Article

What is the impact of e-books on students' mathematics performance? A qualitative systematic review

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Abstract: This research explores the impact of digital books on student's performance in mathematics. The theoretical arguments of this research are based on the self-regulated learning theory. To employ the complete research strategy, 65 papers were retrieved in the first round of research, including 30 from Education Resources Information Center (ERIC), 20 from Science Direct, and 15 from Elton B. Stephens CO (EBSCO). Following that, only 40 papers produced findings from the major section screening. The article's systematic literature review and thematic analysis of the published material resulted in a sample size of 23 articles for this study. A qualitative thematic analysis software, "NVivo 12", was used to evaluate qualitative data. The findings indicated that motivation, technological advancement, information technology, learning objectives, sources for digital application, challenges of technology, traditional learning style, and visual information have a significant collision with students' mathematical learning.

Keywords: e-book; mathematics; learning; student performance; self-regulated

1. Introduction

The textbook is one of the many learning resources in education. It plays an essential role in the discussion and learning that take place in the classroom. However, the printed textbook has transformed in the era of digital advancement and is now commonly known as the e-book [1]. An electronic book is defined as an image and text-based publication that is available in digital format and readable through the use of a computer or digital device [2]. The popularity of digital books is rising due to easy accessibility and the integration of Internet services and other e-book reading tools like Google Play Books [3]. Also, e-book offers distinctive features such as full availability and easy accessibility, word or phrase search options, bookmark, word highlight, change in the font size, as well as the use of different multimedia effects like animations, oral reading, sound, and music effects which improves the preference over traditional books specifically within the young generation [4]. Though the acceptance of traditional books is still prevalent, e-books are being acknowledged for offering a pleasant reading experience that is more enjoyable and easier.

The percentage of students who have personal electronic devices is growing gradually year by year. They professionally use portable electronic gadgets such as tablets, smartphones, and others [5]. Considering the growing popularity of mobile devices, publishers are making many textbooks available in digital format for various devices. So, a wide variety of electronic learning characteristics are expected to develop exponentially over the next few years [6]. Sadly, like with many other technology developments, educational research to demonstrate the efficacy of e-books in student learning takes a significant period. Mobile technology, for example, is

underperforming in terms of development and acceptability [7].

In education, the use of technology tools and media has been assessed in several ways, but the improvement in student performance has been the most common measure of effectiveness. Learning has typically been regarded as a cognitive capacity and quantified by one's grade or score on a proficiency test [8]. While grades and test scores are considered credible indicators and should be examined carefully, they may not be the best metric for students in education [4]. In addition, assessing learning based only on its cognitive aspects is a limited approach. Bloom [9] proposed that education should be seen as a process that takes place on three levels: cognitive, affective, and psychomotor. In other words, learning involves acquiring factual information about a subject, forming sentiments and perspectives towards that subject, and motivating participants to engage in activities and experiences directly relevant to the subject.

1.1. E-book and student performance

Academic research has defined and classified electronic books in a variety of ways. Most studies on e-books identify them as digital texts on electronic displays [10]. These electronic textbooks provide accurate page renderings and reflowable digital content [11]. E-textbooks that can be reflowed make use of a versatile format system that incorporates dynamic media and gives the user the ability to change not only the layout of the e-textbook but also its interactive elements better to fit the display medium [12]. The e-book improves academic performance when is linked to a better understanding of the concepts with the integration of cognitive thinking to promote mathematics skills. The multimedia support through audio, video, and other similar features offers an added advantage over the traditional books that are suited for improved learning in students [13]. A multitude of research has indicated improvements in mathematical comprehension among students due to added visual aids and audio representations [10,14,15].

On the other hand, e-books may not offer a quiet level of usability and convenience if they are not well designed [16]. Also, the students' performance might be reduced if they are not equipped to use the e-books well [17]. Although multiple studies have made a comparison between traditional printed books and e-books within educational settings, some studies have shown that there is no difference between student performance either using printed books or e-books. Woody et al. [18] and Shepperd et al. [19] found no difference in the improvement of the student's learning and academic performance despite the fact that e-books were offered with easy access to the supplemental material. In addition, Wijaya et al. [20] assured that students found digital textbook forms to be usable but uncomfortable due to a lack of accessibility in mobile formats and confined geometric connectivity evident in most previous versions of mobile e-reader devices. The results of multiple types of research also concluded that students preferred traditional printed books [21–23].

1.2. Theoretical underpinnings and research analysis

Self-regulated learning is defined as an active, constructive method by which students establish learning objectives and then make an effort to track, manage, and

govern their behavior, cognition, and motivation under the direction and restraint of their goals [24]. Self-regulated students are learners who are metacognitively, behaviorally, and motivationally active and employ techniques to manage their thoughts and regulate resources to achieve individual learning objectives [25]. Self-regulation and cognitive strategies are two distinct self-regulated learning techniques and strategies. It involves planning, observing, and adapting [26]. It entails planning, monitoring, and altering cognition for self-regulation, understanding, and comprehension. It utilizes organizational, recollection, and construction cognitive strategies techniques for cognitive stimulation intrinsic motivation self-efficacy, and intrinsic value [27].

Self-regulated learning theory is important to textbook learning for in-person and online students utilizing traditional and e-textbook formats because the desire to learn and the application of cognitive techniques while learning are highly autonomous parts of the learning process [28]. Additionally, previous studies have demonstrated that the format of the text can affect both the cognitive and grueling activity of learning, indicating that the textbook format's impact on motivation and cognitive processing needs to be investigated more [29].

2. Research questions

The following is the primary research question to better understand how e-book plays a role in education and how it affects students' performance in mathematics.

- Does e-books help improve students' performance in their mathematics learning?

Conceptual research design

After identifying the relationship between digital books and student performance, this research framework is based on the systematic literature review used for qualitative analysis using NVivo 12, as shown in **Figure 1.**
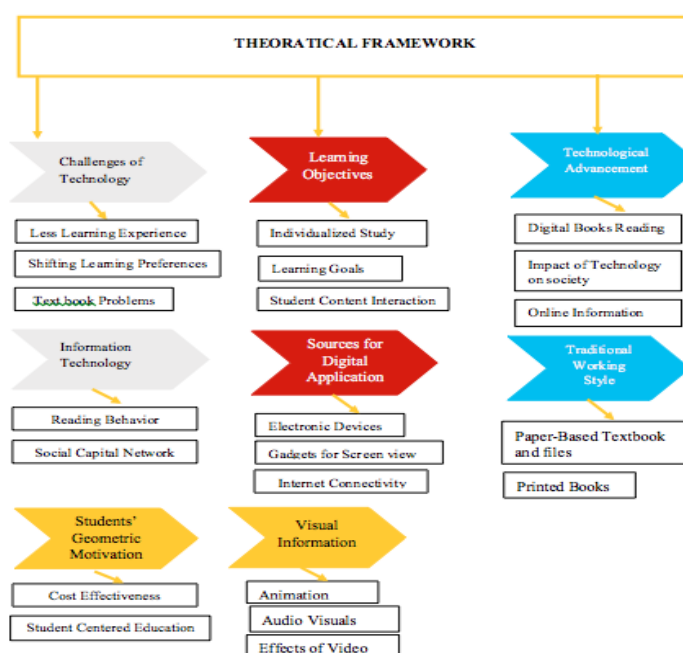

Figure 1. Research theoretical framework.

3. Methodology

This research implemented secondary data from scientific articles that were already published. For the social sciences, common information sources include official statistics and information originally gathered for other research purposes [30]. To consider the collection's generalization, confirmability, and visibility that constitute a systematic literature review (SLR)—a research technique for SLR is required [31]. By doing comprehensive literature studies, it helps to reduce any prejudice that could have been evident. Determining the subject of the inquiry is one of the most challenging issues at this stage. It is essential to specify research issues and limitations once the study's scope has been determined to select the best research method [32]. The search engines used for this study were ERIC, EBSCO, and Science Direct. The articles were from conferences and journals that subject-matter experts had reviewed, and the collection through the existing literature was accomplished on 29 December 2022.

These resource searches were carried out to acquire data on digital books and student performance in mathematics. Publisher Elsevier is in charge of running Science Direct, an online archive of previously published scientific research. ERIC is a worldwide repository with papers from all around the globe that other professionals have evaluated, and Science Direct serves as academic search citations [33,34]. EBSCO provides a papers list, published list, publishing type list, information on the time frame covered by items, or whether the documentation has been peer-reviewed, contrary to the Web of Science, Scopus, and Science Direct. You can benefit from EBSCO's search engine incorporating citations not covered by other sources [35]. Many publications that are accessible and the period that they were obtained ought to be listed, and each resource relevant to the search has to be searched.

However, the number of publications used in the overall SLR assessment was influenced by the search terms that the researcher would use and the anticipated aim [36]. The size and variety of resources used to search for relevant articles can, to some extent, decide the sample size used for analysis [37]. In the first round of searching, 65 papers were retrieved, including 30 from ERIC (to use the comprehensive search strategy), 20 from Science Direct, and 15 from EBSCO. Only 40 further papers produced results through the main section screening after that. The article's systematic literature review and thematic analysis of the published material included 30 research publications, making the sample size for this study stage 23 articles. The qualitative thematic analysis software, "NVivo 12", is used in the current study to evaluate qualitative data.

3.1. Results

The primary aim of this study may be achieved by analyzing the qualitative data collected from the 23 articles. It was developed using the topics discovered in the literature. The issues are analyzed based on the variables shown in **Figure 2**.

Figure 2. Nodes.

3.2. Hierarchy charts

While using hierarchical diagrams, students could more quickly identify the values that should be allocated to the objects review articles, and observe the source code linkages [38,39]. Hierarchy charts can be extremely helpful when a user chooses to investigate various data analyses and observe the many member perspectives. The two fundamental categories from which the diagrams may be divided are tree maps and hierarchical charts [40]. Depending on the magnitude of the stored they comprise, TreeMap assesses and analyzes the structures. Furthermore, it is easy to adapt the hierarchical chart's curving lines to its rectangle. It makes it simple for learners to comprehend the cultural elements that influenced systematic literature review thinking and how SLR assesses student performance by using the figures below to look at digital learning and student performance. The following themes and charts further clarify the classification.

Theme 1: Challenges of technology

The study identified the first theme of challenges of technology, including sub-themes: Textbook problems, shifting learning preferences, and fewer learning experiences, as shown in **Figure 3**. The digital textbook is more alarming and a major technology challenge [10]. Shifting learning preferences is also another obstacle in the learning process of students and distracts the learning motivation of the students [2].

When incorporating technology and digital media into the classroom, teachers frequently face the following difficulties and worries: students abusing technology [41]. Today's key challenges in implementing and integrating technology into classrooms include students' attitudes, resistance to change, training, time, access, and cost [16]. The obstacles can be overcome, and technology can fulfill its potential to revolutionize education [42,43].
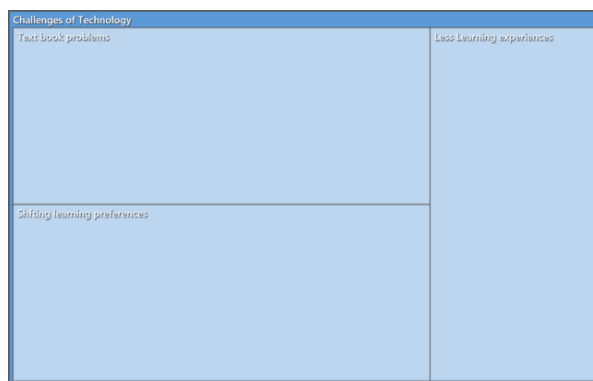

Figure 3. Challenge of technology themes.

Because those learners who are more involved in technology learn a lot more than the students who choose the traditional way, technology allows teachers to customize teaching and modify it to meet the needs of specific students so that every child may achieve their full potential [44]. According to Bienkowski et al. [45], there are a number of features of learning technologies that have been utilized in education. It encompasses elements of the intake, output, and process of education. It places a strong emphasis on creating processes and procedures for efficient learning [8]. It is the use of scientific understanding in training and education. Enhancing learning and raising educational standards are the two main goals of educational technology [6]. So, technology should improve the processes of learning and teaching and aid educational institutions in operating more effectively since it places a focus on efficiency and quality [46,5]. Increased use of technology will improve students' grasp of the material and the growth of their reasoning, problem-solving, knowledge, and creative-thinking abilities [14].

Theme 2: Information technology

The study identified the second theme information technology in **Figure 4**, including sub-themes: social capital network and learning behavior. The analysis found that social capital network enhances information technology and students' performance. Also, it stated that learning behavior uplifts the students' motivation toward mathematics.

Theme 3: Learning objectives

The study identified the third theme of learning objectives, including sub-themes: student content intention, learning objectives, and individualized study, as shown in **Figure 5**. The analysis showed that student content intention gives competitive advantages to students' learning motivation and performance. Also, the study found that the student's learning objectives increased their knowledge of the educational revolution in this technological era.
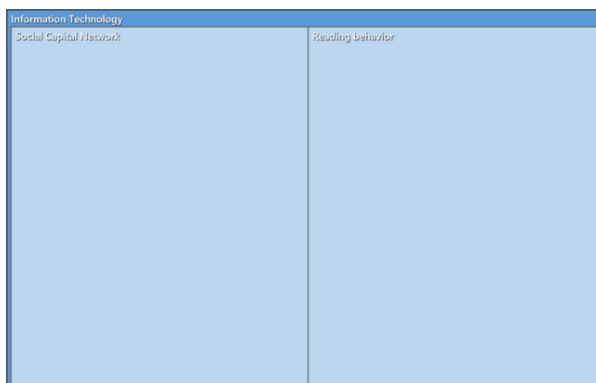
Figure 4. Themes of information technology.

Figure 5. Themes learning objectives.

Theme 4: Sources for digital application

The study identified the fourth theme of sources for digital application as shown in **Figure 6**, including sub-themes: electronic devices, gadgets for screen view, and internet connectivity. The analysis showed that electronic devices and internet connection play a vital role in digital learning for students. In addition, the study found that different gadgets for screen view also significantly impact students' motivation and learning performance.
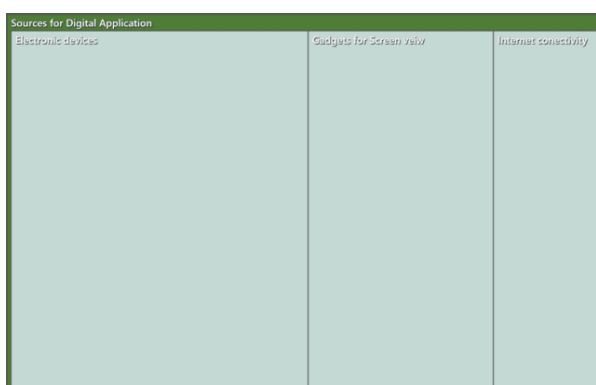

Figure 6. Themes source of digital application.

Theme 5: Students' learning motivation

The study identified the fifth theme of students' learning motivation as shown in **Figure 7**, including sub-themes: student-centered education and cost-effectiveness. The study reported that student-centered education has a significant role in

strengthening students' performance and motivation. On the other hand, cost-effectiveness motivates students to move forward with digital learning.
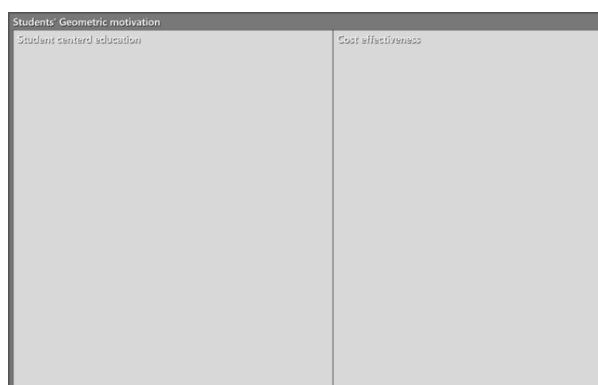

Figure 7. Themes of students learning motivation.

Theme 6: Technological advancement

The study identified the sixth theme of technological advancement as shown in **Figure 8**, including sub-themes: digital books, the impact of technology on society, and online information. The analysis reported that digital books positively impact students' performance. The study also stated that the impact of technology on students' learning process especially using digital text is more beneficial for them.
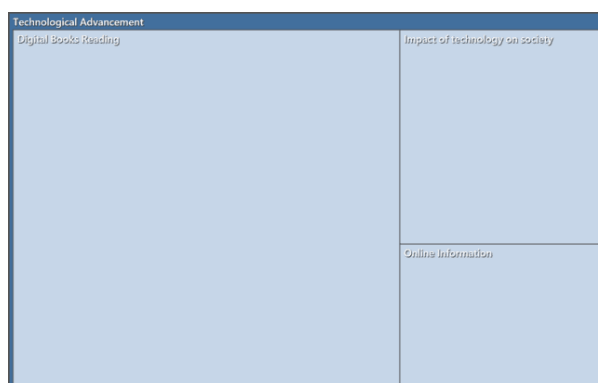

Figure 8. Themes technological advancement.

Theme 7: Traditional learning style

The study identified the seventh theme of traditional learning style as shown in **Figure 9**, including sub-themes which are printed books and paper-based textbooks and files. The analysis showed that printed textbooks have more value in students' learning than electronic books. It is also learned that printed textbooks and files are more reliable for the students to grab the concerning knowledge.

Theme 8: Visual information

The study identified the eighth theme of visual information as shown in **Figure 10**, including sub-themes that are effects of videos, audiovisuals, and animations. According to the analysis, the benefits of videos are more effective for students to learn easily and for a longer period of time. Students do not easily forget what they have learned from videos. Audiovisuals and animation also have a great positive impact on students' learning performance.

Figure 9. Themes traditional learning style.

Figure 10. Themes visual information.

3.3. Word clouds

Word clouds are visual representations of the elements that emerge most frequently throughout the content analysis [39]. The outcomes of a query based on word frequency are also displayed as a word cloud [47]. The phrase "learning" occurred most frequently in the current study's contextual information, the content review. It results from a systematic literature analysis that discusses the challenges and issues of digital books textbooks, as shown in **Figure 11**.

Figure 11. Words cloud.

3.4. Tree map

A tree map shows the contribution to the quality of a structure as interlinked

geometric shapes with different lengths, breadth, and quantities [38,40]. By examining the sizes of the rectangles, the reader may determine the approximate number of nodes. The number of nodes utilized would focus directly on the rectangle's length. The rectangle area with the best description is also assessed using a tree map, which is also used to create linkages between the components [39]. The opposite is represented by the smaller rectangular parts on the right side, **Figure 12**. The paper asserts that electronic books, mathematics, motivation, and student performance are related to systematic literature reviews. It is noted that learning is the word most commonly used since the study evaluates the impacts of students' digital learning on their performance, which was deemed important. In the systematic literature review, the terms "digital" and "students" are usually used to denote the scope of the research.
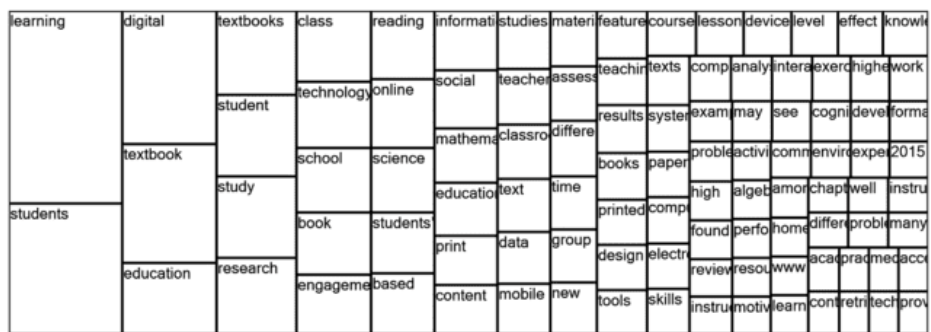

Figure 12. Tree map.

3.5. Cluster diagram

Cluster analysis is an empirical design for grouping references or nodes containing specific words and resemblances coded by nodes/themes [47]. It shows a comprehensive picture of the nodes/themes and their extraction resources to clarify the differences and overlaps between the nodes/themes and their separating sources. A cluster analysis graphic displays more relationships than differences between sources or nodes compared to other cluster representations. The differences between nodes/themes and their source properties are contrasted in NVivo 12. **Figure 13** shows how the themes and sub-themes relate to one another.

Figure 13. Cluster diagram.

3.6. Project map

The project graph demonstrates the project's elements that seem to be under

consideration right now [48]. Project maps are created to aid in identifying and illustrating the many connections between the data [49]. In order to evaluate how the data is organized for analysis, the study mainly provides infographics through elements of the project and comprehension of the link and demonstrates the relationships between the primary and secondary nodes, as shown in **Figure 14**.
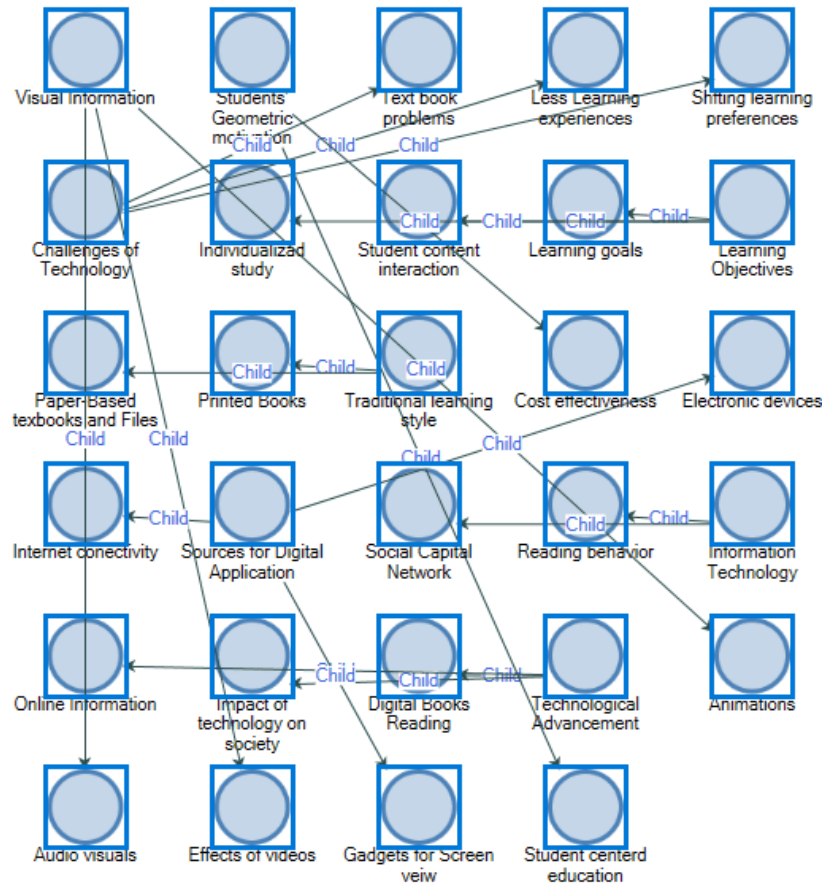

Figure 14. Project map.

3.7. Word tree

The word tree is employed when looking for ideas for SLR [39]. A word tree is a straightforward visual aid that may be quickly created to illustrate the level of learning depending on a specific topic [38]. One can outperform other keywords by recognizing a topic and its connections with common concepts [47]. In a nutshell, it demonstrates the consistency and quality of the information provided by the texts and the SLR data. A word tree is employed to study the many subject-specific presentations during the break. The following figures present a summary of the research findings, which concentrated on students' performance through electronic books and the contribution of printed textbooks to check the reliability and correctness of the qualitative analysis. The word trees are made and given in the **Figures 15–19**. A specific word tree structure can be recognized in the following ways:
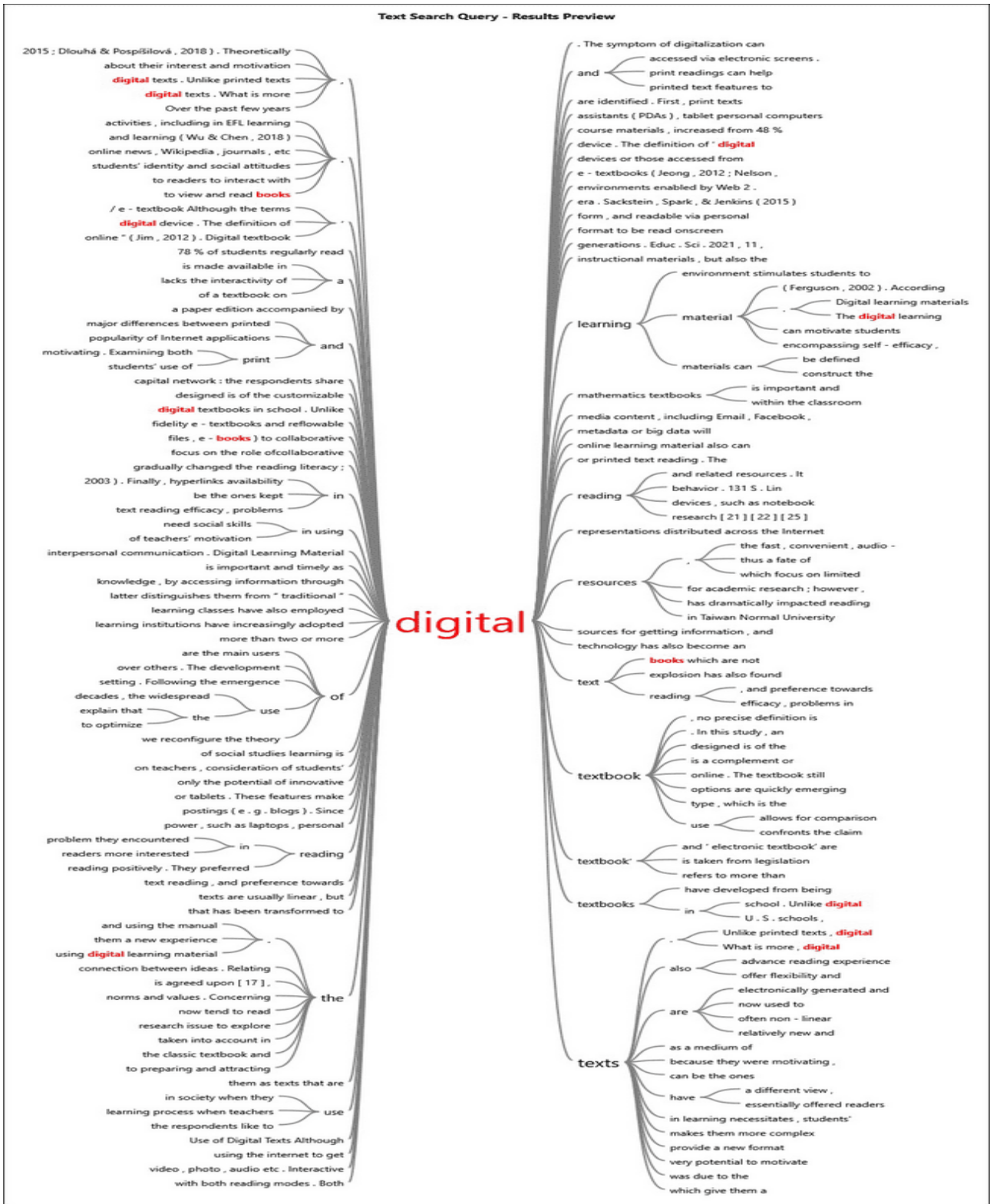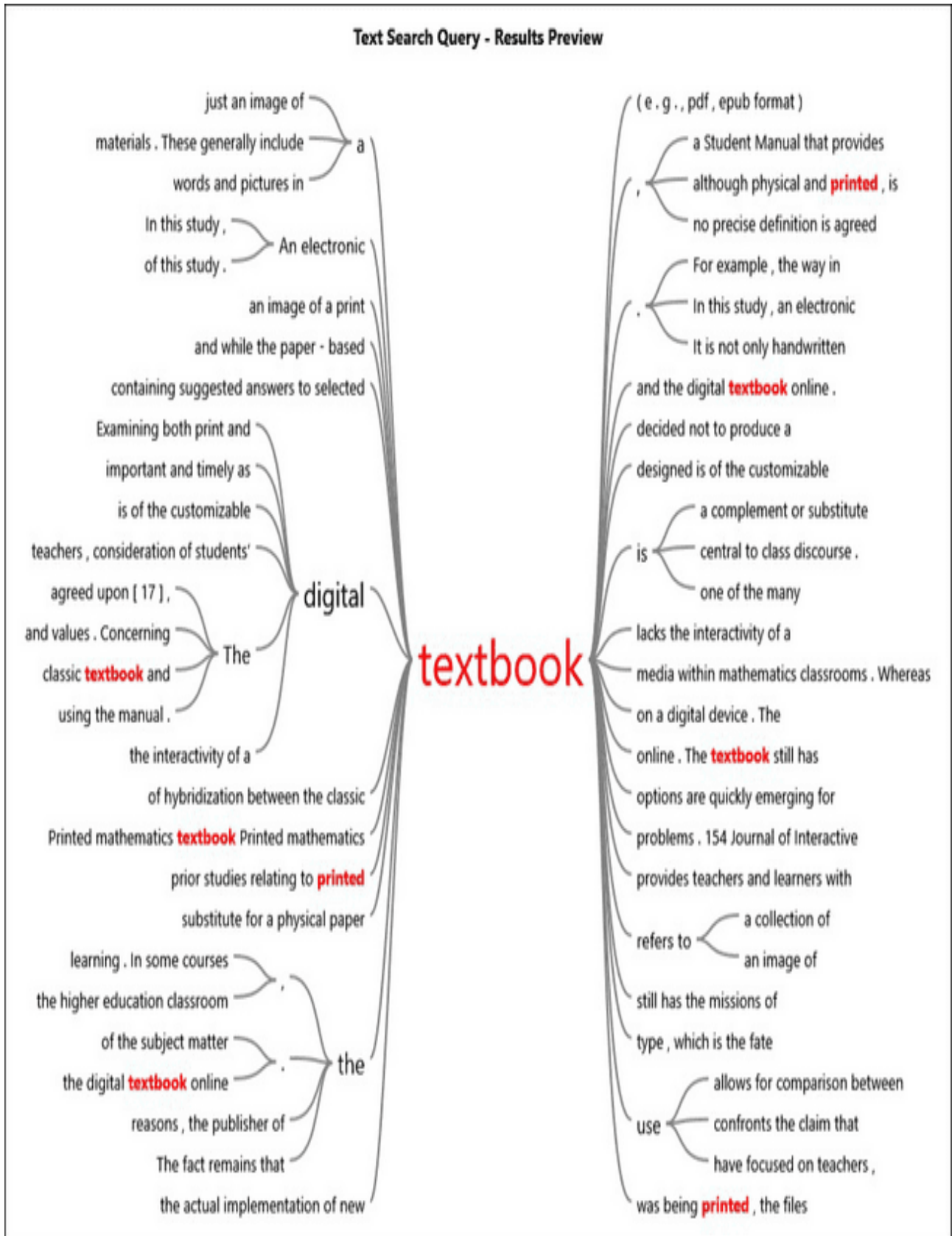
Figure 15. Word tree of digital.
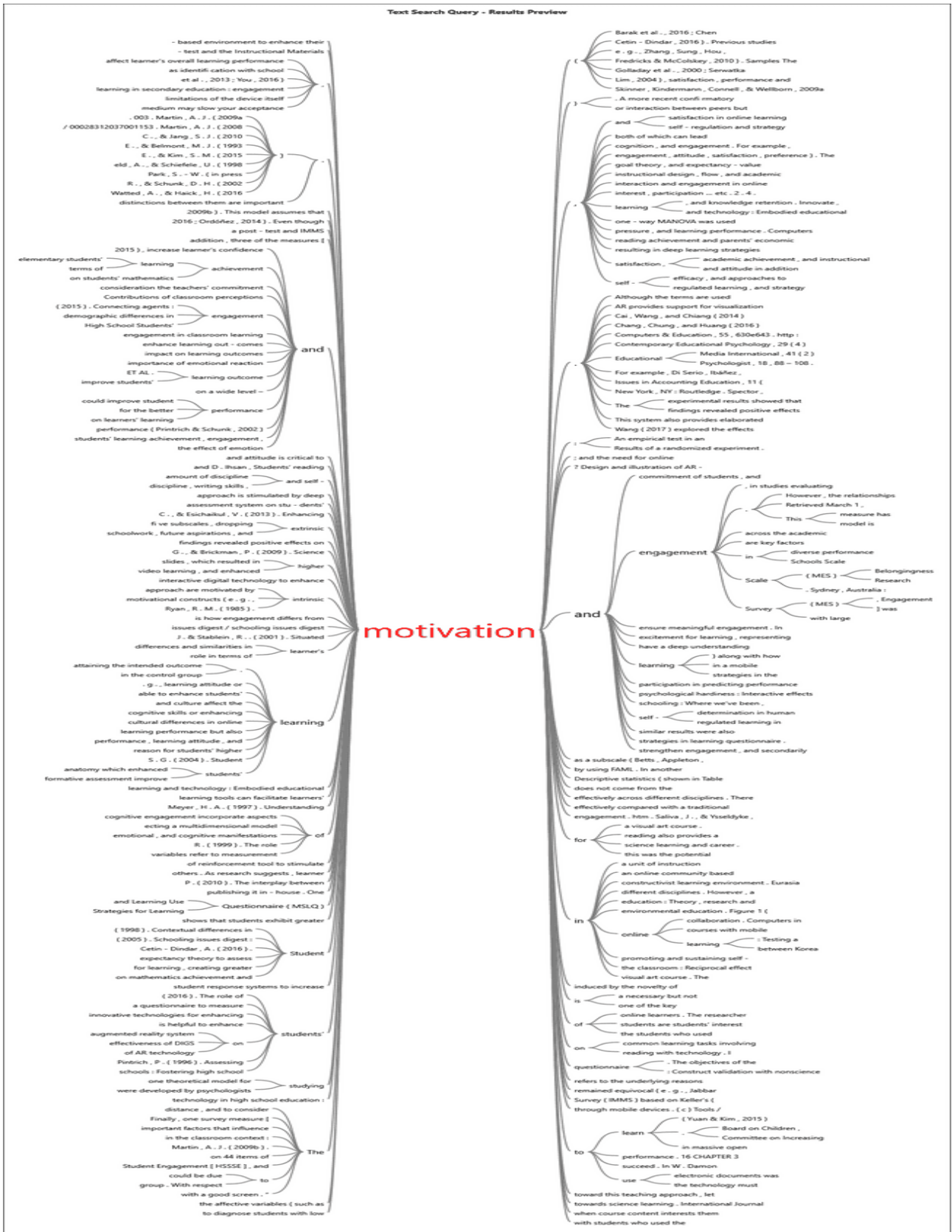
Figure 16. Word tree of textbook.
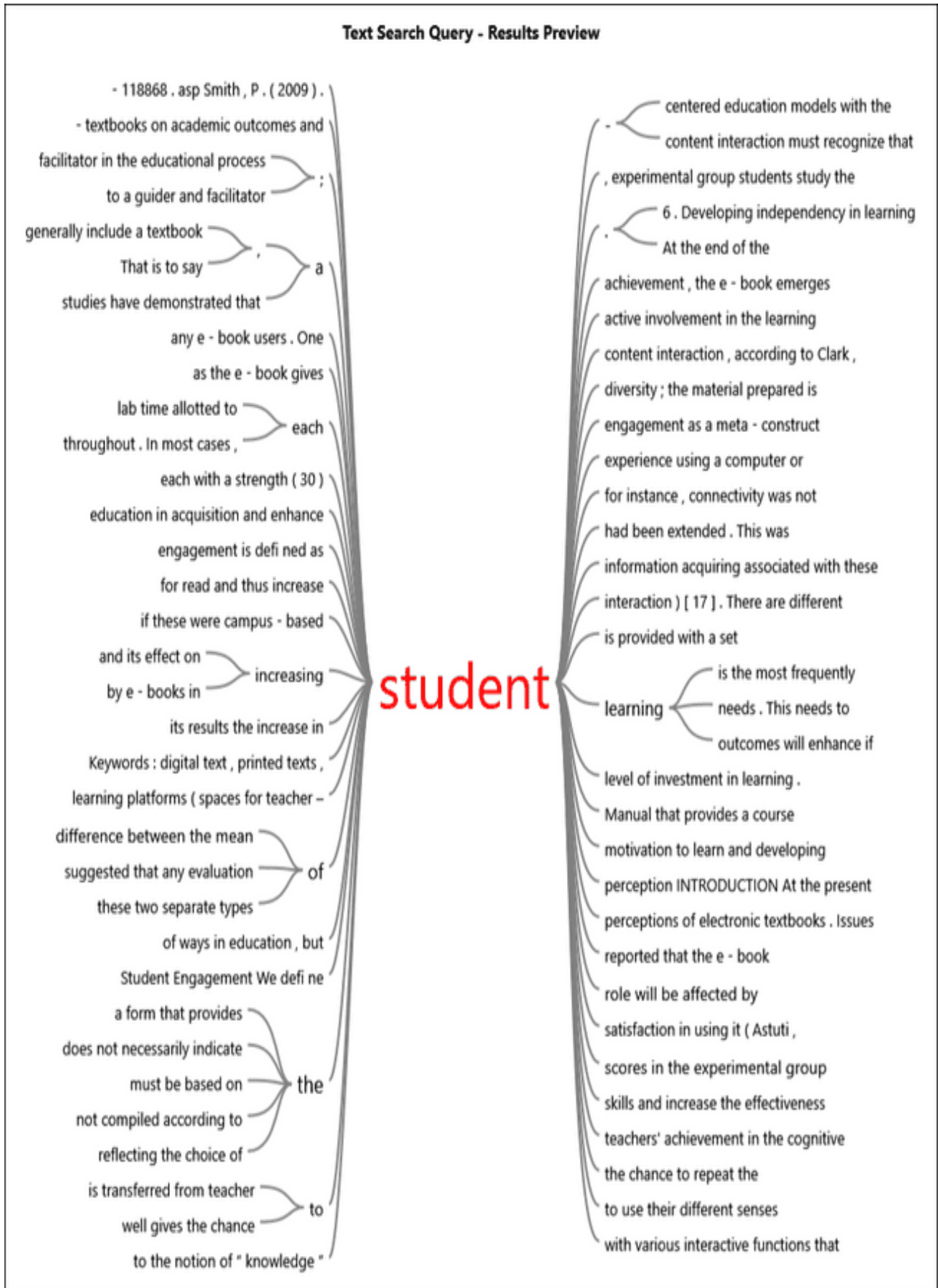
Figure 17. Word tree of motivation.

Figure 18. Word tree of students.

Figure 19. Word tree of information.

4. Conclusion and recommendation

According to the above-mentioned data and justifications, the authors of the published papers had a favorable opinion of the e-book. Students are more interested in and prefer using digital texts over printed textbooks since they know that most of their instructors assign digital learning to their students. They have the additional motivation to read digital materials since they are readily available, convenient, and affordable. On the other hand, the findings could not be extended to groups beyond the boundaries of the study. It is recommended that future research involve more published papers from various fields. It is recommended that research look at how students feel about using digital books to acquire more specialist mathematics learning areas including measurement, algebra, and geometry.

The accessibility of e-books will expand students' ability to use them in a range of academic and public settings, including schools and universities. The current study

examines the effects of using an e-book on academic student performance. It highlights the many advantages that e-books offer for increasing students' motivation to learn and fostering academic success. The use of multimedia in e-books, accessibility, structure, and ease of return; the ability to load the book on tablets and mobile phones; and the titles and texts in the e-book, make it much easier to use whenever and wherever.

As a method of curriculum management, textbooks are available to enhance learning productivity and effectiveness. The textbook offers ease for the instructor and students, however, that does not mean it is without flaws. The recommended e-book has been shown to increase students' learning outcomes. Interactive e-books can be a solution to the problems with textbooks (printed)—this is demonstrated by the fact that some studies showed the student's interactions when using e-books. Despite the positive outcomes of developing an interactive e-book, it's critical to keep in mind that suitable teaching materials must be tailored to students' needs. The students must considerably benefit from using the e-book.

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