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Research Article

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Investigating cognitive and metacognitive components of WebQuest-based education in the 7th grade work and technology curriculum according to Shannon's entropy technique

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ABSTRACT

The current research was conducted to investigate the cognitive and metacognitive components of WebQuest education in the 7th grade work and technology curriculum using the strategy of quantitative content analysis and Shannon's entropy technique. From the total population, it was selected as the sampling method of the research, therefore, all content elements, including activities, images, texts, and self-evaluations, were analyzed and investigated. These content elements were organized as the content analysis checklist and data collection tool. In this research, for the core components, the components obtained from the research with the title of "The application of WebQuest in teaching third-grade elementary science" were used, which included two core categories, cognitive and metacognitive, along with basic themes. The results of the examination of the cognitive components showed that in the 7th grade work and technology curriculum, the most attention was paid to the component of "pluralistic thinking" with an importance coefficient of (0/128) and also the least attention was paid to the components of "constructive thinking" and "creative thinking" with an importance coefficient of (0/061). Also, the results of the metacognitive components analysis illustrated that in the 7th grade work and technology curriculum, the most attention was paid to the components of "self-efficacy skills", "self-management skills", and "self-control skills" with an importance coefficient of (0/164) and the least attention was paid to the components of "self-directed skills" and "self-monitoring skills" with an importance coefficient of (0/109).

Keywords: cognitive and metacognitive components, WebQuest education, quantitative content analysis, Shannon's entropy technique

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INTRODUCTION

In today's world, where the speed of progress in the field of science and knowledge has reached minutes and seconds, joining the electronic world is the only way to enter this vast and busy highway (Sarker, 2021). Entering the electronic world requires the activity of citizens who can use electronic devices in their daily lives (Buchholz et al., 2020). It is for this reason that in this era, a term called "electronic citizen" is mentioned (Kocaoğlu & Karabulut, 2023). A citizen who is by the electronic citizen standard, a person who has the minimum necessary knowledge in the field of basic concepts of information and communication technology, the minimum required ability to apply the windows operating system and Microsoft Word, sufficient potential to develop communication with the Internet and the World Wide Web, the ability to exchange electronic contents through e-mail technology, enough potential to search for initial information by conducting effective surveys on the web, the ability to deal with the negative consequences and possible miseducation of the Internet and utilize the positive uses of this technology, the ability to find information about how to do various things through the Internet, the ability completing online forms on the Internet and doing various daily tasks through the Internet will be beneficial. In short, electronic citizenship means that people have the necessary capacity to use the Internet, mobile phones, and other electronic media. We all need to practice safe, legal, and ethical behaviors in the age of electronic media. Electronic citizen programs include proper educational and planning tools for children, parents, and teachers in all age groups (Dedebali & Dasdemir, 2019).

In any society, the training of electronic citizens needs to inform the citizens of that society, and there is no more important and practical system than the education system that can train such people and prepare them to enter the colorful world of all kinds of technologies. Based on this, today, due to the penetration of technology in all aspects of life, one of the most important and at the same time key tasks of the educational systems of countries such as America, Canada, Colombia, Australia, etc., is considered the

This article was extracted from the dissertation of Aslanyan-rad et al. (2023).

electronic citizen education by curriculum and to succeed in this procedure, it requires a lot of effort (Mora et al., 2021).

In this context, Karnvey (as cited in Eslamieh, 2009) acknowledges that having active, effective, and successful citizens of the 21st century requires that educational systems, products, and in other words, educate their students in such a way that after the end of their education, they can be equipped with special abilities and knowledge so that while being able to solve the problems of their time, they can challenge the problems of the local, national and global society in the future (Eslamieh, 2009). Digital tools and technology-based activities provide new and promising opportunities for students (Vahey et al., 2020).

These cases are considered those issues that are discussed among educational researchers and thinkers at the levels of universities and research centers and have fascinated the views of education experts, teachers, parents, and society (Mahmoudi & Imani-far, 2020). Since the workforce is mainly trained by educational systems (secondary education, technical and vocational education, and higher education) and sent to the labor market and updated by the in-service education system, the question that arises is whether the current curriculum of these educational centers is suitable for training such workforce (Jalili et al., 2017). With a brief look at the curriculum of the education system, it is clear that the design of this curriculum is more subject-oriented, and in this way, what is transferred to the learner is a collection of knowledge and information, and it is unlikely that this approach can succeed in the field of creating the necessary skills and competencies (Foster, 2002). This is even though progress and excellence in any society become possible when the planners and policymakers of the society put attention on children and teenagers at the top of their work (Karimi, 2022). Textbooks are the focus of the attention of education administrators due to their great importance in determining the content and educational policy. The importance of textbooks in centralized educational systems such as Iran, where almost all educational factors are determined and implemented based on their content, is more than in other types of educational systems, and because of this, it is so important that the time spent by experts in evaluating and analyzing textbooks can open the way to solve many of the current problems of education (Khanjani et al., 2023). Currently, textbooks are considered as one of the most important references and resources for learning. Because most of the educational activities take place within the framework of this media (Pike et al., 2010).

One of the most important changes in the field of education at present is the formation of a learner-centered education system next to a teacher-centered education system, which is considered the opposite (Hajizadeh et al., 2021). Therefore, the structure of the textbook should be planned in such a way as to be the foundation for the realization of a desirable and effective learning process (Arık, & Kezer, 2010). A textbook should have features such as comprehensiveness, appropriateness to the goals, appropriateness to the characteristics of the audience, usefulness for learners, linking content components and elements, connection and coordination with the books that the learners have already read or will read later, choosing the appropriate organization method, presenting research questions, the introduction of more sources, etc. (Keklik, 2011). The work and technology textbook in the 7th grade has been prepared and edited in the form of modules, where each module, in addition to general life skills, also represents a job group in the world of work. The educational approach of the book is active and collaborative. For the work and technology course, the teaching package includes a textbook, a teacher's guide, a teacher's guide video, and a projected student learning software provided to the teacher. What is of great importance in this lesson is the realization of the goals of all modules and projects for all students (Khanjani et al., 2023).

To eliminate the available obstacles, relatively new approaches in the field of education and learning and teaching activities related to curriculum structures have emerged, most of which have been proposed and introduced by experts and researchers in the field of education in recent decades; among these methods, which often choose an inductive approach, are: learning based on problem solving, learning based on design thinking, learning with the help of computers, learning with the help of peers, learning with the help of a research-based learning project. Almost all of these methods have tried to provide different and new methods of education and rely on improving the level of learning and increasing its durability, as well as improving the sense of self-confidence in learners (March, 2006). In this article, WebQuest is considered one of the new methods of teaching and learning introduced in the last three decades, which is based on searching and attempting to find solutions to questions through the Internet and by accessing web pages in the 7th grade work and technology textbook.

WebQuest Technology

WebQuest technology is an innovative, learner-centered, activity-based method along with effort and motivation for learning that uses computer technology to engage and motivate learners individually or collaboratively to search, analyze, and combine data to create knowledge or new meaning. WebQuest technologies as a learner-centered educational method, facilitate and promote high-level cognitive skills such as analysis, synthesis, evaluation and judgment, critical thinking, searching spirit, and problem-solving. Based on the idea of search and research as well as constructivism theory, WebQuest technologies engage learners in collaborative learning and group projects. In addition, there is a strong relationship between WebQuest technologies and multimedia techniques that provide important opportunities for using Internet resources in teaching and learning (Karimi & Armat, 2013).

Investigations and studies on metacognitive components indicates that WebQuest technologies can be considered as an efficient and effectiveness teaching and learning method, so that these metacognitive components included, self-management skills (Jahromi et al., 2016; Koutsogianni, 2014); self-control skills (Jahromi et al., 2016); self-directed skills (Abdelaziz, 2012; Boling, 2003; Koutsogianni, 2014); self-efficacy skills (Dogru et al., 2011; Dousti et al., 2021; Gurji, 2015; King, 2003; Mohammadi et al., 2023; Rakerda et al., 2020; Velasco-Zárate & Meza-Cano, 2020); self-regulation skills (Hartman, 2015; Hsiao et al., 2012; Lara & Repáraz, 2007; Lewis & Litchfield, 2011; Mousavi-Beidle et al., 2021). Other authors (Aslanyan-rad & Ghaderi, 2023; Awada et al., 2020; BinTaleb, 2021; Chen, 2021; Ebadi & Rahimi, 2018) are struggling to reveal the existing gaps in the penetrating procedures that WebQuest technologies can obtain in the learning and teaching process.

Considering the importance that WebQuest technologies have as a web-based method rooted in the basics of information and communication technologies in promoting the productivity of knowledge and learning in the lives of instructors and students, therefore, the current research seeks to examine and analyze the existing content of textbooks as the most important educational element, to determine the level of attention paid to each of the desired concepts. In this regard, the following questions were raised:

1. What are the cognitive components of WebQuest in the 7th grade work and technology curriculum?
2. What are the metacognitive components of WebQuest in the 7th grade work and technology curriculum?

Table 1. Steps to calculate Shannon's entropy (Hashemi et al., 2021)

Stage	Stage name	Definition
First stage	Frequencies matrix	$P_{ij} = \frac{F_{ij}}{\sum_{i=1}^{m} F_{ij}}$ where i=1, 2, 3, …, m, j=1, 2, 3, …, n, i: respondent number, j: component number, P: normalized frequencies matrix, F: component abundance.
Second stage	Information load of each category	$E_j = K\sum_{i=1}^{m}(P_{ij}\ln P_{ij}), K = \frac{1}{\ln M}$ where i=1, 2, 3, …, m, j=1, 2, 3, …, n, E_j: information load, P: normalized frequencies matrix, i: respondent number, j: component number.
Third stage	Calculating information load of indicators and importance coefficient	$W_j = \frac{E_j}{\sum_{i=1}^{m} E_j}$ where E_j: information load, W_j: importance coefficient, j: component number.

METHODOLOGY

The current research was conducted to investigate the cognitive and metacognitive components of WebQuest-based education in the 7th grade work and technology curriculum using the strategy of quantitative content analysis and Shannon's entropy technique. The unit of pages analysis (text, image, self-evaluation, and activities) was the 7th grade work and technology book. Content analysis has three main steps. These steps included the following:

1. pre-analysis stage (preparation and organization),
2. check the material (message), and
3. data processing (Sarmad et al., 2018).

Today, many techniques have been presented in this regard, which are based on the percentage of the frequency of categories. Therefore, in this research, an attempt has been made to analyze the 7th grade work and technology book based on the level of attention to the research approach using Shannon's entropy method. **Table 1** illustrates the steps to calculate the technique of Shannon's entropy.

The field of research included the Iranian 7th grade work and technology book of secondary school with the code number 717 in the academic year 2022-2023, which was compiled and printed by the educational research and planning organization in two sections and contains 12 modules. From the total population, it was selected as the sampling method of the research, therefore, all content elements, including activities, images, texts, and self-evaluations, were analyzed and investigated. These content elements were organized as the content analysis checklist and data collection tool. In this research, for the core components, the components obtained from the research of Aslanyan-rad et al. (2023) were used, which included two core categories, cognitive and metacognitive, along with basic themes. In this regard, the cognitive components included: creative thinking, critical thinking, content thinking, analytical thinking, logical thinking, reflective thinking, formative thinking, organizing thinking, meaningful thinking, stabilizing thinking, constructive thinking, Process-oriented thinking, and pluralistic thinking. Also, the metacognitive components included: self-management skills, self-directed skills, self-monitoring skills, self-evaluation skills, self-regulation skills, self-efficacy skills.

FINDINGS

What are the Cognitive Components of WebQuest in the 7th Grade Work and Technology Curriculum?

The findings of the study and examination of WebQuest cognitive components in the 7th grade work and technology curriculum were prepared according to each component in **Table 2**, and then based on Shannon's entropy method, the data of **Table 2** were obtained as normalized data, and finally, considering the third stage in the mentioned method, the importance coefficient of the prepared information was also determined to distinguish which cognitive style generally receives the most attention and importance. The results are shown separately in the following tables.

Table 2. Frequency of cognitive components of WebQuest in the 7th grade work and technology curriculum

Source	7th grade work and technology curriculum	
Chapter titles	First part: Prescriptive modules	Second part: Semi-prescriptive modules
Creative thinking	32	11
Critical thinking	18	12
Content thinking	25	31
Analytical thinking	16	21
Logical thinking	14	13
Reflective thinking	21	10
Formative thinking	14	12
Organizational thinking	24	26
Meaningful thinking	11	15
Stabilizing thinking	19	19
Constructive thinking	14	43
Process-oriented thinking	12	19
Pluralistic thinking	10	2

Table 2 shows the frequency of the cognitive components of WebQuest in the 7th grade work and technology curriculum separately.

Table 3. Normalized data from analysis of cognitive components of WebQuest in the 7th grade work and technology curriculum

Source	7th grade work and technology curriculum	
Chapter titles	First part: Prescriptive modules	Second part: Semi-prescriptive modules
Creative thinking	0/74	0/25
Critical thinking	0/6	0/4
Content thinking	0/44	0/55
Analytical thinking	0/43	0/56
Logical thinking	0/51	0/48
Reflective thinking	0/67	0/32
Formative thinking	0/53	0/46
Organizational thinking	0/48	0/52
Meaningful thinking	0/42	0/57
Stabilizing thinking	0/5	0/5
Constructive thinking	0/24	0/75
Process-oriented thinking	0/38	0/61
Pluralistic thinking	0/83	0/16

Table 3 shows the normalized data, P_{ij}, obtained from the analysis of the cognitive components of WebQuest in the 7th grade

work and technology curriculum separately. After normalizing the data using Shannon's formula of the second step, the amount of information load and the importance coefficient of each of the components have been obtained. Any category or component that had more information load is more important.

Table 4. Amount of information load, importance coefficient, and rank of cognitive components of WebQuest in 7th grade work and technology curriculum

Source	7th grade work and technology		
Chapter titles	E_j	W_j	R
Creative thinking	0/21	0/061	5
Critical thinking	0/25	0/073	3
Content thinking	0/26	0/076	2
Analytical thinking	0/26	0/076	2
Logical thinking	0/24	0/076	2
Reflective thinking	0/26	0/076	4
Formative thinking	0/26	0/076	2
Organizational thinking	0/26	0/076	2
Meaningful thinking	0/26	0/076	2
Stabilizing thinking	0/26	0/076	2
Constructive thinking	0/21	0/061	5
Process-oriented thinking	0/25	0/073	3
Pluralistic thinking	0/44	0/128	1

The results of **Table 4** have shown the rank, the amount of information load, E_j , and importance coefficient, W_j , of the cognitive components of WebQuest in the 7th grade work and technology curriculum. According to the results, the component of "pluralistic thinking" was known as the first rank with the importance coefficient (0/128) and therefore it can be said that the most attention was paid to this component in the 7th grade work and technology curriculum.

Also, "constructive thinking" and "creative thinking" were known as the fifth rank with an importance coefficient (0/061). So, it can be said that the least attention has been paid to these components in the 7th grade work and technology curriculum. Altogether, other results were shown separately in **Table 4**.

What are the Metacognitive Components of WebQuest in the 7th Grade Work and Technology Curriculum?

The findings of the study and examination of WebQuest metacognitive components in the 7th grade work and technology curriculum were prepared according to each component in **Table 4**, and then according to the previous question, other steps were described based on Shannon's entropy method.

Table 5. Frequency of WebQuest metacognitive components in 7th grade work and technology curriculum

Source	7th grade work and technology	
Chapter titles	**First part: Prescriptive modules**	**Second part: Semi-prescriptive modules**
Self-management skills	40	68
Self-control skills	26	46
Self-directed skills	35	7
Self-monitoring skills	25	5
Self-assessment skills	56	19
Self-regulation skills	20	48
Self-efficacy skills	83	125

Table 5 shows frequency of WebQuest metacognitive components in the 7th grade work and technology curriculum separately.

Table 6. Normalized data from analysis of WebQuest metacognitive components in the 7th grade work and technology curriculum

Source	7th grade work and technology	
Chapter titles	**First part: Prescriptive modules**	**Second part: Semi-prescriptive modules**
Self-management skills	0/37	0/62
Self-control skills	0/36	0/63
Self-directed skills	0/83	0/16
Self-monitoring skills	0/83	0/16
Self-assessment skills	0/74	0/25
Self-regulation skills	0/29	0/7
Self-efficacy skills	0/39	0/6

Table 6 shows the normalized data, P_{ij} , obtained from the analysis of the metacognitive components of WebQuest in the 7th grade work and technology curriculum separately. In this section as in the previous question, after normalizing the data using Shannon's formula of the second step, the amount of information load and the importance coefficient of each of the components have been obtained. Any category or component that had more information load is more important.

Table 7. Amount of information load, importance coefficient, and rank of WebQuest metacognitive components in 7th grade work and technology curriculum

Source	7th grade work and technology		
Chapter titles	E_j	W_j	R
Self-management skills	0/33	0/164	1
Self-control skills	0/33	0/164	1
Self-directed skills	0/22	0/109	4
Self-monitoring skills	0/22	0/109	4
Self-assessment skills	0/28	0/139	3
Self-regulation skills	0/30	0/149	2
Self-efficacy skills	0/33	0/164	1

The results of **Table 7** have shown rank, amount of information load, E_j , and importance coefficient, W_j , of metacognitive components of WebQuest in the 7th grade work and technology curriculum. According to the results, the components of "self-efficacy skills", "self-management skills", and "self-control skills" were the first rank with the importance coefficient (0/164) and therefore it can be said that the most attention was paid to these components in the 7th grade work and technology curriculum. Also, the components of "self-directed skills" and "self-monitoring skills" had the fourth rank with an importance coefficient (0/109). So, it can be said that the least attention has been paid to these components in the 7th grade work and technology curriculum. Other results were shown separately in **Table 7**.

CONCLUSIONS

The current research was conducted to investigate the cognitive and metacognitive components of WebQuest-based education in the 7th grade work and technology curriculum based on Shannon's entropy technique. The results of the examination of cognitive components showed that in the 7th grade work and technology curriculum, the most attention was paid to the category of pluralistic thinking, and the least attention was paid to the components of constructive thinking and creative thinking.

In explaining these findings, it can be stated that the educational approach of WebQuest has found an important status among different approaches of educational technologies today. From this viewpoint, the analysis of the findings of WebQuest cognitive components indicated the existence of wide attention to these

categories. From the perspective of researcher, the learner in such WebQuest courses is able to rearrange the educational content based on one or more cognitive rules (organizing thinking); the students can explore the logical relationships between claims, truths and reasons and increase the ability to obtain reliable results in various problems in the context of web content (logical thinking); by a person's native language, in reality, it shapes the way a person thinks about many aspects of the world, including space and time, etc. (formative thinking); have the ability to analyze and evaluate ideas, solve problems and make decisions and promote a set of information processing, beliefs and habits based on intellectual commitment and the use of these skills to guide behaviors that can be created by acquiring and maintaining information (analytical thinking) (Sternberg & Grigorenko, 2007). The student can link the longitudinal and transverse content of the hierarchy of learning courses well and analyze the issues properly in this way (content thinking).

Çığrık and Ergül (2010) mentioned that learning with WebQuest technologies can be considered an effective tool for students' logical thinking skills. The analysis of cognitive components results also showed that WebQuest has a significant impact on critical thinking. These findings were identified to be aligned with studies of Auditor and Roleda (2014), Averkieva et al. (2015), Bayram et al. (2019), Chen (2021), Ebadi and Rahimi (2018), and Liang and Fung (2020).

In this research, the results of meta-cognitive components analysis indicated that in the 7th grade work and technology curriculum, the most attention was paid to the category of self-efficacy skills, self-management skills, and self-control skills, and the least attention was paid to the components of self-directed skills and self-monitoring skills. In explaining these findings, it can be stated that metacognitive resources play the most significant and strategic role in the category of metacognitive resources because they describe those skills that lead to the restoration and generalization of skills in other cognitive aspects, and as a result, they significantly improve and increase the efficiency of academic performance. These skills act as a kind of learning scaffolding for the two fields of cognitive and psychological resources of this class and equip people with skills so that they can recognize the functions of other aspects of the sub-themes of this class and in cases, where they suffer from a functional deficiency or weakness, be considered a factor in solving their problems.

Aslanyan-rad et al. (2023) in their study based on Strauss and Corbin's paradigm model stated that one of the focal reasons for choosing the main organizing category of metacognition as the intervening condition of WebQuest training was the sub-category of metacognitive skills because the learner's focus and supervision on their skills are regarded a potential factor in determining the possible paths of success and progress of his work or, conversely, his failure to receive positive academic feedback, so this sub-category as a broad and general cognitive condition acts as a facilitator or limiter role of strategies. The skills of this metacognition category facilitate and accelerate the implementation of educational instructions or delay them as an obstacle, so they were assumed intervening conditions in their research. According to the researchers, this research showed perhaps one of the most complete basic themes around metacognitive skills, and perhaps one of the best frameworks available in the research can be found in this sub-category. These skills included self-management, self-control, self-directed, self-monitoring, self-evaluation, self-regulation, and self-efficacy, which were categorized as metacognitive skills.

According to the study of Mousavi-Beidle et al. (2021), WebQuest teaching has a positive effect on students' progress motivation and self-concept as the basic themes of the subcategory of psychological skills and self-regulation learning as the basic theme of the sub-category of metacognitive skills in English course. Jahromi et al. (2016) also believe that WebQuest is an effective strategy for increasing self-directed learning indicators, i.e., students' self-control and self-management skills. Also, according to the analysis of Jahromi and Mosalanejad (2015), the average of self-regulated learning and self-directed learning increased after the educational intervention. According to Rakerda et al. (2020), the poster created by the student using WebQuest as a teaching-learning method is counted an active learning activity that increases students' understanding of self-efficacy in the reading comprehension of the text and the writing of information in the poster and evidence of the student's participation in the behavioral, emotional, and cognitive domains. The themes derived from participants' perceptions are perceived self-efficacy, novelty or usefulness of poster creation, and technical and content knowledge. Student-made posters as an active approach using WebQuest can be included in the secondary school English learning context to increase student's English skills and develop integrated skills of the current century. Practical implications for teachers when designing assignments (the sub-organizing theme of instructor) student made posters using WebQuests include

(a) following a model for poster development,

(b) providing additional time for content learning and revision, and

(c) group assessment composition.

In general, it can be stated that although WebQuest has emerged in active learning approaches for information and communication technoşogies for nearly three decades, and recent observations and research indicate the limitations of the implementation and application of this educational technology in today's modern classrooms, it has achieved acceptable progress and achievements in cognitive and metacognitive fields.

In the following, the researchers proposed the cognitive and metacognitive themes of WebQuest in this research for the development of other domains of e-learning to provide a basis for promoting this active educational approach in the education community.

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