 4	108 F.3d 1361 134 F.3d 1473 927 F.2d 1200	test generating and formatting system
Factor 5	US5987443A US5974446A US5441415A	computer-aided instruction
Factor 6	US5286036A US5306154A US5035625A	game-aided instruction
Factor 7	US5035625A US4931018A US4680014A	training system and method
Factor 8	US6155840A US6688889B2 US6988138B1	internet-based education support
Factor 9	US5275567A US4968255A US5823782A	early childhood education aids the system
Factor 10	US6118973A US5779486A US6077085A	technology-assisted learning
Factor 11	US5692906A US5957699A US5813862A	cognitive ability training system

5. Conclusions

In teaching, teachers often need to prepare teaching plans through teaching aids according to the characteristics of students. With the advancement of technology, more teaching aids are developed to incorporate science and technology. Teachers can learn about the development of patent-related issues and enhance their understanding of patents and their application in teaching.

This study aimed to develop a co-citation classification method for technology-assisted instruction by examining the characteristics of the specifications and applying the co-citation classification method. Bibliometrics was used for the classification of technology-assisted instruction. This method enabled us to identify the relationships among specification citations. Subsequently, factor analysis was employed to classify specifications with close citation relationships and name the categories.

As a result, technology-assisted instructions were classified and named for categories to assist teachers in conducting patent specification searches. Each specification resembles a small database that contains a variety of data. In the future, the application of this method can be extended to develop a specification citation database, where helpful information such as patent numbers and relevant rulings can be accessed. The proposed specification can be used as basic information for a particular patent.

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