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Intelligent Tutoring Systems (ITS) to Improve Reading Comprehension: A Systematic Review

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ABSTRACT

Intelligent Tutoring Systems (ITS), the product of collaborative work of researchers in Education, Psychology and Artificial Intelligence, are effective learning systems produced for individualized and adaptive learning. ITS differ from traditional computer-assisted learning with one main feature: The system can change itself according to data it gets from students and teachers. These systems have been frequently used in the development of reading comprehension and their effects have been proven. Therefore, in this study, it is aimed to review and critically evaluate the studies on the development of reading comprehension skill with Intelligent Tutoring Systems. the method of this study is systematic review and Experimental studies conducted in primary and secondary education with mother tongue related to reading comprehension and ITS are included to review. Conclusions indicate that Intelligent Tutoring Systems are more effective than the traditional teaching methods in developing reading comprehension skills, a variety of software used as ITS but Intelligent Tutoring System for the Text Structure Strategy is the most common one in studies, and the results are differed in favor of low-reading level students.

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INTRODUCTION

The field of information and communication technologies has been integrated in education for years. Computer-based teaching is widely used in homes, schools, universities, business and government institutions, but it is far from permanent learning experience (Corbett & Anderson, 1997). Researchers agree that the way to achieve permanent learning in computer-based teaching is to produce computer environments that work like human teachers. For this purpose, Intelligent Tutoring Systems / ITS were designed with the collaboration of researchers in Education, Psychology and Artificial Intelligence. The aim of the Intelligent Tutoring Systems is to improve learners' skills by performing one-to-one interactions with them and enable tasks created for them to perform in highly interactive learning environments. Computer-based systems such as Computer Assisted Learning (CAL) or Computer Assisted Education (CAE) use traditional teaching methods to provide standard (not adaptive to individual differences) knowledge to students, which may lead to inadequate training. In contrast, ITS evaluate the actions of each student in interactive environments and develops a model of their knowledge, skills and expertise. Based on the student model, it can adapt teaching strategies in terms of both content and style and provide individual students with relevant explanations, tips, examples, demonstrations and implementation problems (Phobun & Vicheanpanya, 2010). The ITS must have 3 main elements: (a) knowledge of the content (expert model), (b) knowledge of the learner (student model) and (c) knowledge of the teaching strategies (teacher model). The expert module contains domain knowledge, the student module diagnoses what the students knows and the teacher module identifies which deficiencies in knowledge to focus on and selects strategies to present that knowledge. As a complex, knowledge-based, problem solving, computer assisted tutoring system, 7 kinds of expertise are essential for ITS: (1)content expertise in the expert module, (2) diagnostic expertise (determining what learners know and need to learn), (3) instructional and curriculum expertise in the instructor module, (4) expertise in creating instructional environments, (5) human-computer interface expertise, (6) implementation expertise, and (7) evaluation expertise (Burns & Capps, 2013:18).

Intelligent Tutoring Systems are more effective than known Computer-aided Education methods, as mentioned above, since it creates an education system that is adjusted according to individual differences. In a study on the impact of ITS on learning outcomes, ITS shows a better performance than all other teaching methods and learning activities (traditional classroom education, reading printed text or computerized materials, computer-assisted instruction, laboratory, homework, etc.) except for private human tutors. In addition, the effectiveness of the Intelligent Tutoring System does not vary according to the system used, subject area, forms of education and training, or degrees (Steenbergen-Hu & Cooper, 2014). The fact that the positive effect of Intelligent Tutoring Systems on learning is superior to other methods demonstrates that these systems can be used in developing skills which students have difficulties like reading comprehension. Reading comprehension skill is one of the basic skills that all students need to acquire and many have difficulties with. According to Guthrie et al. (2009), children who grow up with this skill deficiency may lack multiple skills in the future and may develop various insufficiency. Although reading comprehension skill is so important, it is observed that this skill is still insufficient in the world. According to a research, approximately 20% of students in OECD countries have not reached the basic proficiency level in reading, and the average reading proficiency of students has not improved since 2000 (OECD, 2016). Intelligent Tutoring Systems have the potential to develop reading comprehension skills as they provide students with personalized applications instead of standard exercises. It is known that students make readings at different rates and therefore faster students need more difficult reading passages than slower students. ITS selects the required number of documents for each student, and these documents are determined by the system based on specific lexical, syntactic and readability criteria of the current student's knowledge model. Finding a large number of suitable documents for all students in the classroom is challenging and time consuming for teachers, but the ITS can do this automatically, which makes this system valuable for language teachers (Heilman, Collins-Thompson, Callan & Eskenazi, 2006). There are many studies on the development of reading comprehension skills by Intelligent Tutoring Systems.

However, in compilation of the studies, research related to mathematics (What Works Clearinghouse, 2010; Steenbergen-Hu & Cooper, 2013), STEM and learning outcomes in general (Steenbergen-Hu & Cooper, 2014; Ma, Adesope, Nesbit & Liu, 2014) are discussed more. There is no systematic review study on the development of reading comprehension skill with Intelligent Tutoring Systems. Therefore, in this study, it is aimed to review and critically evaluate the studies on the development of reading comprehension skill with Intelligent Tutoring Systems. Depending on the purpose of this research, answers to the following research questions were sought:

1. Are Intelligent Tutoring Systems an effective method to improve reading comprehension?

2. Which ITS environments have been used to improve reading comprehension in the studies?

3. Does the effect of Intelligent Tutoring Systems on developing reading comprehension skills differ among students?

METHOD

This study is a systematic review which is conducted to determine the effectiveness of Intelligent Tutoring Systems in developing reading comprehension skill. Systematic reviews aim to research, evaluate and synthesize research evidence systematically. In systematic review research, reporting of reviewed articles is transparent to make it easier for others to repeat the process (Grant & Booth, 2009). Unlike traditional reviews, systematic reviews use a more rigorous and well-defined approach to review literature in a particular subject area. Systematic reviews are used to answer well-focused questions about clinical practice. Moreover, the purpose of a systematic review is to provide a complete list of all published and unpublished studies related to a particular subject area as much as possible. While traditional studies try to summarize the results of a series of studies, systematic reviews use clear and rigorous criteria to define, critically evaluate and synthesize all literature on a particular subject (Cronin, Ryan, & Coughlan, 2008). According to Okoli and Schabram (2010), there are 8 steps to follow when writing a systematic review:

1. Purpose of literature review: The first step in any review requires the researcher to clearly determine the purpose and objectives of the review. This is necessary for the review to be open to its readers.

2. Protocol and training: For any review using multiple reviewers, it is important that the reviewers agree on the detailed procedure, which is completely clear and must be followed. This requires both a written, detailed protocol document and training for all reviewers to ensure consistency in conducting the review.

3. Literature research: The reviewer should be open to explain the details of the literature research and should explain and justify how the research is comprehensive.

4. Practical screening: Also known as an insertion screening, this step requires eliminating which studies are taken into consideration for the reviewer review and which ones without further investigation (a very necessary part of any literature review). For excluded studies, the reviewer should state what are the practical reasons for them to ignore, and justify how comprehensive the review can be, given the practical exclusion criteria.

5. Quality assessment: The reviewer, also known as the exclusion screening, should clearly indicate the criteria for deciding which articles are in poor quality to be included in the review synthesis. Depending on the research methods used by the articles, all articles included must be scored for their quality.

6. Data extraction: Once all the studies that should be included in the review are identified, reviewers should systematically extract valid information from each study.

7. Synthesis of studies: This step, also known as analysis, involves combining facts extracted from studies using quantitative, qualitative, or both appropriate techniques.

8. Writing the Review: In addition to the standard principles to be followed when writing research articles, a systematic literature review process should be reported in sufficient detail that the results of the review can be reproduced independently.

Inclusion Criteria

In this study, it is aimed to review and critically evaluate international studies written in English on the development of reading comprehension skill with Intelligent Tutoring Systems. For this purpose, 4219 results have been reached by searching for "intelligent tutoring" keyword group in the "ISI Web of Knowledge" database. Among the results, the studies with the keyword "reading" were filtered as genre: article, subject: Education, Educational Research or Education Scientific Disciplines or Psychology Educational or Education Special. Among the 47 articles reached as a result of filtering, 16 studies that were not related to the subject or were not articles were removed. Then, in line with the purpose of the research, 11 final articles were reached by eliminating the studies conducted in primary and / or secondary education, on non-mother tongue studies and non-experimental studies.

Exclusion Criteria

In order to conduct this study systematically, examined articles divided into categories and coded according to their type (Article, Thesis, Book Chapter), content (Education, Engineering), research sample (K12, Pre-School, Graduate, Post-Graduate, Adult Education), discipline (Foreign Language, Native Language), research design (Exploratory, Descriptive, Experimental). The studies which are not suited into inclusion criteria were extracted. Data extraction criteria are given below:

1. Non-article studies (Type): In this study, only the articles which are published in an English-written journal were selected to examine in order to make scope of this research is worldwide published journals.

2. Not-related to education (Content): In this study the subject of the articles is restricted with Educational Research topics in order to avoid inclusion of studies in other disciplines.

3. Not K12 related (Research Sample): Studies that have not been carried out in primary or secondary education have been extracted because reading comprehension skill in compulsory education is examined.

4. Not native language (Discipline): Studies that do not carried out with native language education have been extracted. In other words, foreign language studies have been extracted since reading comprehension skill is likely to be developed in native language.

5. Not empirical studies (Research Design): Studies which do not measure effects of ITS media have been extracted in order to examine the evidence related to experimental studies.

Retrieved 47 articles were screened and coded, and according to the exclusion criteria above, 11 articles are remained for review (Table 1).

Table 1. *Examined Articles.*

Article	Article Title	Journal Title
Wijekumar et al., 2019	Supplementing teacher knowledge using web-based Intelligent Tutoring System for the Text Structure Strategy to improve content area reading comprehension with fourth- and fifth-grade struggling readers	Dyslexia
Ji et al., 2018	Using latent transition analysis to identify effects of an intelligent tutoring system on reading comprehension of seventh-grade students	Reading and Writing
Serrano, Vidal-Abarca & Ferrer, 2018	Teaching self-regulation strategies via an intelligent tutoring system (TuinLECweb): Effects for low-skilled comprehenders	Journal of Computer Assisted Learning
Wijekumar et al., 2017	Evidence of an Intelligent Tutoring System as a Mindtool to Promote Strategic Memory of Expository Texts and	Journal of Educational Computing Research

	Comprehension With Children in Grades 4 and 5	
Wijekumar, Meyer & Lei, 2017	Web-Based Text Structure Strategy Instruction Improves Seventh Graders' Content Area Reading Comprehension	Journal of Educational Psychology
Vidal-Abarca et al., 2014	TuinLEC, an intelligent tutoring system to improve reading literacy skills	Infancia y Aprendizaje
Wijekumar et al., 2014	Multisite Randomized Controlled Trial Examining Intelligent Tutoring of Structure Strategy for Fifth-Grade Readers	Journal of Research on Educational Effectiveness
Jackson & McNamara, 2013	Motivation and Performance in a Game-Based Intelligent Tutoring System	Journal of Educational Psychology
Wijekumar, Meyer, & Lei, 2013	High-fidelity implementation of web-based intelligent tutoring system improves fourth and fifth graders content area reading comprehension	Computers & Education
Mich, Pianta & Mana, 2013	Interactive stories and exercises with dynamic feedback for improving reading comprehension skills in deaf children	Computers & Education
Wijekumar,Meyer, & Lei, 2012	Large-scale randomized controlled trial with 4th graders using intelligent tutoring of the structure strategy to improve nonfiction reading comprehension	Educational Technology Research and Development

RESEARCH FINDINGS

All 11 articles examined are experimental studies with control and experiment groups in which the data were collected quantitatively. Articles were published in Dyslexia, Reading and Writing, Journal of Computer Assisted Learning, Journal of Educational Computing Research, Journal of Educational Psychology, Infancia y Aprendizaje, Journal of Research on Educational Effectiveness, Computers & Education, Educational Technology Research and Development journals. Journal of Educational Psychology and Computer & Education journals had two articles while other only have just one. The detailed review of the articles is shown in Table 2.

The Effectiveness of ITS on Reading Comprehension

One of the common points observed in all the studies carried out is that the effect of ITS on reading comprehension skill is positive. The majority of the studies compared traditional education system with Intelligent Tutoring Systems. Those studies (Wijekumar et al., 2019; Wijekumar et al., 2017; Wijekumar, Meyer & Lei, 2017; Wijekumar et al., 2014; Wijekumar, Meyer & Lei, 2013; Wijekumar, Meyer, & Lei, 2013) were conducted in the Language Arts course and they compare traditional teaching with ITS which resulted in these systems are effective to increase students' reading comprehension skill regardless of student differences. In those studies, assessment was made through a standard national test (GSRT-Gray Silent Reading Test) and a test developed by researchers. The results of both tests agree with the benefit of ITS. These studies are all wide ranged studies involving more than one school.

In one of the remained studies (Ji et al., 2018), only the test developed by the researchers was used. In that study, students were firstly divided into 4 groups according to their reading levels as “weak readers, delayed readers, expert readers, readers with certain deficiencies in problem solving”. As a result, it was revealed that the experiment group students were more likely to pass to the expert reader level than the control group. Another research (Serrano, Vidal-Abarca & Ferrer, 2018) was carried out in a two-stage study. In the first stage, 47 students from 6^{th} and 7^{th} grades were selected regardless of the reading level. In the second stage, 68 students with low reading comprehension skills were selected. As a result, in both stages, ITS has improved students’ reading comprehension skills. In the study conducted by Vidal-Abarca et al. (2014), it was found that the Intelligent Tutoring System helped the 6^{th} grade students to improve their literacy skills. In addition, ITS developed the skills of the students to answer questions from continuous and discontinuous texts, which is a sufficient measure according to PISA to measure reading literacy skills. In addition, the ITS environment was found motivating and enjoyable for students.

In the study of Jackson and McNamara (2013), the Intelligent Tutoring System and game environment were combined. The effects of both the game-based ITS environment and the normal ITS environment on reading comprehension skills were measured with high school students. As a result, the game based ITS

environment was more successful in motivation and enjoyment, and the normal ITS environment was more successful in learning outcomes. Despite these differences, both environments improved students' reading comprehension skills.

In the study conducted by Mich, Pianta and Mana in 2013, reading skills of students with hearing disabilities were tried to be developed with the Intelligent Tutoring System. In this study, in which the students with and without hearing impairments are compared, the reading skill of the hearing-impaired students has reached or exceeded the level of other students thanks to ITS.

Types of ITS Media

In the majority of studies (Wijekumar et al., 2019; Ji et al., 2018, Wijekumar et al., 2017; Wijekumar, Meyer & Lei, 2017; Wijekumar et al., 2014; Wijekumar, Meyer & Lei, 2013; Wijekumar, Meyer & Lei, 2013) an animated pedagogical agent called I.T. was used. This pedagogical agent is described as an Intelligent Tutoring System for the Text Structure Strategy-ITSS, a subtype of ITS. In this system:

1. The words (signal words) of the general top-level structure of the descriptive text (such as comparison, problem and solution) are explained. Students mark the words in a passage and get feedback on their answers. After the signal words are determined, the students are asked to write which text structure is used by the authors. Again, they get feedback on their answers. A pop-up table is available to help students find commonly used signal words.

2. They are asked to write the main idea using patterns for each of the different text structures. For example, comparison structures are compared with _____ and _____ (two or more ideas) _____, _____ and _____ (number of numbers compared). In ITSS, students choose important ideas and form their main ideas using special text structure sentence structures. The software evaluates student responses considering misspellings, synonyms, keywords, and the hierarchical structure of the main idea.

3. Understanding and remembering of students can be organized by using structure and main idea. Students are asked to carefully read the passage again and press the "finish" button. The student writes the main idea and the student is asked to remember and rewrite the passage. Students' responses, top level structure, main ideas, details and signal words are carefully evaluated. Feedback is provided on the basis of interference and response quality.

4. The student is provided to comprehend comprehension, conclusion, application and monitoring by using text structures. In some lessons, students are asked to produce inferences, check their understanding, and apply them to write text explanatory tests.

The web-based ITS named TuinLECweb was used in the study of Serrano, Vidal-Abarca and Ferrer (2018) on self-regulation strategies. TuinLECweb consists of eight lessons spread over two phases: the teaching phase and the implementation phase. At the first phase, TuinLECweb instructs the reader to monitor strategic decisions about task-based reading situations, following the accuracy. Students learn how to create the first representation of the text, how to create a task model, how to search for the text, and how to correctly track the person's search for information and how to organize it on its own. Metacognitive strategy instruction is carried out through open instruction, modeling and guided practice through dialogues between the two animation agents. It combines instructions on how to use tracking and self-regulation strategies by highlighting conditional information about when and why such strategies will be used, because they are essential elements of self-regulation learning. After the teaching phase, students are trained in a comprehensive practice of using information from real texts to answer multiple choice questions. Students receive computer-generated formative and adaptive feedback based on their performance and strategic search decisions, which are crucial in answering questions.

In the study of Vidal-Abarca et al. (2014), TuinLEC, the previous version of the TuinLECweb mentioned above was used. TuinLEC consists of eight lessons organized in two stages: teaching and practice. In the first stage, four strategies are taught, one for each lesson: how to read continuous and discontinuous texts, how to

understand and answer questions, when to decide to re-read the text for correspondence, and how to search for the text to answer. During the implementation phase (four final lessons), these four strategies are applied together. TuinLEC was established as a game-like environment where students can earn points with correct answers that turn into gold, silver or bronze stars at the end of each lesson. This has been done to maintain motivation and commitment to the task. Scores depend on correct answers and use of the help section. Therefore, using the help section comes at a price: it reduces the points earned when answering.

In the study of Jackson and McNamara (2013), iSTART-ME, the game-based version of the same environment with the Intelligent Tutoring System iSTART, was used. Strategy teaching takes place in three stages, which require increased interaction of the student at each stage. During iSTART's Introduction Module, a series of animated characters introduce the concept of self-explanation and associated reading strategies by providing information to students, asking questions, and discussing examples. In the second stage, called the Demonstration Module, two representatives demonstrate the use of self-disclosure using a science text and identify the strategies used by trainee agents. During this module, the teacher character (Merlin) specifies what strategies the student character (Genie) from the trainee used to create their own description. Finally, Merlin gives Genie feedback on the quality of his own statement. In iSTART - ME, students earn points as they interact with the texts and present their own explanations. The rubric is designed to consistently reward good performance. Therefore, students earn more points if they repeatedly provide good self-explanations, but less if they fluctuate between high and low performance. These points help go beyond the qualitative responses of animated agents to provide an additional, measurable form of feedback as students learn and implement self-disclosure strategies. In addition to earning points within iSTART - ME, it serves two main incentive goals as a form of feedback: progress and purchase rewards across levels. As students earn more points, they progress through a series of levels. Each subsequent level requires an increasing number of points. Therefore, students should spend a little more time or effort for further progress (i.e. increasing task difficulty to reach a new level). When a student progress to a level, a new subset of features automatically opens and becomes available in the interface (thus acting as an incentive and providing additional control). Each of the levels is labeled to help provide incentives, increase interest and serve as global indicators of progress between texts (eg, the last bookworm, serious strategist, etc.).

In the study conducted by Mich, Pianta & Mana in 2013, there was an ITS, which is called LODE (Logic-Based Web Tool for Deaf Children), for children with hearing disabilities to develop reading comprehension skills. LODE was made as the pilot of LODE-2, the research was carried out with the improved version of LODE, LODE-2. LODE-2 contains interactive stories. The story pages can be divided into two groups: picture pages and textual pages. The pages shown have a picture as a background. When the child first comes to one of these pages, he only sees the picture. In order to continue reading the story, he must find an active area of the image and click on it. Active areas are shown with simple animations. Clicking opens a text box containing a textual piece of the story. The user must move the mouse around the picture to find the active area because the location of the animated area changes from one page to the next. The system will visualize the arrow that allows the child to move to the next story page only after clicking on the active area and opening the text box. This is an attempt to focus the child on the task of reading the text, as opposed to just browsing the story images. Text pages are a small group of pages that contain only text. This type of page is presented to highlight the focus of the tool, which allows the user to work on reading skills. However, in order to keep the vehicle entertaining for children, the number of pages shown is greater than the number of pages that are text only. After reading an entire story, children are invited to solve some exercises. After a warm-up exercise to make the user familiar with the left-to-right arrow metaphor, LODE proposes three types of exercises: reordering exercises, word reordering exercises, relationship selection exercises. Games / exercises are recommended to the child in a predetermined and motivated order. The first exercise aims to evaluate the global understanding of the story and uses only images. The second exercises evaluate the understanding of local temporal relationships. The exercises of this second stage first use a combination of images and text. Finally, the last exercise is based on pure text that does not contain images.

The Variations of ITS Effect Among Students

The studies which are investigated were conducted with students from different groups such as different age, level, gender, and region. In one of the studies conducted with 4th grade students (Wijekumar, Meyer, & Lei, 2012), the effect of the ITS on boys was greater than that of female students, the effect does not change compared to the pre-test reading comprehension score (low, medium / high), but It was observed that low level students developed more comparison ability than high level students, and the ability to produce ideas was more developed in high level students than low level students. In addition, there was no difference between studies in rural or local areas, but it was found that the distribution of some post-tests varied according to schools. Finally, students who use the ITS environment longer are more successful than students who use less.

Multiple studies with the 4th and 5th grade students were reviewed (Wijekumar et al., 2019; Wijekumar et al., 2017; Wijekumar, Meyer & Lei, 2013). One of these studies (Wijekumar et al., 2019) were conducted with students with reading difficulties only. These students were determined from those who were below the 25% of GSRT standard reading test. The positive effect of the ITS did not vary depending on gender, region or student level. However, it was observed that the performance of 5th grade-level students was better than that of 4th grade-level students. The reason for this result might be the fact that the 5th grade students attended all the ITS courses, while the 4th grade-level partially participated in the ITS courses. In another study (Wijekumar et al., 2017), it was revealed that the ITS environment was statistically significant in all posttests, and the probability of memory self-regulation of the students in the experimental group was higher than those in the control group. Results did not differ by gender, region or grade-level. In the study of Wijekumar, Meyer and Lei in 2013, the differences were not measured, and it was seen that the effect of the ITS application improved its reading comprehension by measuring the standard test scores and the tests designed by the researcher.

In a study with 5th graders (Wijekumar et al., 2014), it was observed that low reading level students showed more development with ITS compared to high reading level students. Results do not vary by school, gender, or region, but those who solve more questions in the ITS environment have improved more in reading ability than those who do less. In the study conducted with 6th graders (Vidal-Abarca et al., 2014), it is observed that reading levels of experimental group students (who are using ITS) were higher than the control group significantly. However, the differences among experimental group students was not measured.

In the study with 6th and 7th grades (Serrano, Vidal - Abarca & Ferrer, 2018), students were divided into groups in accordance with high and low reading skills. It was revealed that the effect of the ITS environment on reading comprehension was higher in low-level readers than in high-level readers, and the permanence of learning was achieved only in low-level students. Morever, in this study it is concluded that ITS helps students to improve their self-regulation skills, that is using ITS could be an effective way in a strategy instruction.

Among the studies conducted with 7th grade-level students (Ji et al., 2018; Wijekumar, Meyer, & Lei, 2017), Ji and his colleagues (2018) classified students as “weak readers, delayed readers, expert readers, readers with certain deficiencies in problem solving” in 4 group. While the proportion of weak and delayed readers among total students decreased after the application of ITS, the rate of readers with special deficiencies in experts and problem solving increased. As a result of the analysis, it was seen that the most beneficiaries of the program are readers with certain deficiencies in problem solving. In the study conducted by Wijekumar, Meyer and Lei (2017), it was observed that the effect of the ITS was stronger for high-level readers than for low-level students, and female students benefited from ITS more than male students. While the results were highly positively inclined in favor of urban students, the results do not differ according to schools. In addition, students who spend more time in the ITS environment have improved better than those who spend less.

In the study conducted with high school students (Jackson and McNamara, 2013), Intelligent Tutoring Systems (iSTART- Intelligent Tutoring System and iSTART-ME- Game-based Intelligent Tutoring System) were compared and student differences were not examined. In a study on two groups of students, ages vary

between 8-11 and 12-14 (Mich, Pianta and Mana, 2013), the hearing-impaired students of the ITS developed better reading skills than other students and they enjoyed the course. Deaf students developed their reading comprehension better with the simplified stories, illustrated with drawings and extended with definitions among ITS components.

Table 2. *Context of the Articles.*

Article	Its Media	Age/Grade-Level	Research Sample	Data Collecting Method	Data Analysis Method
Wijekumar et al., 2019	I.T. - Intelligent Tutoring System for the Text Structure Strategy-ITSS	5th grade-level	1442 students (725 4th grade, 717 5th grade)	GSRT (Gray Silent Reading Test)	Hierarchical linear model (HLM)
Ji et al., 2018	I.T. - Intelligent Tutoring System for the Text Structure Strategy-ITSS	7th grade-level	1808 students	Problem solving Test	Latent transition analysis (LTA)
Serrano, Vidal-Abarca & Ferrer, 2018	TuinLECweb- Web-based Intelligent Tutoring System	6th -7th grade level	1.study: 47 students	Comparison Test	Judgments of Learning-JOL
Wijekumar et al., 2017	I.T. - Intelligent Tutoring System for the Text Structure Strategy-ITSS	4th - 5th grade-level	2.study: 68 students	Main Idea Test	Multinomial Logistic Regression Using SAS
Wijekumar, Meyer & Lei, 2017	I.T. - Intelligent Tutoring System for the Text Structure Strategy-ITSS	7th grade-level	4001 students (1944 4th grade 2057 5th grade)	GSRT (Gray Silent Reading Test)	Hierarchical linear model (HLM)
Vidal-Abarca et al., 2014	TuinLEC- Intelligent Tutoring System	6th grade-level	2489 students	Problem solving Test	-
Wijekumar et al., 2014	I.T.- Intelligent Tutoring System for the Text Structure Strategy-ITSS	5th grade-level	25 students	Comparison Test	Hierarchical linear model (HLM)
Jackson & McNamara, 2013	iSTART- Intelligent Tutoring System iSTART-ME- Game-based Intelligent Tutoring System	High School	2645 students	Main Idea Test	ANOVA
Wijekumar, Meyer, & Lei, 2013	I.T.- Intelligent Tutoring System for the Text Structure Strategy-ITSS	4th -5th grade-level	84 students	Test of Comprehension Processes	Hierarchical linear model (HLM)
Mich, Pianta & Mana, 2013	LODE- Logic-Based Web Tool for Deaf Children	8-11 y.o. & 12-14 y.o.	45 schools	GSRT (Gray Silent Reading Test)	-
Wijekumar, Meyer, & Lei, 2012	I.T.- Intelligent Tutoring System for the Text Structure Strategy-ITSS	4th grade-level	Unknown	Problem solving Test	Hierarchical linear model (HLM)

CONCLUSION

In this study, the contributions of Intelligent Tutoring Systems (ITS) on reading comprehension skill have been mentioned. For this purpose, ISI Web of Knowledge database (type: article; subject: Education, Educational Research or Education Scientific Disciplines or Psychology Educational or Education Special; keyword: "intelligent tutoring" and "reading") is searched and only experimental K12 studies which examine native language are included. Studies carried out with preschool, graduate or adult learners are eliminated as well as foreign language studies and non-experimental studies, which resulted in 11 studies to be reviewed. It has been proven that in all the reviewed articles ITS environment has improved the reading comprehension skill. 45% of the articles are conducted with 4^{th} or 5^{th} grade students while 36% of them are managed with 6^{th} or 7^{th} grades. There was only one study with secondary education, and there was another study that covers both (4^{th} ,5^{th} ,6^{th} and 7^{th} grade) groups. From this point of view, it can be concluded that the reading comprehension skill is mostly measured in primary education. Completing reading or reading comprehension deficiencies at secondary level takes longer than those at other education levels (Wexler, Vaughn, Edmonds, and Reutebuch, 2008). Therefore, it may not be selected as a sample in research. However, given the large number of reading materials offered to high school students, it would be more efficient for students to develop fluent interventions that require reading more appropriate material (Hawkins, Sheeley, Ling, 2011). Especially for students preparing for the college/university exam, the ITS environment can be created and thus students can improve their reading skills in individualized settings according to their own characteristics.

Another striking feature in the articles is that the used software varies according to the authors. In other words, the same author or groups of authors have always used the same media or an upper/lower version of the same media. For example, I.T. software was used in 7 studies: Wijekumar et al., 2019; Ji et al., 2018, Wijekumar et al., 2017; Wijekumar, Meyer and Lei, 2017; Wijekumar et al., 2014; Wijekumar, Meyer, and Lei, 2013; Wijekumar, Meyer, and Lei, 2013, which consists of the same group of authors. Similarly, TuinLEC and TuinLECweb (a higher version) software were used by Serrano, Vidal - Abarca and Ferrer, 2018; Vidal-Abarca et al., 2014. It is understood that academics do not share the software they used with other researchers. At the same time, the narrow sample size of this research may have led to the continuation of the articles written by the same authors.

The fact that the studies were conducted with students from different age groups or different levels of learning indicates that Intelligent Tutoring Systems can be applied to various learner groups. Considering the studies conducted according to the level of reading skills of the students; there are studies in which higher level students benefit more from the ITS environment (Wijekumar, Meyer, & Lei, 2012; Wijekumar, Meyer & Lei, 2017), there are studies in which low-level students benefit more as well (Wijekumar, Meyer & Lei, 2012; Wijekumar et al. 2014; Serrano, Vidal - Abarca and Ferrer, 2018). In one study (Ji et al., 2018), students who made mistakes only in certain problems that could not be evaluated as low / high grade were provided more benefits. In general, it is seen that students with low reading skills from the ITS environments provide more benefits. The effect of the ITS environment on reading skills does not vary generally by gender. However, in one study (Wijekumar, Meyer, Lei, 2017), female students showed more development compared to male students, while in one study (Wijekumar, Meyer & Lei, 2012), male students showed more development than female students. The fact that results differ related to region (Wijekumar, Meyer & Lei, 2017) or school (Wijekumar, Meyer, & Lei, 2012) can be seen in only two studies. In the majority of studies (Wijekumar et al., 2019; Ji et al., 2018, Wijekumar et al., 2017; Wijekumar, Meyer & Lei, 2017; Wijekumar et al., 2014; Wijekumar, Meyer & Lei, 2013; Wijekumar, Meyer, & Lei, 2013) It was observed that the duration of studying in ITS environment or the number of questions solved in the ITS environment had a direct impact on the development of reading skills. Accordingly, the reading comprehension skills of those who use the environment more or solve more questions in the environment have improved at a higher level compared to those who use the environment less or solve less questions. Likewise, in another study conducted to review the effects of ITS-based education on reading comprehension skill, it was found that strong intensity–duration of the course resulted in a much larger effect than weak intensity–duration (Xu, Wijekumar, Ramirez, Hu, & Irey, 2019).

It has been observed in studies that the effect of Intelligent Tutoring Systems on reading comprehension skill does not differ in general according to student differences, but in some cases, it provides higher development in low level students. The fact that it provides more benefits to low level students shows that these environments are appropriate for applying to students who have learning disabilities or who are learning at low pace. However, students with disabilities were participated in, only one of the studies (Mich, Pianta & Mana, 2013), and one of the studies (Wijekumar et al., 2019) is conducted with low level students. 4th to 8th grade-level students were participated in the entire the reviewed studies. As reading in early ages could be challenging, various technologies have been used like electronic storybooks, interactive storybooks and multimedia applications to improve reading comprehension skill (Danaei, Jamali, Mansourian & Rastegarpour, 2020). Although ITS can be used as well as various technologies to increase early literacy level there was no study carried out at primary school (1st -2nd -3rd grade levels), which creates a gap in the literature. In addition, only one of the studies (Jackson & McNamara, 2013) examined the effect of ITS on motivation and pleasure. Measuring the attitudes of students towards ITS environments may also make a good contribution to the literature. As it is concluded that the time spent in ITS-based education is in accordance with the achievement, the intensity duration of ITS-based course should be increased in future studies. Since the sample of this study consists only articles compiled from one database and written only in English, it will be more beneficial for future studies to be selected from more than one database and to include articles written in Turkish.

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