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STUDIES ON EDUCATION 4.0 AND EDUCATION 4.0 IN SCIENCE AND MATHEMATICS EDUCATION

Mehmet POLAT[1], Emine ÇİFTÇİ[2], Selim ASLAN[3], Ayşenur ÇAKMAK[4], Ersan AKIN[5]

Abstract

While technological developments increase the quality of individual and social life, they lead to the emergence of new competencies and skills in the labor market. This situation forces the education system to adapt to technological innovations and respond to changing needs. The concept of education and its components gain a new content in this process, and the traditional understanding of education is replaced by a new paradigm called Education 4.0. Education 4.0 is an education model that can meet the requirements and expectations created by Industry 4.0. Teachers are of great importance in increasing quality and success in education. Teachers' attitudes and competencies regarding technology integration determine the digital transformation of education. For this reason, determining how to integrate technology in science education and determining teachers' opinions and competencies about Education 4.0 is important for the effectiveness and efficiency of the science learning-teaching process. Technology contributes to the development of new concepts and approaches in the field of education. Some of these are pedagogical practices such as blended learning, flipped classrooms, social media, web 2.0, gamification and game-based learning, and online learning management systems. In addition, a new technological revolution called Industry 4.0 also plays an important role in education. Industry 4.0 includes elements such as programming, robotics, 3D design, cloud computing systems, virtual and augmented reality, digital citizenship, animations and simulations, and artificial intelligence. These elements necessitate the acquisition of new competencies and skills in the science learning-teaching process.

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Key Words: *Science Education, Mathematics Education, Educational Technologies, Digital Transformation, Education 4.0*

Introduction

In our age, where global competition in the fields of technology and economy is intensifying and digitalization is gaining momentum, it is inevitable to revise the education system according to the requirements of the age in order to adapt to changing conditions and gain the qualifications required by change (Çelik, Önal Karakoyun and Asiltürk, 2022; Erbek, Asiltürk and Kahyaoğlu, 2023; Polat and Yılayaz, 2023a; Taguma and Barrera Fernandez, 2019; İç and Tutak, 2019; Tutak, 2010). In this context, all elements that make up the education system, such as educational philosophy and theories, educational programs, learning and teaching processes, teaching methods and techniques, learning environments, student, teacher and administrator roles, are addressed by relevant stakeholders at global and local levels, and are designed to meet the expectations of the 21st century. Recommendations are being developed for this purpose (Almeida and Simoes, 2019; Önal Karakoyun and Asiltürk, 2020; Fernandez, 2016; Gelen and Demircioğlu, 2020; Himmetoglu et al., 2020; Polat and Önal Karakoyun, 2022; Tanrıöğen, 2019). For this purpose, representatives from the business world, academia, politics and education sectors in different countries organize various studies, reports and events and try to contribute to the training of individuals with competencies that can meet the needs of the age (Asiltürk, Polat and Önal Karakoyun, 2023; Gelen and Demircioğlu, 2020; Goel, Kumar, Johri, Srivastava, and Suhag, 2020; Urban and Johal, 2020). It can be stated that countries, societies and individuals that realize and embrace this change will be better prepared for the future, and countries that can keep up with developing technology and the pace of change will be in a superior position compared to countries that cannot adapt to change.

The use of technology in the field of education supports and facilitates the learning and teaching process in disciplinary fields such as science and mathematics, where abstract and complex subjects are intensively included (Asiltürk and Almaz, 2023; Aydoğdu, Akgül and Tutak, 2015; İç and Tutak, 2019; Hariharasudan and Kot , 2018; Polat and Yılayaz, 2023b; Taşdemir, 2018; Tutak, İlhan, İç and Kılıçarslan, 2018). However, technology alone is not enough to improve the quality of education. Technology-based learning tools allow students to learn in a way that suits their own learning rhythms and improves their skills (Hariharasudan & Kot, 2018). Especially when new technologies such as artificial intelligence, internet of things, virtual reality and cloud computing are used appropriately and effectively in the field of education, personalized courses in which students interact can be created, more practice and experience can be made, and projects can be designed for meaningful and contextual learning (Baygın et al. ., 2016). In addition, technologies in classrooms enable teachers to identify learning problems, adjust learning according to student needs, monitor student development by evaluating their projects, provide feedback and make decisions about the effectiveness and efficiency of learning for students, teachers and administrators, and enable teachers to focus on active learning, practical application and interaction. It can contribute to organizing classes in the best way (Silva et al., 2021). The personalized learning approach called Education 4.0 can facilitate students' learning of science and mathematics by giving them the opportunity to choose content suitable for their learning purposes and by providing both feedback on their learning performance and suggestions on future learning content (Puncreobutr, 2016; Viet Tran and Hong Le, 2020).

Education 4.0

Education 4.0 is an up-to-date education approach that aims to make individuals innovative, able to adapt to the requirements of the age and willing to learn throughout life. Education 4.0 allows students to improve themselves according to technological and social changes. The emergence of new technologies requires the person to constantly renew himself and maintain his motivation for lifelong learning. Education 4.0 is not only an education model, but also a vision and a paradigm (Sinlarat, 2016).

Education 4.0 is a current education approach that aims to enable individuals to acquire innovation skills so that they have innovative, creative and innovative minds. Education 4.0 uses the changes occurring in the social, cultural and economic fields as an observation tool to meet a human-oriented need. Education 4.0, individuals; It requires students to acquire 21st century skills such as innovation and creativity, leadership, collaboration, creativity, digital literacy, problem solving and group work (Tangahu, Rahmat and Husain, 2021).

Education 4.0 puts the student at the center of an education ecosystem. The basis of Education 4.0 necessitates the use of different learning styles and tools together, such as mobile learning, networked learning in communities, learning free of temporal and spatial dependency, self-organized and responsible learning, and learning when needed. Education 4.0 can be defined as a life-oriented system, not exam-oriented. In this approach, personalized learning takes place without time and space restrictions (face-to-face application in the classroom), and the student learns field interest, learning flexibility, and project-based MAKER application by implementing what he has learned on a real project instead of transferring it to paper (Oliveira & Souza, 2022).

Figure 1. Skills intended to be developed with Education 4.0 applications

Education 4.0 is a student who can produce solutions to problems, is compatible with cooperation and teamwork, is interested in robotic design, is effective in time management, sees life as continuous development rather than a single exam, gains experience through projects, and stores information in long-term memory. It is an up-to-date education approach that aims to raise individuals who are centered, integrated with technology, constantly learning and improving themselves. Education 4.0 represents a new phase in which humanist ideas adapt to the digital world. In Education 4.0; Students benefit from excellent distance learning opportunities according to their own learning pace, place and time. Thus, the theoretical part can be learned outside class hours and a reverse classroom approach is followed. The Education 4.0 vision is constantly being improved and implemented in the contemporary school, step by step. It is an integral part of human social and cultural life. Parents, teachers and students have expectations for the new school model. Education 4.0 is a vision of a school of the future that can contribute to educational changes. With the introduction of artificial intelligence, these changes may also include students with special educational needs, who will be accurately and continuously defined in terms of educational achievements (Huk, 2021; Hussin, 2018; Oliveira, Guerino, Oliveira & Pimentel, 2023).

Education 4.0 is a current approach to education that highlights four approaches. These are (Dzulkifli, 2017; Halili, 2019; Özkaynak, 2018);

- Learning can be done anywhere and anytime. Online education tools provide students with distance and self-learning opportunities. Effective learning environments are created with the flipped classroom approach and theoretical sections are learned outside of school.

- Students are given the right or tool to choose how they want to learn. Even if the curriculum is predetermined by educational institutions, students can choose their own learning styles, methods and tools. Blended learning, 'Bring Your Own Device' (BYOD) and flipped classroom approaches are implemented to develop students' creativity and be effective.
- Applied learning opportunities such as internships and mentoring projects are offered. In this way, students are supported to acquire communication and face-to-face communication skills.
- Students can be freer and more independent in their own learning processes. Therefore, the role of teachers is based on guiding rather than directing them. Education 4.0 makes it an important part of the process that directs both students and teachers to new learning.

Education 4.0 reflects the demands of today's student profile. Today, students exhibit different behaviors than previous generations. For this reason, current technologies need to adapt to education, education needs to adapt to current technologies, and teachers need to be more creative when planning lessons.

Education 4.0 Tools Used in Science and Mathematics Education

Education 4.0 is a current education approach that uses technological developments. Education 4.0 can increase the efficiency of the learning and teaching process by incorporating the latest technologies (Vawn, 2018). Thanks to new technologies, students will be more interested in learning and will be able to actively participate in the learning-teaching process (John & Cedric, 2004). Some of the Education 4.0 applications used in the learning-teaching process are:

3D Printers

3D printing technology can be applied in a wide variety of areas. Industrial production, medicine and health, aviation and space, architecture and construction, military applications, textile, food, education and many other fields can be given as examples. The issue of education is of strategic importance for 3D printers. It is considered an important tool in developing creativity in interactive, mechanical and technical courses. By using this technology effectively in the educational environment, various experiences can be gained in many different fields. From primary education to university, 3D printers used in schools are a technology that provides confidence and offers new and new learning opportunities that increase students' imagination. This technology shifts the paradigm of critical thinking, giving students the ability to create physical objects that solve problems using logic and reasoning. 3D printing technologies are used in some schools to prepare interactive, mechanical and technical lessons. This inspires young minds and makes learning more fun. The use of 3D printing technologies is seen in areas such as architectural education, art education, biology education, chemistry education, geology education, history education, mathematics education, science and engineering education (Kökhan and Özcan, 2018).

Figure 2. 3D printer

Augmented Reality

Augmented Reality (AR) is a technology that makes virtual objects perceived as a component of the real world (Azuma, 1997). AR is a rapidly developing technology that has attracted great interest in both commercial and educational fields (Bower et al., 2014). Gartner, Inc. IT research and consultancy company named publishes a report and graph every year showing the "maturity and prevalence of technologies" (URL-1). According to this report, AR has left behind the "trough of disappointment", which is the stage where a technology will either succeed or fail, and has reached the "plateau of productivity", the stage where the technology will become widespread and commonplace in the next five to ten years (Panetta, 2017). Similarly, in the last decade, research on the use of AR for education has proliferated. AR technology has been applied to diverse subjects such as science, mathematics, language learning, and visual art appreciation (Chen et al., 2017). These studies have revealed that AR contributes to students learning information or abstract or complex concepts that cannot be observed in the real world or require a special device. AR technology allows students to interact with invisible mechanisms and notice changes in time and scientific details in the event (Yoon and Wang, 2014). AR technologies have also been identified as an important technology for primary and secondary education in the next five years (Johnson et al., 2010). Therefore, it is very important to conduct research on how to use this new technology for education and how effective it is. AR is one of the potential technologies to eliminate and correct misconceptions frequently encountered in science education (Yoon, et al., 2017). Yoon et al. (2017) demonstrated that AR is effective in reducing misunderstandings about physics topics and grasping difficult scientific concepts. For example, a common misconception about Bernoulli's Principle is that there is a direct relationship between air speed and air pressure. However, in reality, there is an inverse relationship between these two variables; As air speed increases, air pressure decreases. Yoon et al. (2017) offered museum visitors an AR experience in which they could perceive the speed and pressure of two air currents in real time. In this way, participants were able to observe how the inverse relationship between air speed and air pressure inside the room keeps a ball floating in a fast-moving air current in the real world (Asiltürk and Almaz, 2023).

Figure 3. Augmented reality applications in education

Virtual Reality

Virtual reality is an artificial environment in which real situations are reflected in the computer environment with certain laws, rules and various software. In this environment, users can receive responses to their reactions, similar to the real world. In this way, experiences close to real experiences can be carried out effectively in artificially created environments. It is a technology that activates human emotions and is very effective in creating behavioral change. It provides the interaction environment through visual and auditory means as well as through feeling. With these features, virtual reality allows students to actively use all their sense organs with its sound, light and interaction features (Arıcı, 2013).

Figure 4. Virtual reality applications in education

Cloud Technology

The development and spread of internet infrastructure and web-based application software has enabled individuals to produce information collaboratively. Cloud Computing, also called cloud computing or cloud technology, is a model that allows access to computing resources such as networks, servers, storage, applications and services from anywhere and on demand, with minimal management and methods. Cloud computing services, which are an important trend in technology-supported learning environments and the use of cloud-based technologies, offer advantages in terms of access to online services, scalability, availability and cost savings. Cloud computing technologies, which consume less hardware resources, run on virtual servers, are pre-installed, can be easily updated, and offer software as a service, eliminate the need to establish a laboratory (Horzum, Kıyıcı, & Akgün, 2015; González Martínez et al., 2015).

Figure 5. Cloud computing applications in education

Internet of Things

The Internet of Things is increasingly present in our daily lives. Initial research has revealed that the use of IoT in education and training environments provides positive contributions to the process. Gómez et al. (2013) worked with physical learning objects that carry digital information with QR codes. With this simple method, physical and virtual worlds could be integrated and analog learning content could be supported with multimedia. Another study showed that automatic control of external factors such as lighting, heating and cooling positively affects learning processes (Uzelac et al., 2015).

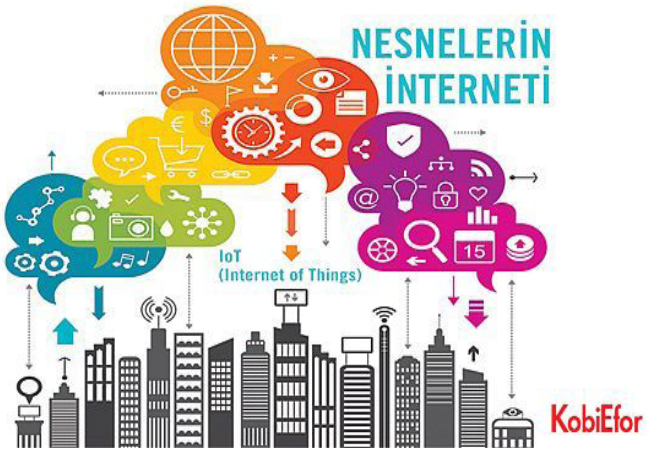

Figure 6. Internet of things

Big Data

This technology supports the institution’s data management, evidence acquisition, and institution-student data sharing. In this way, institutions can predict students’ learning levels, school dropout risks, academic success or participation status with relevant data (Khan, 2020).

Figure 7. Big data technology applications in education

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CLOUD COMPUTING TECHNOLOGY APPLICATIONS IN SCIENCE AND MATHEMATICS EDUCATION

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Abstract

Technology has not only made our lives easier, but also led to a digital transformation in many sectors. This transformation has also made itself felt in the industrial field, opening the door to a new era called Industry 4.0. With Industry 4.0, industrial production has been strengthened and improved with technologies such as autonomous robots, smart networks, system integration, cyber physical systems, cyber security systems, internet of things, big data analysis, cloud computing, simulation and augmented reality, additive manufacturing and 3D printers. . These technological developments have also influenced the education sector and new approaches have been developed to meet education and learning needs. Classes enriched with educational technology tools have been established in schools, and teaching programs have been updated taking technology integration into consideration. Teachers are asked to use educational technology tools effectively in the teaching process and to support science and mathematics education with hands-on, interactive and collaborative learning environments. One of the new technologies that can fulfill these demands and has attracted attention recently is cloud computing technology. Applications based on cloud computing technology provide an effective learning environment for students and teachers and offer interaction, communication, feedback, collaboration and sharing opportunities.

Key Words: *Science Education, Mathematics Education, Cloud Computing, Digital Transformation, Industry 4.0*

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Introduction

The use of technology in the field of education facilitates teachers and students' access and sharing of information and thus increases the effectiveness of learning and teaching processes (Nayıroğlu and Tutak, 2023; Önal Karakoyun and Asiltürk, 2022a; Önal Karakoyun and Asiltürk 2022b; Polat, 2022a; Polat, 2022b; Tutak , Nayıroğlu and Özer, 2023; Tutak, Nayıroğlu and Süzen, 2023; Uğraş and Çil, 2012). Industry 4.0, defined as the fourth industrial revolution, has increased the contribution of digital technologies to the student-centered education process (Kurtoğlu Erden&Uslupehlivan, 2020; Yıldızay & Çetin, 2018). Thanks to the development, acceleration and cheapening of the internet infrastructure and the widespread use of personal computers or smartphones, today's people can access information by taking advantage of information technologies (Gonzalez-Martínez, Bote-Lorenzo & Gomez, Sanchez, 2015). Global IT companies have supported the development of cloud computing services by integrating their new investments with internet technologies and providing various applications to end users in simple or service form via the internet (Çelik, 2021; Demirkaya&Sarpel, 2018; Gupta et al., 2023).

Cloud computing is seen as one of the new technology trends in the field of education (Yadav, 2014; Sultan, 2014; Abdul-Rahman Al-Malah, Aljazaery, Salim Alrikabi & Mutar, 2021). Cloud computing allows creating new learning scenarios by providing broad access, advanced online tools, and innovative opportunities for collaborative education (Wigati, Wibisono & Hidayanto, 2021). Cloud computing has become a technology option that can be chosen in resource-constrained situations with flexible scaling and effective use of resources. The accessibility, usability and performance of cloud services have led many universities and businesses to use these services (Alan and Kırbağ Zengin, 2023).

Cloud computing is a technology that allows different users to work on a common file or document at the same time. With this technology, online platforms such as Google Docs Application enable users to perform synchronous operations on files or documents with different extensions (such as .ppt, .xls, and .doc). In addition, cloud computing ensures that files or documents are stored not on a fixed computer, but in an area that can be accessed from anywhere with an internet connection (Qasem, Abdullah, Yaha, Atana, 2020). Thus, users can access files or documents via computers or mobile devices and track previous changes. For this reason, cloud computing solves many problems and offers group work opportunities for studies such as text, visuals or projects (Demirkaya and Sarpel, 2018).

Cloud computing is a technology that develops social learning environments compatible with both active learning and constructivist approaches in the education process. This technology allows students to collaborate not only in the classroom but also outside the classroom (Horzum, Kıyıcı, & Akgün, 2015). In this context, cloud computing strengthens the active learning approach in peer learning applications. In peer learning applications, students can interact with each other and exchange information and documents. Information and communication technologies respond to the areas of interest of new generation individuals and allow them to be introduced to technology at an early age. Using this interest in educational environments is an important advantage in increasing students' contributions to education and learning processes (Yavuz, 2014).

Cloud computing enables users to access the cloud system from any device they want and benefit from the services offered. Cloud computing service models are as follows (Mutlu, 2015):

Infrastructure Services (IaaS): Customers can determine their own processor, storage, network and other computing resources and install operating systems and applications. They cannot fully control the infrastructure, but they can handle the operating system and some network components. IaaS services are aimed at system experts.

Platform Services (PaaS): The service provider provides customers with an application development and running environment. This environment includes the necessary services and technological infrastructure. Customers cannot control or manage the platform infrastructure. PaaS services appeal to application developers.

Software Services (SaaS): Users can access and use applications in cloud computing over the internet without installing them on their own systems. They can access applications from a variety of devices through interfaces such as web browsers. Customers do not manage or control infrastructure components. They can only adjust application settings.

Cloud computing is one of the popular technologies of recent years and is expressed as cloud-based learning in educational environments. When used in science education, this technology will contribute to students and teachers meeting innovative and technological methods and creating the educational environments of the future. In this study, research on cloud computing in science education was evaluated in terms of its subject, research method, study group, data collection tools, data analysis methods, findings and results regarding the effect of cloud computing on science education, and some suggestions were made for future research on the use of cloud computing in science education. has been found.

Cloud Computing Applications

Cloud computing is a technology that has attracted attention in recent years and is constantly evolving in harmony with internet technology. It attracts the attention of many companies, institutions and organizations due to the many opportunities it offers (Masud and Huang, 2012). Service providers offering cloud computing infrastructure are also striving to constantly improve their capabilities to serve users in the same harmony. Amazon Web Service (AWS), Aptus, Cloudturk, Dropbox, Eucalyptus, Evernote, EyeOs, IBM Cloud, iCloud, Oracle, Zoho, Microsoft Azure, Microsoft Office365, Google Apps, Google Drive provide application, platform and infrastructure services to users in cloud computing technology. can be given as examples of companies and practices that provide Some of the service providers are introduced below (Armutlu, 2014; Batı, 2015; Çetiner, 2014; Mcmorran, 2013).

Microsoft OneDrive: Provides a cloud environment where users can store their files, share them with other users and work collaboratively.

Microsoft Azure: It offers a cloud platform where institutions and users can develop their own applications and have distribution and management rights. On this platform, institutions can get help with private or hybrid cloud infrastructure.

Google App Engine: It is a cloud platform that offers institutions and users the opportunity to develop, distribute and manage applications.

Google Suite: It is a cloud service that offers institutions and users storage, sharing, collaboration and management opportunities.

Use of Cloud Computing in Science and Mathematics Education

Information technologies have led to significant changes in the field of education and training from past to present (Gülbahar, 2009). Traditional education and training environments have been reshaped with new technologies, and the processes of teachers and students in accessing information, learning and teaching have differentiated (Şemsettin, 2007). These changes have redefined many educational elements by affecting the structure and functioning of educational institutions, the design, implementation and evaluation of teaching activities (Erişti, 2010). Internet technologies, which have become widespread in all areas of life since the beginning of the twenty-first century, also play a major role in the field of education. Web technologies, which only allowed one-way communication in the early days, have now gained a dynamic structure and turned into cloud computing technologies that offer online and simultaneous collaboration and interaction opportunities. Thanks to cloud computing, users have the opportunity to work together and produce joint content. This situation carries an important potential for the development of effective teaching methods (Borisch, 2014; Sarıtaş and Üner, 2013, Sultan, 2010). Conducting teaching activities in an electronic environment by providing information access and interaction with multimedia applications through information and communication technologies over the internet, without time and space restrictions, is called e-learning (Gülbahar, 2009). The use of cloud computing technologies, which emerged with the development of internet technologies, in e-learning environments is referred to as cloud-based learning (Boiros, 2014). The concept of cloud-based learning does not only include in-class activities. Cloud-based learning; It includes all stages of the learning-teaching process such as preparation before the lesson, cooperation and interaction in the learning process, and evaluation activities (Horzum, Kıyıcı, & Akgün, 2015). Cloud computing technologies not only improve the quality of the teaching process but also provide infrastructure services to educational institutions. Educational institutions can perform operations such as infrastructure installation, maintenance and management through cloud service providers. This situation reduces the infrastructure burden of educational institutions and allows them to focus more on educational activities (Sarıtaş and Üner, 2013). Educational institutions experience great difficulties in providing and maintaining the extensive hardware and software equipment that forms the infrastructure of informatics. Students also demand better information technology services from the institution. To meet these demands, provide and maintain infrastructure, cloud computing [technology] is a suitable solution for educational institutions (Attaran et al., 2017). According to Ercan (2010); Thanks to cloud computing, students and staff in educational institutions can easily access various application platforms and resources through web pages. While these organizations provide more functional competence for institutions, they also reduce the costs of many services such as e-mail services, software licensing and hardware costs. Traditional knowledge management platforms used in knowledge management systems at universities may not be sufficient to provide teaching and research services (Hu, Yang, & Li, 2016). In addition, the hardware and software infrastructures used may not keep up with the rapid changes in information technologies and become obsolete after a while. This creates a necessity for institutions to purchase or update hardware and software every time. In this context, cloud computing offers effective and alternative solutions (Sarıtaş and Üner, 2013).

Cloud computing also makes significant contributions to the development of distance education models. One of the benefits of cloud computing in education is massive open online courses (MOOC). Mass open online courses are open to anyone who wants to attend online courses without any fee or participant limit (Kaya, 2015). In recent years, interest in massive open online courses has been increasing (Beştaş, 2017). Higher education institutions benefit greatly from cloud computing to create this structure (Attaran et al., 2017). Tan and Kim (2011) divided the use of cloud computing technology in education into three categories: e-learning, communication and management. According to this; In e-learning, teachers and students can use cloud computing technologies in the management and organization of course contents and collaborative learning. In the communication category of this technology, teachers, students and other stakeholders benefit from cloud computing technologies for e-mail communication and notification management. In the management category, cloud computing technologies are used for student records and human resources management. Agandi (2015) classified the use of cloud computing in teaching activities according to cloud computing service models. In the Software Service (SaaS) model; Students can collaboratively use various software offered by cloud computing, such as word processing, calculation, presentation and simulation, and conduct research. In the Platform Service (PaaS) model; Students studying in the field of information technologies can have a platform where they can develop their own applications. In the Infrastructure Service (IaaS) category; Institutions can provide virtual computers to students according to need and demand. Additionally, the Data Service (Daas) category; It can be used to store materials such as course contents, presentations and exam papers.

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INTERNET OF THINGS IN SCIENCE AND MATHEMATICS EDUCATION

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Abstract

Technological developments create global impacts in different fields such as industry, communication, sociology and education. Rapid developments in information technologies and the evolution of the internet increase the connections between people and devices and allow more devices to access the internet every day. This situation increases the momentum of digital transformation around the world. The recently developed Internet of Things (IoT) technology attracts attention with the benefits it provides and the innovations it brings. IoT technology has offered innovative solutions in many sectors by enabling communication between physical devices and objects connected to the internet. IoT devices can increase efficiency, improve business processes and contribute to smarter decision making. The continuous development of this technology also plays an important role in the education sector.

Key Words: *Science Education, Mathematics Education, Educational Technologies, Internet of Things, Industry 4.0*

Introduction

Today, technology is used effectively in many aspects of human life and offers significant benefits. Science and mathematics education is a field where abstract and complex concepts are frequently discussed, and the use of technology supports the learning processes of students in this field. Technology science (Polat and Yılayaz, 2022a; Polat and Yılayaz 2022b; Çelik, Önal Karakoyun and Asiltürk, 2022; Erbek, Asiltürk and Kahyaoğlu, 2023; and mathematics (Nayiroglu et al., 2021; Tutak and Güder, 2014; Türkdoğan, Baki and Tutak, 2010; Tutak, Nayıroğlu and Özer, 2023; Nayıroğlu and Tutak, 2023) enable

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students to better understand and comprehend information by concretizing, visualizing and simulating abstract concepts.

The continuous development of the Internet and information technologies has strengthened the connection between people and devices and increased the number of devices accessing the Internet day by day. This situation has enabled digital transformation to gain momentum in the world. With this transformation, new technologies have been developed that make human life easier, faster and increase efficiency. One of these technologies is the Internet of Things technology, which has been the center of attention lately. The term Internet of Things was first coined by digital innovation expert Kevin Ashton in 1999. Ashton used this term for connected objects that are compatible with RFID (Radio Frequency Identification) tags (Ashton, 2009). However, thanks to developments in wireless connection technologies, Internet of Things technology has begun to be used in a wider scope and has become one of the popular technologies (Özgül, 2023).

In order to achieve the Education 4.0 vision, it is necessary to develop competencies such as critical thinking, problem solving, analytical thinking, creativity, collaborative work, innovative and production-oriented thinking, which are the skills required by the 21st century. At this point, the use of IoT technology in the field of education is of great importance. Although IoT technology is considered a new phenomenon in the field of education, it is predicted that the increase in studies in this field will bring significant improvements in education systems and the integration of IoT technology in education will be even more valuable in the future. Data collected from IoT devices can be used to improve the management and quality of life of schools. In addition, IoT can also be used to improve the quality of teaching through learner analytics, access information more easily, and personalize learning through smart devices. IoT-based systems in the field of education can be listed as follows: open and distance education systems, security systems, student tracking systems, systems for monitoring physical variables of educational environments, wearable technologies (Aydın, Usanmaz and Göktaş, 2017; Khalil and Özdemir, 2018).

Internet of things (IoT) technology is seen as an advanced technology today, and when applied in science education, it will contribute to students and teachers adapting to new and technological methods and creating the educational environments of the future. In this study, the contents, methods, participants, data collection tools, data analysis methods, effects and results of the Internet of Things (IoT) on science education were evaluated. Additionally, some suggestions are presented for future research on the use of the internet of things (IoT) in science education.

Internet of Things (IoT)

The continuous development of information technologies and the prevalence of the Internet create an experience in the world where every physical device can connect with other devices and the Internet. It can be stated that it is quite difficult to define the Internet of Things technology precisely when evaluated in terms of the areas where it is applied. Because there is still no consensus on what Internet of Things technologies actually include (Vashi, Ram, Modi, Verma, & Prakash, 2017; Wortmann & Flüchter, 2015).

The concept of the Internet of Things (IoT) was first put forward by Kevin Ashton, one of the founders of Massachusetts Institute of Technology (MIT) Auto-ID Labs, during a presentation prepared for the Procter & Gamble (P&G) company in 1999 (Ashton, 2009). . For this reason, although the first use of the Internet of Things concept is attributed to Kevin Ashton, Ashton (2009) actually used this concept to describe connected objects compatible with RFID (Radio Frequency Identification) tags.

When the concept of the Internet of Things (IoT) first came to the fore, it was centered on "Objects". Haller, Karnouskos, and Schroth (2008, p. 15) offered a definition of IoT as "a world where physical objects are seamlessly integrated into the information network and where these objects can be active participants in business processes." Vashi et al. (2017, p. 492) defines it as "a global network of uniquely addressed and interconnected objects based on standard communication protocols" and it is seen that an "object-centered" approach is adopted. The definitions here and many definitions of IoT in the literature clearly reveal a perspective in which objects are essentially represented by RFID tags (Doukas, 2012; Xia, Yang, Wang, & Vinel, 2012).

Sarma and Girão (2009), who want to expand the scope of the definition of IoT, define objects from physical objects to virtual objects and define these objects as identities with internet connection. Physical objects; While we can show examples such as airplanes, automobiles, smartphones, home appliances and industrial systems, we can also count animals, people and buildings among these objects according to their usage areas. We can think of virtual objects as a digital reflection of an object in the real world (human or inanimate, static or moving, concrete or abstract) that is semantically enriched and can have information about its context, analyze and interpret it (Nitti, Pilloni, Colistra, & Atzori, 2015). According to studies in the literature, it appears that there is no standard definition of IoT (Zhang et al., 2014). Because IoT refers to a developing and changing field with many definitions (Minerva, Biru, & Rotondi, 2015). Goumagias, Whalley, Dilaver, and Cunningham (2021) stated that the definition of IoT has changed with the rapid advancement of technology. For this reason, IoT has various definitions with different perspectives. It was stated by Firouzi, Farahani, Weinberger, DePace, and Aliee (2020) that almost all of the definitions for IoT include the following basic features:

- Objects or Devices: Objects in the IoT (smart objects, devices, or endpoints) are connected objects that have the ability to sense, actuate, and interact with other objects, systems, or people. To be a device in IoT, the device needs a processing unit, power supply, sensor/actuator, network connectivity, and a tag/address to uniquely identify it.
- Connectivity: IoT involves connecting objects to the internet or other networks. This means that not only does every IoT device have a connectivity module, but the network and the device must both have a compatible communication protocol.
- Data: It refers to the (big) data obtained from objects in IoT. Information received from IoT devices often includes identifying environmental data and reporting on their status.
- Intelligence: The ability to extract meaningful information from data in IoT is key to realizing the potential of IoT. Here, technologies such as Artificial Intelligence, Machine Learning, and Data Analytics can be used together in IoT systems.
- Action: Indicates automatic actions to be taken by or on the device as a result of intelligence. It also covers the actions of stakeholders in the IoT ecosystem.
- Ecosystem: The objects themselves in the IoT, the protocols they use, the platforms they operate on, the communities involved in the data, and the goals and objectives of the parties involved all constitute the ecosystem.
- Heterogeneity: IoT is expected to consist of heterogeneous devices running on different platforms in different networks. Therefore, all components must be interoperable and have the ability to connect, share and present data in a coordinated manner according to a common reference model.
- Dynamic Changes: The state of devices, the contexts in which they operate, the number of connected devices, and the data they send and receive are all assumed to change dynamically.
- Scaling: The number of connected devices will be at least an order of magnitude larger than the existing connections. Since this will cause a proportional increase in the amount of data produced by the devices, this high density of data needs to be scaled (transferred and analyzed).
- Security and Privacy: It is an indispensable element of IoT. This issue is vital as personal data is accessible online. Ensuring the security and confidentiality of data requires data sovereignty, secure networks, secure endpoints, and a scalable data security plan.

Use of the Internet of Things in the Educational Process

There are some difficulties encountered in the implementation of IoT technology. However, in current research, innovative solutions are being developed to overcome these difficulties (Kim et al., 2022; Wang et al., 2022). In this regard, the use of IoT technology is expected to increase in the coming years (Gartner, 2022; Horizon, 2017; Softtech, 2022). It is seen that NI is applied in different fields today and gives positive results (Al-Fuqaha et al., 2015; Gubbi et al., 2013; HaddadPajouh et al., 2021). In particular, health (Islam et al., 2015; Qadri et al., 2020), logistics (Günay et al., 2021), smart cities (Zanella et al., 2014), agriculture (Al-Garadi et al., 2020) and industry (Manavalan & Jayakrishna, 2019) is used in the fields. One of the areas where IoT technology is applied is education (Zeeshan et al., 2022).

There are various examples in the literature regarding the use of IoT technology in education (Alharbi, 2020; Wang et al., 2021). Educational materials are designed using the IoT infrastructure and these materials are used in education and training processes (Li, 2022). For example, studies are being conducted in which sensors and cards are used as educational tools (Cheng et al., 2020). These instructional tools offer a variety of applications with modules used within the scope of NI (Ahad et al., 2018). In this way, students can find learning opportunities everywhere, especially at school (Abdel-Basset et al., 2018). In addition, the richness of interaction in education and training environments can be increased with materials created using IoT technology (Ullah et al., 2018).

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NUMBER SENSİTİVİTY OF 6TH GRADE STUDENTS[1]

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Abstract

The purpose of this study is to determine the number sensitivity levels of 6th grade students with the Panamath test. The study group consisted of 75 6th grade students. Students were randomly selected from randomly determined classes in a public school. Panamath test program was used to calculate students' number sensitivity. The obtained data were examined by cluster analysis. Additionally, in the cluster analysis, two groups were obtained: lower and upper groups. Finally, suggestions were made that the values obtained for the lower and upper groups in the study could be taken into account, especially in identifying students with mathematics learning difficulties.

Keywords: Mathematics learning disability, Number sensitivity, Panamath test.

Introduction

Mathematics is one of the basic sciences that contributes positively to the development of other sciences, such as acting more consciously in daily life, thinking logically, gaining different perspectives (Kükey & Tutak, 2019). However, there are people who face many problems in daily life due to difficulties in mathematics and have dyscalculia, in other words, difficulties in learning mathematics.

Dyscalculia is a specific type of learning disability that affects our ability to acquire arithmetic skills (Butterworth, 2003) and occurs in approximately 6% of the population (Wong et al., 2017; Shalev & von Aster, 2008). Looking at the term dyscalculia in more detail, dyscalculia can best be defined as a deficit in the representation or processing of numerical information specifically (Landerl et al., 2004).

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If a student who has normal success in courses other than mathematics has difficulty even with ordinary numerical operations and often resorts to finger counting in four operations, you can suspect that these characteristics belong to students with dyscalculia and therefore this student is a student with dyscalculia (Bird, 2017). Chinn (2011) listed the characteristic features of students with dyscalculia as follows; They have difficulty understanding simple number concepts, cannot grasp numbers intuitively, and have problems learning number facts and procedures. Even if they implement a correct answer or use a correct method, they may do so automatically and without confidence.

A diagnosis of dyscalculia should only be made if the individual in question exhibits below-average mathematical performance when viewed in the context of individual history, test findings, clinical examination, and relevant information obtained from further psychosocial assessment. Treatment should be directed to individual math problem areas. Treatment should begin early in the primary school years and be carried out in an individual setting by trained professionals; Attention should also be paid to comorbid symptoms and disorders. Those with dyscalculia are also at increased risk of developing dyslexia. The same is true for attention-deficit/hyperactivity disorder and other mental disorders, both internalizing (such as anxiety and depression) and externalizing (such as disorders characterized by aggression and rule-breaking) (Haberstroh & Schulte-Körne, 2019). Strategies for students with dyscalculia can be listed as computer-assisted learning and teaching materials, scenario booklets, concrete materials, computer games, reward-homework and web-supported application (Baldemir & Tutak, 2022).

It is claimed that problems with the number perception ability given to people at birth cause dyscalculia. It is also suggested that this number perception consists of two subsystems. One of these two subsystems is the approximate counting system, which helps to determine the approximate number of multiplicities, and the other is the exact counting system, which helps to specify the exact number of multiplicities (Mutlu et al., 2017).

The aim of this study is to determine the number sensitivity levels of 6th grade students with the Panamath test.

Method

The study was carried out with the scanning model. The survey model is a research approach that aims to describe a past or present situation as it exists (Karasar, 2010).

Participants

75 randomly selected 6th grade students studying at a public school in Turkey participated in the study.

Data collection tool

Panamath test was used to collect data in the study. In the Panamath test, two quantities of blue and yellow are shown separately or mixed to the individual and the individual is asked which color is more abundant. In each task, the differences between blue and yellow colors are gradually reduced to measure the ability of individuals to discriminate. Thus, when comparing quantities, the criterion obtained by the Weber fraction ratio, which results from determining which number is less or more, gives the sensitivity of number sense (Olkun & Sarı, 2020).

Data analysis

In the Panamath test program, the number of correct answers, average item answer time and weber fraction are automatically calculated by the program. Panamath measures your number sense and approximate number system ability. Recent research has shown a relationship between performance on this test and basic mathematical ability. It also provides some comparison of how your number sense and approximate number system compares to others who have taken the test (Panamath, 2023). The obtained data were analyzed by two-step cluster analysis. Cluster analysis, which is defined as a group of methods used to make predictions about the population in cases where there is no clear information about their classification, is a multivariate statistical analysis technique that allows the researcher to find homogeneous groups of individuals in the data set he is working on and to separate them into clusters that are homogeneous but different from others. The main purpose of cluster analysis is to classify ungrouped data according to their similarities and provide useful summative information (Yılmaz & Patır, 2011).

Findings

Two-step cluster analysis was applied to the data obtained from the participants and the results are presented in Table 1.

Groups	%	n	w
Upper Group	90,7	68	,19
Subgroup	9,3	7	,48

Table 1. Weber fraction averages of the lower and upper groups obtained by cluster analysis

After the cluster analysis, two groups were obtained: the upper group consisting of 68 students with 90.7 percent and the lower group consisting of 7 students with 9.3 percent. While the weber fraction average of the lower group is .48, the weber fraction average of the upper group is .19 (Table 1).

Groups	%	W
Upper Group	90	,17
Subgroup	10	,40

Table 2. Panamath test program lower and upper group weber fraction averages

The values we obtained regarding the Weber fraction after the cluster analysis can be compared with the average of eleven-year-old children in the Panamath program. In the Panamath program, the average weber fraction of the bottom 10% group is .40, while the average weber fraction of the top 90% group is .17 (Table 2).

Conclusion

As a result of the cluster analysis performed in the study, two groups were obtained: lower and upper groups. While the average weber fraction in the lower group of 9.3% was .48, the average weber fraction of the upper group of 90.7% was determined to be .19.

The values obtained for the lower and upper groups resulting from the average of the Weber fraction can be used especially in the process of identifying students with mathematics learning difficulties (Mutlu et al., 2017). Research has shown that the average Weber fraction predicts how well students perform in mathematics (Libertus et al., 2013). It also appears that approximate number system sensitivity is impaired in children who have difficulties in learning mathematics. This is not the case for average or high achieving children (Mazzocco et al., 2011).

Suggestions

- Students' number sensitivity can be learned with the panamath test.

- Panamath test can be used to identify students with mathematics learning difficulties.

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ARTIFICIAL INTELLIGENCE SUPPORTED LEARNING AND EXAMPLE APPLICATIONS IN SECONDARY SCHOOL MATHEMATICS EDUCATION

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Abstract

Technology has become an indispensable element of our rapidly changing and developing world and has had a great impact in every field. Education and training have transformed and developed under the influence of this technological progress. Especially recently, artificial intelligence applications have come to the fore, allowing everyone to access their interesting content without any space or time limitations. In addition, artificial intelligence applications for mathematics education have become an attractive tool and it is obvious that they will develop further in the future. With a student-focused teaching approach, easy availability and access to artificial intelligence applications in mathematics education is an important development. The main purpose of this study is to examine in depth the literature on artificial intelligence applications used in mathematics education and to present existing data on the use of these tools. The literature review aims to provide researchers with a valuable data source for new studies in this field and aims to contribute to new research.

Key Words: *Artificial Intelligence Applications, Mathematics Education, Technology*

Introduction

Mathematics is an indispensable part of modern society; Mathematical knowledge and skills are required in many fields, from science to art, from engineering to economics. However, learning math is not always easy. Students may encounter various difficulties, lose motivation, or have difficulty understanding the topics. Therefore, the use of technology in mathematics education is an important opportunity. Technology can help students learn mathematics in a more engaging, meaningful and fun way. For example,

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technologies such as computer games, virtual reality, and artificial intelligence allow students to discover, apply, and develop mathematical concepts (Heid, 1997). Technology has great potential to increase students' understanding, mathematical skills and interest. NCTM (2015) emphasizes that in order to make the most of this potential, the opportunities offered by technology should be used effectively in education. MEB's Secondary Education Mathematics Curriculum (2018) envisages the use of technology to improve students' mathematical and digital competencies. The program includes examples and explanations of the use of tools such as dynamic mathematical software and information and communication technologies. Mathematics books approved by the Ministry of Education also include activities for the use of technological tools such as graphic drawing programs. Thanks to these activities, students can more easily draw graphs, manipulate variables, and discover relationships between graphs. In this way, mathematics teachers should create technology-enriched learning environments and support students in developing their mathematical thinking and problem-solving skills.

Aim

The aim of this study is to examine and highlight the literature on artificial intelligence applications in mathematics education.

Method

This study was prepared to examine the literature on artificial intelligence applications in mathematics education. Therefore, a literature review was conducted in this study. In this study, the data in the literature were described and evaluated in detail.

Artificial Intelligence Technology in Education

Over the last two centuries, research in education has focused on concepts such as e-learning, distance education, web-based learning, flipped classrooms, online education, artificial intelligence, etc., trying to support or replace traditional face-to-face education. However, research on online education before the Covid-19 pandemic increased rapidly after the pandemic and contributed to a deeper understanding of this new classroom culture (Albrahim, 2020; Murphy, 2020; Noor, Isa and Mazhar, 2020). Educators and researchers have gained a theoretical understanding of e-learning approaches and have addressed the skills and knowledge that these new learning environments require for teachers and students. While traditional classroom environments are expected to transform into digital classrooms in the future, the pandemic seems to have accelerated this transformation. In the past, it was considered sufficient for the teacher to talk in the classroom and the students to just listen. However, today, with the spread of digital technologies, students now have the opportunity to learn interactively (Poçan, 2023).

It is not possible for an artificial intelligence system to learn anything without a program (Kaku, 2016). In addition, although artificial intelligence consists of very complex programs, it is not designed as complex and superior as the human brain, which has intelligence (Çelebi and İnal, 2019). From Edward Fredkin's perspective, there are three major events in history that are noteworthy. First comes the formation of the universe, then the beginning of life, and ultimately the emergence of artificial intelligence. Based on this statement, the potential of artificial intelligence may be beyond human imagination. This rapidly advancing technology can greatly improve learning processes by providing new opportunities and solutions in the field of education. Tekgüç and Adalıer (2019) mentioned that teachers should use artificial intelligence technologies to structure the appropriate learning process by accurately analyzing the preferences and needs of each student.

Use of Artificial Intelligence Technology in Mathematics Education

An interest in learning mathematics is vital in students' education; however, for many educators this remains a challenge. Students often have difficulty relating it to mathematics, perceiving mathematics as an abstract and difficult to understand subject. This can lead to emotional reactions such as apathy, frustration, and even anxiety, making learning even more difficult. One solution to overcome this problem is the effective use of technology in mathematics education. Technology can provide students with opportunities to better understand math concepts and increase interest in math. The development of digital technologies in mathematics education will be shaped by adopting an approach that takes into account students' different learning styles. In this context, it is extremely critical for teachers to develop their skills in using technological tools effectively and successfully integrate these tools into their lessons. Because the use of digital technologies in mathematics education has great potential to improve students' mathematical abilities and understanding. Effective use of technological developments that support traditional learning by teachers and educational institutions helps students develop mathematical thinking skills (Poçan, 2023). It also provides opportunities for collaborative problem solving, feedback, and personalized learning, allowing students to develop math skills in a way that suits their needs. By leveraging technology in mathematics education, educators can help students overcome math challenges and equip them with the skills they need to succeed in the 21st century.

It is known that there are many different technology tools that educators can use to enrich students' mathematics learning. With these tools, educators can provide students with a more immersive and interactive mathematics learning experience that encourages curiosity, creativity, and critical thinking.

Artificial Intelligence Supported Learning and Sample Applications in Mathematics Teaching

Desmos

Desmos is a platform that enriches the online mathematics learning experience with the advantages it offers for students and educators. Here are some of these advantages:

1. Ability to provide real-time feedback and visual mathematical representations that facilitate understanding and learning.
2. Customizable features that allow educators to create engaging activities and assessments that they can customize.
3. Students can access Desmos from any device, only with an internet connection.
4. Interactive and collaborative activities that encourage student participation and problem-solving skills.
5. Seamless integration with popular learning management systems such as Google Classroom and Canvas, making it easier for teachers to manage and grade assignments.

Educators have reported that the use of Desmos engages student interest and positively impacts mathematics learning outcomes. Activities such as graphing calculators, simulations, and interactive tutorials that Desmos offers provide a highly effective and versatile tool for enhancing mathematics education. Figure 1 shows an example visual of the Desmos application.

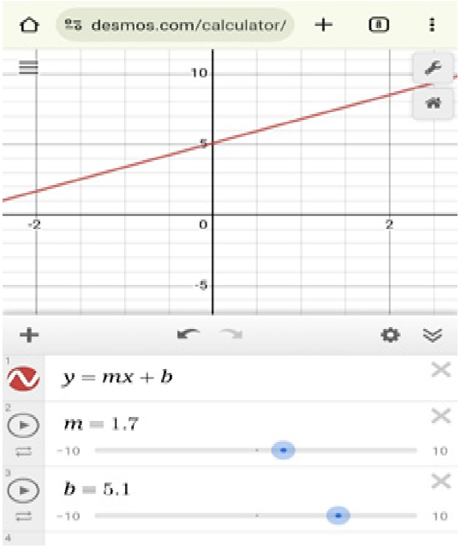

Figure 1. Sample Content for Desmos Application

Mathway

Mathway is an online math tool that helps solve arithmetic problems by providing step-by-step solutions. The advantages of Mathway in mathematics education are as follows:

1. Real-time feedback and prompts help students learn to solve math problems independently.
2. Offers a wide range of mathematics, from basic arithmetic to advanced calculations.
3. It can be accessed from any device with an internet connection, so students can work on math problems at any time and place.
4. It offers engaging and interactive features that make learning math more fun.
5. Useful for students who do not need traditional classroom instruction or need extra support.

Mathway helps students better understand math concepts and improve their problem-solving skills. Educators can provide personalized support to their students by creating specific math problems and assignments. Overall, Mathway is a useful math technology tool to make math learning more effective and engage students. Figure 2 shows an example visual of the Mathway application.

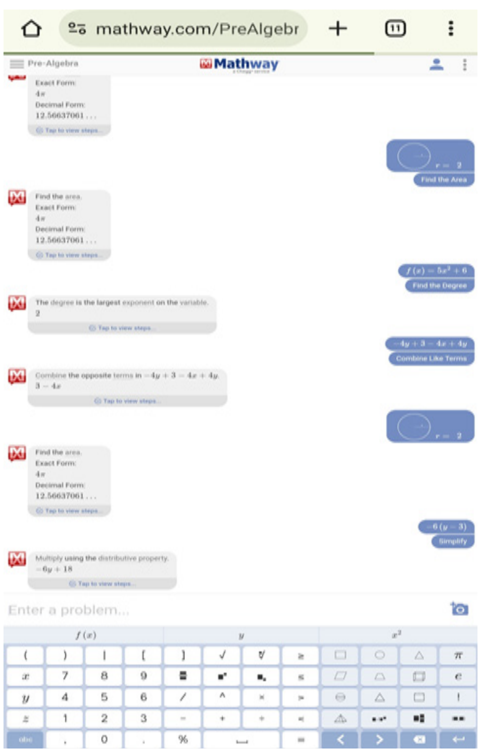

Figure 2. Sample Content for Mathway Application

Mathigon

Mathigon is an online platform that stands out as the textbook of the future for secondary school mathematics education. Some of the advantages of using Mathigon in mathematics education are:

1. Contents with multimedia features, including interactive textbooks, support a better understanding of mathematical concepts such as videos, animations and simulations.
2. Educators can use customizable elements to design engaging activities and assessments.
3. Easy access from any device with an internet connection gives students the ability to study math whenever and wherever they want.
4. It personalizes learning mathematics by providing appropriate content for students of different subjects and levels.
5. Includes puzzles and challenges to help develop critical thinking and problem-solving skills.

Mathigon is a platform used as an innovative tool to improve mathematics education. Educators have successfully used Mathigon to engage students, stimulate their curiosity, and improve math learning outcomes.

In addition, textbooks called Math Techbook, developed by Discovery Education, offer multi-module content suitable for different student levels. These contents work in harmony with the "Mathigon.org" site, which offers interactive and personalized online content equipped with web 2.0 tools to support mathematics learning. These projects and related research show that improvements are needed to align existing mathematics textbooks with e-learning environments and meet student needs.

Some suggestions to make textbooks more useful in e-learning environments: Providing content that suits the current needs of students (for example, video-supported lectures or exam preparation contents), increasing the interaction capacity (for example, the applicability of e-learning activities), easily integrating digital contents. (for example, QR codes for the use of web 2.0 tools) and supporting textbooks with flexible writing and note-taking tools. Figure 3 shows an example visual of the Mathigon application.

Figure 3. Sample Content for Mathigon Application

Khan Academy

Khan Academy stands out as an online platform that offers free math resources and educational videos. Some of Khan Academy's contributions to mathematics education are listed below:

1. A large library of mathematics resources covers different topics and levels, providing students with a wealth of resources.
2. Provides personalized feedback and support thanks to learning features that can be customized to students' needs.
3. Khan Academy can be easily accessed from anywhere in the world from any device with an internet connection, providing students with flexibility.
4. Compatibility with widely used learning management systems provides convenience for teachers to manage and evaluate student work.
5. Gamification features make learning more fun by increasing student participation and motivation.

Educators have reported that Khan Academy engages students, improves math learning outcomes, and provides students with personalized learning experiences. Examples of Khan Academy's activities include interactive exercises, video lessons, and virtual tutoring sessions. Overall, Khan Academy is a valuable resource for enhancing mathematics education, especially for students who do not have access to traditional classroom resources. Figure 4 shows an example visual of the Khan Academy application.

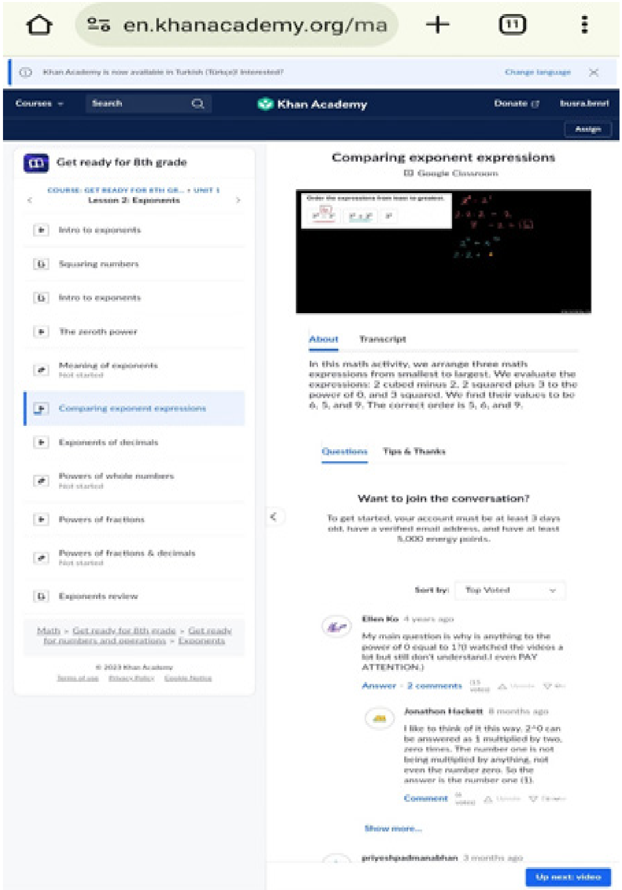

Figure 4. Sample Content for Khan Academy Application

GeoGebra

GeoGebra is an important mathematical tool that contributes to mathematics education by combining geometry, algebra and calculus on a single platform. Some advantages of using GeoGebra in mathematics education are:

1. Visualization of mathematical concepts through graphs, 3D models and other interactive tools
2. Offering teachers flexible settings to develop engaging lessons and tests for students
3. Students can use GeoGebra on any device with an internet connection
4. Compatibility with well-known learning management systems, facilitating teachers' course management and grading processes
5. Sharing ideas, resources, and feedback through a supportive community of educators and students

Examples of GeoGebra activities include learning experiences such as creating dynamic math simulations, exploring geometric shapes, and solving complex algebraic equations. According to many educators, GeoGebra is used effectively to increase students' interest in mathematics, improve mathematics learning outcomes, and assist in deeper understanding of mathematical concepts. Figure 5 shows an example augmented reality visual made in GeoGebra.

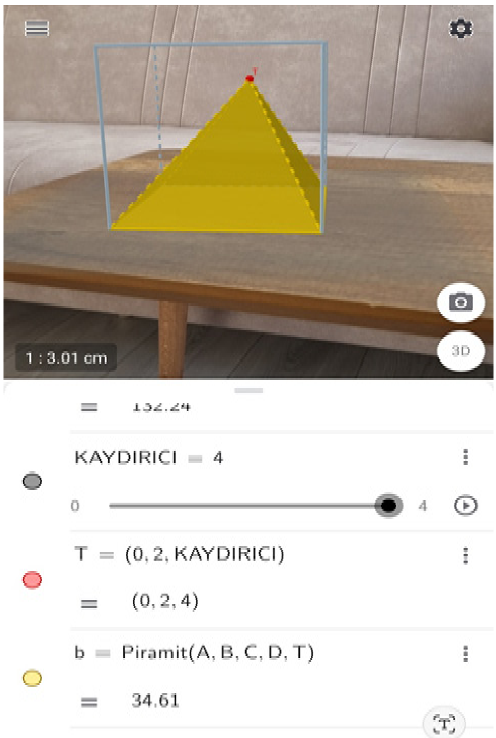

Figure 5. Example of Augmented Reality in Geogebra Application

Result and Suggestion

Integrating technology into mathematics education can be a highly effective tool to engage students and encourage active learning. Below are some suggestions and strategies for using math technology tools effectively.

1. Set specific learning goals and align technology-based activities with those goals.
2. Provide adequate training and support to both students and educators to successfully implement technology-based activities.
3. Encourage collaboration and active learning by including interactive and group work in mathematics lessons.
4. Encourage exploration and experimentation with math concepts through simulations and visualizations.

5. Use technology-based assessments to track student progress and provide targeted feedback and support.
6. Regularly evaluate the effectiveness of technology-based activities and make adjustments to align these activities with student needs.

By following these best practices, educators can successfully integrate technology into mathematics education and create engaging and effective learning experiences for students. In conclusion, technology is a powerful tool that contributes to mathematics education, and mathematics technology tools offer unique benefits and functions to students. Educators can create a more effective and engaging learning experience for students by using technology in mathematics education. This may be particularly useful for students seeking additional support and guidance through their mathematics course.

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NEW APPROACHES IN TEACHING MATHEMATICS WITH ARTIFICIAL INTELLIGENCE SUPPORTED MBLOCK

Büşra NAYIROĞLU[1], Tayfun TUTAK[2]

Abstract

Artificial intelligence-supported mBlock tool is a software with a block-based programming structure. Since it is compatible with Arduino, Makeblock, mBot and other robotic products, users can design and program their own robots. Additionally, mBlock offers coding blocks for AI projects. In this way, users can benefit from cognitive services such as text-to-speech, translation, machine learning and artificial intelligence service. With mBlock in mathematics learning, it is possible to discover, apply, solve and evaluate mathematical concepts, create games and simulations, enrich and personalize learning, and develop creativity and innovation in teaching. The aim of this study is to reveal how artificial intelligence-supported applications are made in mathematics learning with mBlock, what advantages and disadvantages they have, what learning outcomes they contribute to and what suggestions can be made. The literature review aims to provide researchers with a valuable data source for new studies in this field. This study aims to contribute to new research.

Keywords: *mBlock, Artificial Intelligence Applications, Mathematics Teaching, Technology*

Introduction

Mathematics is one of humanity's oldest and most universal branches of science. Learning mathematics helps students develop skills such as logical thinking, problem solving, creativity and critical thinking. However, mathematics education has to adapt to today's rapidly changing and developing technological environments. Technology offers both new opportunities and new challenges in teaching mathematics. Therefore, it is necessary for mathematics teachers to effectively integrate technology into mathematics education to

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increase students' mathematics learning and achievement.

One of these approaches is artificial intelligence-supported mathematics teaching. Artificial intelligence (AI) is a branch of science that enables computer systems to perform functions such as perception, learning, decision-making and problem solving by imitating human intelligence. AI also offers many opportunities and potential in the field of education. In particular, AI-powered tools allow students to have a customized and personalized learning experience based on their individual learning needs, interests, and learning styles.

Mblock is an AI-powered programming tool. While Mblock teaches students coding with a Scratch-based block programming language, it also introduces them to subjects such as artificial intelligence, internet of things, robotics and electronics. Mblock allows students to create creative and innovative products by designing their own projects.

Mblock is a Scratch-based programming tool. Artificial intelligence supported mblock is the enriched version of mblock with artificial intelligence modules. By using these modules, students can learn mathematical concepts, problems and algorithms in an easier and more fun way.

Aim

The purpose of this study reflects the potential of mBlock in mathematics teaching, its usage areas by examining the literature, and the aim of creating a framework for future research in this field.

Method

The method of this study was described and evaluated in detail and the data in the literature examining artificial intelligence-supported applications in mathematics learning with mBlock.

What is Mblock and How Does It Work?

Mblock is a Scratch-based programming tool. Scratch is a visual programming language and environment developed by the MIT Media Lab that allows students to create animations, games, stories and interactive projects using blocks of code. Mblock includes all the features that Scratch offers, while also being extended to be compatible with Arduino, micro:bit, Makeblock and other hardware devices. Mblock allows students to develop their coding skills while also making creative projects related to STEM (Science, Technology, Engineering and Mathematics) subjects.

While it teaches students basic programming concepts through a block-based programming interface, it also offers the opportunity to interact with physical devices. It provides a user-friendly interface for beginners and is often used in the development of educational robots that can be easily assembled and programmed (Evripidou et al., 2020). In a study by Duran (2022), an educational robot was developed using the mBlock extension, allowing the robot to be programmed without the need to upload programs to Arduino and to work with its own firmware in mBlock Scratch mode.

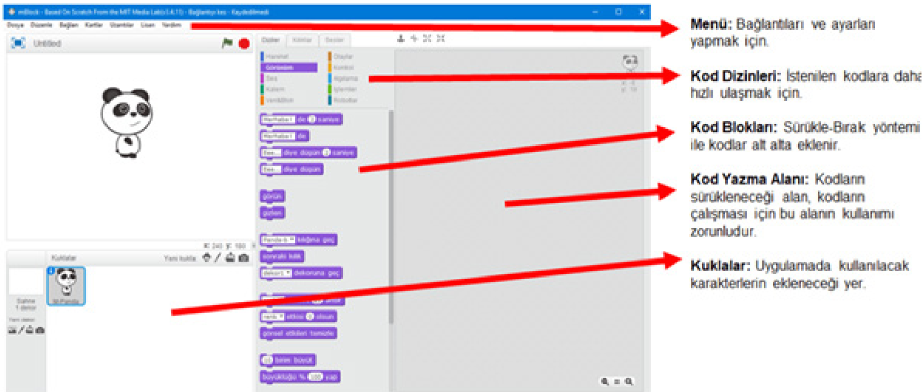

Figure 1. mBlock Interface Overview (URL1).

Open source tools such as mBlock are designed to be simple and used for robot programming, making them suitable for educational purposes (Barisic et al., 2018). Additionally, the mBlock platform is often used with hardware such as Arduino that can be programmed using block-based coding. This combination allows the development of educational robots that can be easily programmed and modified to create robots of different shapes (Evripidou et al., 2020). The mBlock platform's compatibility with Arduino and its block-based programming approach make it a valuable tool for teaching STEM skills, especially in the context of educational robotics.

mBlock is a block-based coding platform widely used in educational robotics for programming robots. It provides a user-friendly interface and is often used with hardware such as Arduino. Its compatibility with Arduino and its block-based programming approach make it a valuable tool for teaching STEM skills, especially in the context of educational robotics.

Exploring and Applying Mathematics Concepts with Mblock

Mblock can be used as an effective tool to explore and apply mathematical concepts within STEM education. mBlock can facilitate the understanding of abstract mathematical concepts by providing students with the opportunity to concretize and visualize mathematical concepts. Using mBlock's interactive features, students can solve mathematical problems and learn concepts by trying them out. In a study conducted by Numanoğlu and Keser (2017), it was stated that the use of robots in programming teaching helps concretize abstract concepts and is effective in developing students' problem solving and computational thinking skills. In addition, programmable robots developed by

Hsieh (2021) attract attention with their customizable structures for STEAM education.

Mblock can be integrated into STEM education by providing students with the opportunity to explore and apply mathematical concepts. Students can experience abstract mathematical concepts in a concrete way through programmable robots and thus improve their mathematical skills. In this context, the use of mBlock in mathematics teaching has the potential to strengthen students' mathematical thinking skills. In light of this information, it can be said that mBlock is an effective tool in STEM education to explore and apply mathematical concepts. mBlock, which allows students to strengthen their mathematical thinking skills while improving their programming skills, can contribute to teaching mathematics in STEM education.

Solving and Evaluating Mathematics Problems with Mblock

Mathematics can sometimes be a scary and challenging subject for students. However, with the impact of technology in education and the use of programs such as Mblock, students can be supported to develop their skills in solving mathematical problems. mBlock's interactive nature allows students to solve mathematical problems and then analyze these solutions. This process can improve students' problem-solving skills while also strengthening their mathematical thinking and analytical abilities.

Studies conducted by Mason (2003) and other researchers provide important insights into understanding students' beliefs about mathematical problem solving. Villeneuve et al. (2019) emphasized an integrated approach by examining the relationships between cognitive ability, mathematical calculation and mathematical problem solving. This approach can provide an important framework for understanding how students use their cognitive processes when addressing mathematical problems.

Studies on associating Mblock with mathematics education have provided insight into teachers' attitudes towards mathematical problem solving (Mršnik et al., 2023). Teachers' guidance and training on how to use Mblock can play an important role in improving students' mathematical problem-solving skills. Skvortsova et al.'s (2021) study examined the differences between students with mathematical learning difficulties and those who successfully solved mathematical word problems. This study may offer clues about how Mblock can be used to support students with different learning needs. Roy & Roth's (2018) study showed that Mblock was effective in improving declarative knowledge and problem-solving skills in mathematics. This finding may inspire teachers and educators on how Mblock can be used in mathematics learning.

The visual programming interface offered by Mblock can enable students to see and solve mathematical problems in a more concrete way. Using this tool, students can improve their problem-solving skills, learn algorithmic thinking, and gain a deeper understanding of mathematical concepts. Future research on the use of Mblock in the process of students solving mathematics problems may help us better understand the effects of the integration of learning technologies and programs into mathematics education on student achievement.

As a result, tools like Mblock can enable students to think creatively when solving math problems, improve their problem-solving skills, and strengthen their relationship with mathematics. Educators and researchers more effectively integrating such technological tools may have the potential to have a positive impact on mathematics learning.

Creating Math Games and Simulations with Mblock

Mathematics can be an enjoyable way to learn and teach with mBlock. mBlock allows students to visualize, manipulate and explore mathematical concepts, operations, functions, shapes, patterns, probabilities and statistics with blocks of code. By creating math games and simulations with mBlock, students can develop skills such as mathematical thinking, problem solving, logical reasoning, abstraction, generalization and creativity. They can also gain 21st century skills such as collaboration, communication, critical thinking and reflection by sharing math games and simulations with mBlock. mBlock provides students with the opportunity to learn math concepts in a fun way. Students can direct their own learning process by creating games and simulations and interact with other students by sharing these mathematical contents.

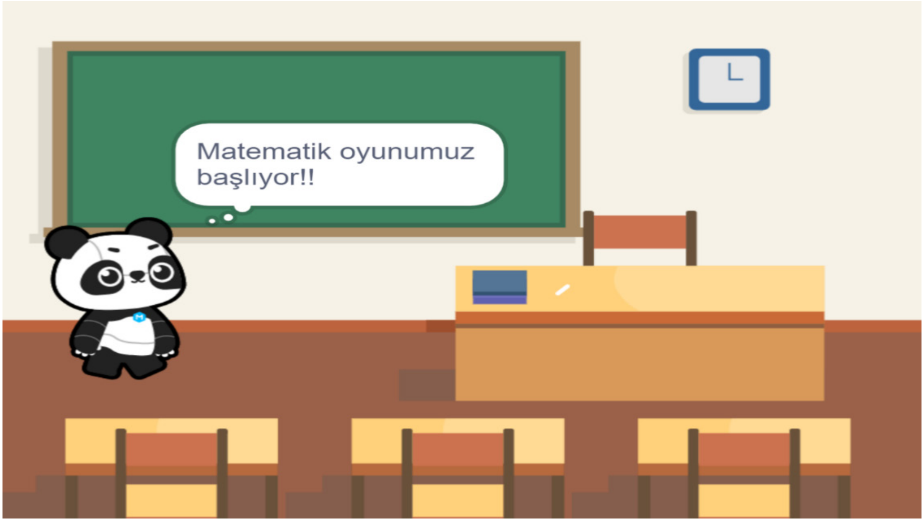

Figure 2. Stage example based on codes with Mblock

Games and simulations in mathematics teaching can offer advantages such as increasing student participation, making learning fun, and concretizing abstract mathematical concepts. There are many studies in the literature on the pedagogical results of using game and simulation-based approaches in Mblock's mathematics teaching.

Ke & Grabowski (2006) investigated the effects of gaming on fifth grade students' mathematics performance and attitudes. In the study, students were divided into three groups: gaming group, non-gaming group and control group. The gaming group played math games created with Scratch. The non-gaming group used printed materials containing the same mathematical content. The control group continued their regular mathematics lessons. As a result of the study, it was found that there was a significant increase in the mathematics performance and attitudes of the game-playing group compared to the non-game group and the control group. This result shows that playing games is a tool that supports and motivates mathematics learning.

Koparan (2019) examined the effect of a learning environment supported by games and simulation on probability teaching. In the study, 8th grade students were divided into two groups: experimental group and control group. The experimental group learned about probability using games and simulations created with Mblock. The control group learned the subject of probability using traditional methods. As a result of the study, it was found that the experimental group's probability success and attitudes were significantly higher than the control group. This result shows that games and simulations are effective methods in teaching probability.

This (2019) aimed to understand and explore a classic problem called Ducci's Four Number Game using mobile simulation. Ducci's Four Number Game can be defined as starting from a four-digit number, obtaining two new numbers by ordering from largest to smallest and smallest to largest, subtracting these two numbers from each other and repeating this process to reach the number 6174. In this study, students tried to solve this problem using a mobile simulation created with Mblock. As a result of the study, it was determined that simulation was useful in students' problem solving processes and helped them understand the problem, explore it and find solutions.

Trinter et al. (2015) conducted a research project to design and implement differentiated mathematics games. In this project, students designed math games with Scratch and shared them with their friends. It was observed that students applied mathematical concepts, skills and strategies, thought creatively and critically, collaborated and reflected during the game design process. In addition, it was observed that the students reinforced their mathematical learning, were challenged, had fun and became self-confident in the process of playing games.

These studies reveal that creating and sharing mathematics games and simulations with Mblock contributes to students' mathematics learning, positively affects their mathematics performance and attitudes, improves mathematical thinking and problem-solving skills, and provides them with 21st century skills. Therefore, creating and sharing math games and simulations with Mblock is an effective and fun method that can be used in teaching math.

Enriching and Personalizing Mathematics Learning with Mblock

Nowadays, the role of technology in education is increasing and personalized learning experiences are gaining importance in order to meet the individual needs of students. In this context, the flexible structure of the platform called mBlock allows students to personalize their mathematics learning and customize it according to their interests. Research shows that students' individual needs shape adaptive learning spaces and provide a significant opportunity for technology-supported personalized learning (Psyché et al., 2019).

The active participation provided by mBlock in shaping students' learning experiences can significantly increase participation and performance, especially in augmented reality learning environments (Weerasinghe et al., 2022). This participation allows students to be actively involved in personalizing their mathematics learning. The creation of personalized learning activities and units in mathematics can be facilitated through a variety of probabilistic methods, combined with the flexibility offered by mBlock, to support learning experiences specific to individual students (Kurilova and Kurilovas, 2016). This approach is aligned with the aim of enriching mathematics learning with mBlock by emphasizing the suitability of learning activities to students' specific needs and preferences. Additionally, the effectiveness of adaptive learning platforms with personalization components such as machine learning has the potential to optimize learning processes (Biletska et al., 2020). In this context, mBlock's integration with machine learning algorithms may offer a more effective method of personalizing mathematics learning by meeting the specific learning needs of each student.

As a result, the integration of mBlock into secondary school mathematics instruction has the potential to encourage students' proactive engagement, enhance personalized learning activities, and enrich learning experiences using the personalization components of machine learning. These approaches are geared towards the goal of providing authentic and personalized mathematics learning experiences for students using mBlock.

Developing Creativity and Innovation in Mathematics Teaching with Mblock

Technological tools play an important role in mathematics teaching by allowing students to think creatively and produce innovative solutions. In this context, the platform called mBlock helps students come up with original ideas by giving them the opportunity to transfer mathematical concepts into practical applications and use their creativity. The benefits of mBlock in teaching mathematics are great in terms of improving students' understanding of mathematical concepts, problem solving and creative thinking skills. However, in order for this benefit to be fully realized, prospective teachers' concerns and beliefs about mathematics teaching should be taken into account. Başpınar and Peker's (2016) study revealed that prospective teachers' concerns about mathematics teaching had a significant connection with their beliefs about learning and teaching mathematics. Therefore, analyzing the relationship between teacher candidates' anxiety in mathematics education and their competence in mathematics education is important in terms of creating effective methods that support creativity and innovation in mathematics teaching.

The knowledge transformation of mathematics teacher candidates also has an important place in this context. For example, Mutlu and Paksu's (2022) study aimed to examine the change in the knowledge of secondary school mathematics teacher candidates who were involved in the professional development process about division by fractions. Such research can provide important information about the knowledge transformation necessary to foster creativity and innovation in mathematics education. Additionally, understanding mathematics students' beliefs about the nature and teaching of mathematics is important for bringing innovative approaches to mathematics education. Arabacı et al. (2022) study investigated the relationship between mathematics education undergraduate students' beliefs, academic achievements and gender. Such studies are valuable in understanding the understanding of belief systems in mathematics education and how these beliefs affect teaching methods. However, it is important to include creative thinking and innovation in the mathematics education curriculum in higher education, especially in the context of undergraduate business programs (Yaman and Esen, 2021). This inclusion aims to increase the practical applications of mathematics teaching and students' ability to develop creative solutions.

Finally, the impact of mathematics self-efficacy on anxiety related to mathematics teaching is also important. Research has shown an inverse relationship between math self-efficacy and math anxiety; This indicates that self-efficacy beliefs are important in promoting effective mathematics teaching by reducing anxiety (Ural, 2015). As a result, when evaluating the possibility of mBlock to increase creativity and innovation in secondary school mathematics teaching, the anxiety levels, beliefs, knowledge transformations and self-efficacy of prospective teachers should not be ignored. Taking these elements into consideration can contribute to the development of more effective and student-centered approaches in mathematics education.

Conclusion and Recommendations

Mblock stands out as an important tool in the context of STEM education and especially mathematics teaching. While it provides students with coding skills, it also provides the opportunity to concretize, visualize and apply mathematical concepts in practice. This platform allows students to increase their creativity, problem-solving abilities and original thinking abilities while improving their skills in solving mathematical problems.

Providing the opportunity to explore and learn mathematical concepts through games, simulations and applications can increase students' participation and interest in mathematics education. In addition, creating personalized learning experiences according to the individual needs of students becomes possible with the flexible structure of technology and the opportunities offered by mBlock.

However, in addition to the role of technology in mathematics teaching, the education of prospective teachers, teachers' beliefs about mathematics teaching, and students' mathematical self-efficacy should also be taken into consideration. It is important to take these elements into consideration for a student-centered and effective mathematics education.

As a result, tools like Mblock can help students improve their mathematical thinking skills by providing innovative and effective methods of teaching mathematics. However, it is important to integrate the use of these technological tools with teacher training, student needs and pedagogical assessment to create an even greater impact in mathematics education.

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REVIEW OF MEASURING TOOLS USED IN EDUCATION

Ebru KORKMAZ[1], Mehpare GÖNÜLDAŞ[2], Tayfun TUTAK[3]

Abstract

The aim of this study is to explain what traditional measurement and evaluation methods and alternative measurement and evaluation methods are and to determine their advantages and disadvantages. In this study, studies in DergiPark and Yök Tez databases were examined, case study, one of the qualitative research methods, was used and the data was analyzed with the content analysis method. In the study, traditional and alternative measurement and evaluation methods are explained and their limitations are mentioned. As a result, although alternative measurement methods are much more effective for student development than traditional methods, it has been determined that their frequency of preference is low due to reasons such as class size, financial difficulties, student proficiency level, student readiness level and incompatibility with central exams. In addition, although traditional methods do not adapt to student-centered learning environments, they are still widely used for reasons such as easy application in crowded classes, time and financial savings, compatibility with central exams and familiarity. In order to ensure balance between methods, it is recommended to develop constructive studies on class sizes and compatibility with central exams.

Key Words: *Traditional measurement, alternative measurement, written probe, oral probe project task, performance task.*

Introduction

Human beings have been in constant development and change since their existence. The past centuries have always forced humans to renew and develop. During these processes, there have been significant changes in the field of technology and science. These changes have required renewal, especially in the field of education (Şahin, & Kaya, 2020).

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Measurement has an important place in all fields of science. The importance of measurement in science is related to the validity and reliability of measurement results. Measurement results are used in the decision-making process in the field of education (Baykul, 2000). Decisions such as the effectiveness of the education system and the success of students are possible through evaluation (Baykul & Turgut, 2012). For this reason, measurement and evaluation are one of the most important parts of education.

People who can adapt to the requirements of the new world order and understand the living conditions of this order can only be raised through education. They are educational programs that organize the education and training process. The program consisting of all learning-based activities to be implemented within the educational programs is called the curriculum (Varış, 1988).

One of the basic elements of education and training is measurement and evaluation. The purpose of measurement and evaluation in education is to get to know the student in education and training, to place the student in a program according to his/her situation, to identify the missing or disrupted aspects of education and training and to take the necessary precautions (Bektaş & Kudubeş, 2014).

The four basic elements of training programs are; target, content, teaching learning processes and measurement and evaluation. These four processes proceed in harmony and interactively with each other. A change in teaching-learning processes affects all elements (Demirel, 2009; MEB, 1972). Adopting a constructivist approach in teaching and learning processes has necessitated the adoption of new measurement and evaluation methods in the field of measurement and evaluation (Şahin & Ersoy, 2009). We can examine measurement and evaluation methods under two general headings: traditional measurement and evaluation and alternative measurement and evaluation. The main techniques used in traditional measurement and evaluation methods are;

ϖ Written exams

ϖ Oral exams

ϖ Multiple choice tests

ϖ True or false tests

ϖ Short answer tests

ϖ Paired tests

Traditional measurement and evaluation methods are result-oriented measurement methods that are used to measure simple level learning, are based on getting a lot of information in a short time, reveal learning based on memorization through paper and pencil, are learner-centered, do not take into account feelings, thoughts and personal differences, and cannot measure the process (Buldur, 2009; Köklükaya, 2010).

The traditional understanding of education has been replaced by contemporary, innovative and developmental education programs in recent years. This understanding of education is an understanding in which how the student learns is as important as what he learns, the process is as important as the result, and personal differences are taken into account. For this reason, it has become necessary to use different methods in the measurement and evaluation phase. (MEB, 2017). These methods are alternative measurement and evaluation methods. The main ones are;

ϖ Portfolio

ϖ Project

ϖ Performance evaluation

ϖ Self-assessment

ϖ Peer review

ϖ Structured grid

ϖ Diagnostic branched tree

ϖ Concept maps

ϖ Concept network

ϖ Word association

ϖ Observation and interview

Aim

The aim of this study is to examine the measurement and evaluation methods used in education under the main headings of traditional measurement methods and alternative measurement methods, to explain how and where they are used, and to analyze and present their advantages and disadvantages through studies.

Method

Model of the research

In this research, a case study, one of the qualitative research types, was used because it was aimed to describe how measurement and evaluation in education are, how traditional measurement and alternative measurement methods are used, and to interpret the existing situation. The collected data were analyzed using the content analysis method.

Findings

In this part of the research, traditional measurement and evaluation and alternative measurement and evaluation methods, their features, purposes of use, advantages and disadvantages are mentioned.

Traditional Measurement and Evaluation Methods

1. Written exams

Written exams are exams in which the student presents his knowledge and skills in sentences designed by himself. In these exams, the answers to the questions are not presented to the student in any way or they are not made to choose among possible answers. While answering the question, the student must compile and organize his own information and create the answer himself. Among traditional measurement methods, it is a method that measures high-level skills, develops the student's creativity, and allows measurement at the analysis and synthesis (creation) levels in Bloom's taxonomy (Tekin, 2004).

Advantages of written exams:

ϖ It is easy to prepare so it is a useful measuring tool.

ϖ Since the student designs and presents the answer himself, it is suitable for measuring high-level skills.

ϖ Since it is not based on choosing among the possible answers to the question, the chance success rate is zero, therefore it is a safe measurement tool.

ϖ Improves the ability to use written language.

ϖ It provides the student with the opportunity to give independent and creative answers.

Disadvantages of written exams:

ϖ Since it does not allow asking too many questions, not every learning outcome can be tested, therefore its content validity is low.

ϖ When evaluating written exam results, evaluators cannot apply a standard evaluation, therefore it is not objective.

ϖ Non-attainment factors such as page layout and text beauty may be included in scoring, which reduces reliability.

ϖ It is difficult to score, making it an impractical tool.

2. Oral exams

It is the first type of exam used in education. It is an exam in which questions are generally asked orally and answers are given orally (URL 2). Features of oral exams:

ϖ It is the most effective method to measure language and speaking skills.

ϖ It allows measuring the knowledge of students, especially those who have various limitations in writing.

Although it has advantages in this regard, it is a type of exam that generally has various limitations in terms of measurement.

ϖ It takes a long time because it requires preparing and listening to different questions for each student. In this respect, it is a useless type of exam.

ϖ The respondent cannot change, edit or check his answers.

ϖ Personal differences such as excitement, inability to speak in front of a person, ability to use language affect the measurement, in this sense, the reliability of measurement is low.

ϖ It does not provide the opportunity to think about the questions sufficiently.

3. Multiple Choice Tests

In multiple choice tests, the correct answer to the question is given to the student along with other options that do not answer the question. What is expected from the student is to find and mark the correct or most correct answer to the question among the options. It does not provide the student with the opportunity to create an original answer, but requires choosing among existing answers (Tan, Kayabaşı & Erdoğan, 2002).

Advantages of multiple choice tests:

ϖ Scoring is easy and objective.

ϖ It has content validity as it allows to increase the number of questions.

ϖ Useful in ranking selection exams where there are many participants.

ϖ It is suitable for use at all levels.

Disadvantages of multiple choice tests:

ϖ It measures information at the level of knowing and remembering, but cannot reach higher cognitive levels.

ϖ Since it is based on selection, there is a factor of luck success.

ϖ It does not allow for an original answer; it is based on selection.

ϖ It is difficult to prepare and requires expertise.

4. True False Tests

In true-false tests, the student is expected to decide whether the information or proposition he read is true or false. This testing method is easy to prepare. It can be applied at all levels, and content validity can be ensured by increasing the number of questions. Scoring is easy and objective. In addition to all these, luck is the test method with the highest success rate, so its reliability and validity are low. It measures behaviors at the level of knowing and remembering. It is difficult to prepare tests to measure high-level behaviors and cannot measure analysis, synthesis and evaluation steps (Özçelik, 2010).

5. Short Answer Tests

In short answer tests, the student is expected to answer the question with a word, a number, a date or a short sentence. Although short-answer tests have the characteristics of written exams, they are closer to the test technique since the answers consist of one word or short sentences. The number of questions can be increased. Although it is useful in terms of content validity, it is insufficient to measure higher-level cognitive information because it examines information at the recall level (Bektaş, Kudubeş, 2014).

6. Paired tests

In these tests, there are questions in one column and possible answers in the other. Students are asked to match the answers to the questions. Since the number of options is high, it can be said that luck success is low. It is useful in measuring memory information. Since their scoring is objective, they are highly reliable tests.

Alternative measurement and evaluation methods

1. Portfolio

Student product file, also known as portfolio, is a filing method that aims to enable students to see their work in various fields throughout the process. The purposes of the student product file are to follow the student's development throughout the process, to ensure that the student himself notices these developments, and to ensure that the parents are also aware of the process and to show their development. In short, the student product file aims to show the teacher, student and parent what the student has actually learned during the process and how he has learned it (Lambdin and Walker, 1994). The student product file is not a measurement method of a few hours or a few days. On the contrary, it is a process-oriented measurement method that covers a period or a year and contributes to the development of the student and taking responsibility (Orakçı, 2020). Creating the student product file and applying it for each student is limited in that it takes time. In addition, it can cause various problems because students do not do the activities and tasks in the file themselves or do not receive too much support.

2. project

Project tasks are one of the most important methods of measuring higher-level cognitive learning. Students learn the steps of reaching scientific knowledge and conducting scientific research through the project task. They discover the steps of goal setting, resource scanning, research and problem solving to obtain information. They go up to analysis, synthesis (creation) and evaluation, which are the highest levels of cognitive steps. Project tasks are not only a method of measurement and evaluation, but also a way of learning. It is a method that is process-oriented, includes both learning stages and evaluation stages, and plans to give feedback (Arı, 2010). In project assignments, students can choose a course or lessons according to their interests, and they have the opportunity to work individually or in groups, which also enables collaborative work. It also allows conducting studies according to personal differences, interests and needs (Atılgan, Kan & Doğan, 2007; MEB, 2009). Although the project assignment method is such an effective method, various problems may occur in its use. These may include lack of knowledge from practitioners, lack of time, and excess number of students (Anıl & Acar, 2008; Metin & Demiryürek, 2009).

3. Performance Assignments

As with other alternative measurement and evaluation methods, performance assignments (tasks) focus on what the student can do, how he can solve problems in daily life, his capacity to produce solutions and his development in the process, rather than revealing what and how much the student has learned based on results (Orhan, 2007; Secer). , 2010).

Performance tasks do not restrict the student to a certain exam period like traditional methods, they allow a few weeks to complete the task, and during this period, the student has the opportunity to complete his deficiencies and improve the areas he does not like (Yıldız, Okur, Arı & Yılmaz, 2006). Performance assignments, like project assignments, do not limit themselves to just measuring the student, but instead try to activate learning processes such as permanent learning and learning by doing.

4. Self-Assessment and Peer-Assessment

Self-evaluation method is an evaluation method that aims to enable the student to make a judgment about the work, make an evaluation, and evaluate it by comparing their own work with certain criteria. In this way, it is aimed to develop students' skills in taking responsibility for their own learning and critical thinking and self-criticism (Kösterilioğlu & Çele, 2016). The biggest limitation of this method is that successful students underestimate their own success, while students with a low understanding and goal of success inflate themselves and their work and evaluate themselves as better than they are (Ross, 2006).

Peer evaluation is explained as the evaluation of each other's work by students in the same group with similar characteristics (class, age, learning environment, etc.) (Falchikov, 1995). With this evaluation method, students gain awareness of what their peers' and their own work should be like and what their shortcomings are. As they actively participate in the process, learning environments become richer and become more than just an evaluation method (Kılıç & Güneş, 2016). In the peer evaluation method, situations such as the existence of competition between students and the lack of objectivity limit the evaluation method. For this, the use of checklists and graduated scales is beneficial.

5. Structured Grid and Diagnostic Branched Tree

The structured grid method was first introduced by Egan. It is an alternative measurement and evaluation technique that aims to determine the subjects on which students have partial knowledge, as well as measuring their existing knowledge, and also reveals their misconceptions (Bahar, 2001). This technique serves the purpose of learning concepts and establishing relationships between concepts. This concept is a newly used concept and efforts are being made to make it effective in different courses (Temizyürek & Türkkan, 2015).

In the structured grid, key words are written and numbered in sections consisting of 9, 12 or 16 boxes, depending on the student level. Various questions are written at the bottom of this table and you are asked to choose the appropriate numbered words in the table. In this process, while the student completes the parts he knows, he also reveals the information he partially knows and remembers. In addition, misconceptions regarding the subject are also determined (Taşdere & Işıklı, 2018)

Diagnostic branched tree is a method prepared based on the true and false tests in traditional measurement methods, where the previous answer affects the next answer and the student's knowledge reaches the result by choosing wrong and right answers. It aims to reach the correct starting points by choosing whether the information proceeding from general to specific is true or false (MEB, 2005). The diagnostic branched tree method is an important method in terms of revealing whether the student has meaningful learning, misunderstood concepts, incomplete learning, and wrong connections in the mind (Johnstone, McAlpine & MacGuire, 1986; Bahar, 2001).

6. Concept maps and Concept network

Concept maps are based on Asubel's theory of meaningful learning in which new learning depends on previous learning. It is a method developed by Joseph Novak at Cornell University in 1974 as a result of a research project he worked with his students. Concept maps are both a teaching-learning strategy and a measurement method that show how students learn knowledge and concepts and establish meaningful relationships between learning. It requires establishing a meaningful relationship between new information and old information and organizing the information (Ausubel, 1968; Novak, 1993).

Concept networks are graphic tools that enable students to activate existing knowledge and establish relationships between new information to be learned (Alkan, 2010). Thanks to concept maps, existing knowledge is activated, the scope of concepts is expanded, and connections are established with new concepts. While preparing concept maps, the main concept is written in the center, and other related concepts are related according to the degree of closeness (Çepni, 2014).

7. Word Association

Word association technique is a method developed to reveal the relationships that students establish between concepts that already exist in their minds (Atasoy, 2004).

In the word association technique, the student is given a key concept about any subject. The student is asked to write down other concepts that he or she associates with this concept. With the concepts that the student remembers and writes, the student's knowledge of the key concept and the way he structures the knowledge are revealed (Bahar & Özatlı, 2003).

8. Observation and Interview

In the observation and interview method, the student is directly observed by the teacher and the degree of expected behavior is determined by keeping various records. Various checklists or graduated scales can be used to record these observations and interviews. Observations provide accurate and quick information about students. Information can be obtained on many issues such as their participation in the class, their sharing of tasks within the group, their participation in questions and suggestions. In this method, criteria that are the same for everyone are not set, personal differences are taken into account, and the student should be observed several times in different environments or times. Each student is evaluated based on different characteristics, skills and behaviors. To obtain reliable results, observations and interviews should be recorded immediately (URL 1).

Results and Discussion

One of the most important pillars of education and training is the measurement and evaluation phase. Measurement and evaluation enable making very important decisions in education. These decisions may sometimes be to place the student in a suitable program, sometimes to identify learning deficiencies and eliminate them, and sometimes to make a choice. Educational programs have undergone radical changes with the differences in education and the adoption of student-centered learning environments. These changes have also changed the understanding of measurement and evaluation. Traditional methods, which were frequently used in previous years, have now begun to be used in parallel with alternative measurement and evaluation. This study explained what traditional methods and alternative measurement and evaluation methods are and touched upon the advantages and disadvantages of their use.

Traditional measurement and evaluation and alternative measurement and evaluation are used intertwined. There are various reasons for this. Even though alternative measurement is student-based and directs the student not only to measure but also to know himself, to correct his deficiencies, and to work collaboratively, it leads to being inadequate in crowded classroom environments and having trouble making objective choices.

Although traditional measurement methods are result-oriented measurements, they save time, are low-cost, and allow objective measurements. In this sense, it is inevitable to use it in crowded classes. The fact that almost all central exams in our country are conducted using traditional methods forces us to use traditional methods.

It is an important issue that teachers, as practitioners of alternative measurement and evaluation methods, have received the necessary information on this subject and are willing to apply these methods. There are many studies done in this field. These examined teachers' perceptions and competencies against alternative measurement and evaluation methods in many branches such as classroom, mathematics, Turkish, social, science, English and physical education, according to the variables of gender, working year, postgraduate education, and in-service training. As a result of the studies, it was concluded that there is no significant difference in the use and adequacy of alternative measurement and evaluation methods of the gender variable (Kılıç, 2020). In addition, significant differences have emerged regarding the use of alternative measurement and evaluation methods and the proficiency level of teachers who received postgraduate education or participated in in-service training (Kılıç, 2020; Topbaş, 2011). In addition to these results, it can be said that most of the teachers have developed positive attitudes towards alternative measurement and evaluation methods. Many teachers have revealed that they agree that these methods develop students' awareness of taking responsibility, contribute to career choice, gain study habits, and relieve them of exam anxiety (Orakçı, 2020)

Suggestions

In order to use alternative measurement and evaluation methods more;

ϖ Class sizes should be reduced.

ϖ Teachers should be given in-service training on these methods or their postgraduate education should be encouraged and facilitated.

ϖ Alternative measurement methods should be introduced to students, their advantages should be explained and a desire to use these methods should be aroused.

ϖ A harmonious link should be established between central examination systems and alternative measurement and evaluation methods.

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DIGITAL STORYING AND STORYJUMPER

Ünal İÇ[1], Ece AYDIN[2]

Abstract

We are in a digital age where technological developments are increasing rapidly. As a reflection of this, we encounter different methods and techniques with the dynamics of the digital age in education. Digital storytelling, one of these methods, is short-term films prepared using multimedia tools that add a new dimension to traditional storytelling. In this study, the definition of digital story, the process of creating a digital story, digital story tools are briefly mentioned, and "StoryJumper", one of the software and tools that can be used in the process, is discussed in detail. In the study, the effect of the digital storytelling method, which was reached by scanning the literature, on teachers and students was also mentioned. It was aimed to guide researchers for new studies by conducting a literature review on digital storytelling and StoryJumper software in mathematics education. In addition, in the study, an example of a digital story called "One Wish, Two Tournaments" prepared with StoryJumper software was included and data was presented on how to use this method in mathematics lessons.

Keywords: *Technology, Mathematics education, Digital story, StoryJumper*

Introduction

With the development of the internet and digital age, expectations in the teaching environment have changed and the use of new and different methods suitable for the technology of the age has begun to attract attention (Uslupehlivan, Kurtoğlu-Erden, & Cebesoy, 2017). While there are many tools and methods that have become widespread in education and will be used in classrooms, one of these methods is the digital storytelling method used for the first time by

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Dana Atchley (Ulu, 2021; Aldemir-Engin, 2021). There are multiple definitions of digital storytelling in the literature. The digital storytelling method, which adds a new dimension to traditional storytelling, is a cloud-based (Ünal & Çakır, 2023) software that can be explained as telling stories using multimedia (Talan, 2019). multimedia; It may include interactive sharing of information such as audio, video, music, and other media (Ying-Tze, Min-Ju, & Ying-Yao, 2023). In short, digital storytelling can be expressed as a mirror (Gürsoy, 2021) or short-term films that help students develop multitasking skills such as collaboration, peer feedback and 21st century skills, contribute to their imagination and developmental processes, and allow all of these to be reflected (Ulu, 2021).

Digital stories can be prepared by people at all stages of education, starting from pre-school education to undergraduate education (İslim, Özü Doğru, & Sevim-Çırak, 2018), as well as by individuals in every professional group (e.g. farmer, worker, teacher…) (Haliloğlu-Tatlı , 2016) can be prepared easily. In the study conducted by Haliloğlu-Tatlı (2016), it is mentioned that every individual has a story to tell and that digital storytelling can be created by individuals who have never used a computer in their life, have learning difficulties or have a mild level of intelligence deficiency. When the literature is examined, it can be said that digital stories positively affect the writing skills of gifted students (Demir & Kılıçkıran, 2018). Digital stories are accepted in the literature as three types: personal stories designed to be published on the internet and adapted for the digital world (Aydemir & Fetah, 2023), stories telling about historical events, or informative/teaching stories about a certain subject (Gökkurt-Özdemir & Erden, 2023).

Creating a digital story is a gradual process and there are steps to be followed while creating it. These steps are given in figure 1 below.

Figure 1. Digital storytelling process (Özpınar, 2017)

There are many paid and free digital story software on the internet. Examples of these software are Microsoft Photo Story 3, iMovie, Audacity, Microsoft Movie Maker, PowToon, Storyjumper, Slide.ly, Tellagami, WeVideo, Vyond, (Gökkurt-Özdemir & Erden, 2023) GoAnimate, Storybird, PuppetPals (İslim et al., 2018). These digital storytelling tools are divided into different classes according to their features. Considering this classification, a digital story suitable for the purpose can be created and the appropriate digital story environment can be selected (Ünal & Çakır, 2023).

The Effect of Digital Storytelling Method on Students and Teachers

Since these stories prepared with multimedia method on a digital platform can be presented in an entertaining way, they attract students' attention to the lesson, ensure their active participation, increase their motivation and improve their technology usage skills (İslim et al., 2018). Digital stories can be created individually or in groups, and this situation, which encourages collaborative learning, will positively affect the interaction in the classroom (Uslupehlivan et al., 2017). While students create their digital stories on a free and interactive platform, they can create a creative, original scenario by involving their imagination, gamify it and make learning permanent (Haliloğlu-Tatlı, 2016).

In the study conducted by İslim, Özü Doğru and Sevim-Çırak (2018) with 48 primary school mathematics teacher candidates, they were asked to choose a topic from the curriculum and create digital stories in groups with a determined software and gain competence, and as a result, their opinions were examined. As a result of the study, the participants stated that they were satisfied with their experience and wanted to use this method in their future lessons. In their study, Baran-Bulut and Güveli (2023) examined the digital stories they asked prospective teachers to create and concluded that they were inadequate in developing strategies appropriate to the subject. It was stated that in order for teacher candidates to improve their performance, the contents of the "Teaching Methods and Techniques" and "Material Design" courses taken during the undergraduate period should be arranged and methods and techniques such as "teaching with stories" should be included. In the study conducted by Özpınar (2017), prospective teachers stated that they thought that digital storytelling practices had positive effects on success and motivation, that by using digital storytelling in the teaching environment, the achievements could be associated more easily with daily life, and that students' creative thinking and research skills and technological competencies would improve.

Aim

The aim of this study is to scan the literature on digital stories and tools in the context of education, to examine StoryJumper software, one of these tools, and to present an example suitable for mathematics education.

Method

In this study, document analysis method, one of the qualitative data collection methods, was used. The document analysis method covers the processes of collecting, reviewing, taking notes and evaluating all printed and electronic resources for a specific purpose (Sak et al., 2021).

Mathematics Education and Digital Storytelling

Many students who have not been able to concretize the abstract subjects of mathematics in their minds will seek answers by asking the question "What will knowing mathematics do for me?" to their mathematics teachers (Küçükoğlu & İncikabı, 2020). At this point, mathematics teachers can benefit from educational technologies and concretize abstract-based mathematics subjects that the student cannot understand in their minds, in accordance with the curriculum, and make them more meaningful. Thus, the integration of digital technological applications into mathematics education has enabled technology and mathematics to become an integral part of education (İslim et al., 2018).

The National Council of Teachers of Mathematics (NCTM) emphasizes the importance of technology for quality mathematics teaching by emphasizing the importance of using technology in gaining mathematical knowledge and skills. The Council states that with the use of technology, students' learning experience is enriched, they have opportunities such as encountering different problem situations, reasoning and modeling, and even allowing students to access mathematical content can be effective in ensuring equality in classes (NCTM, 2000).

"Storyjumper" in Digital Storytelling

StoryJumper provides the opportunity to use images and characters freely by creating interactive stories containing images, text and sound on the internet (Gökçe, 2021; Ezeh, 2020). The site can be accessed at https://www.storyjumper.com/. Figure 2 below shows the login screen of the application.

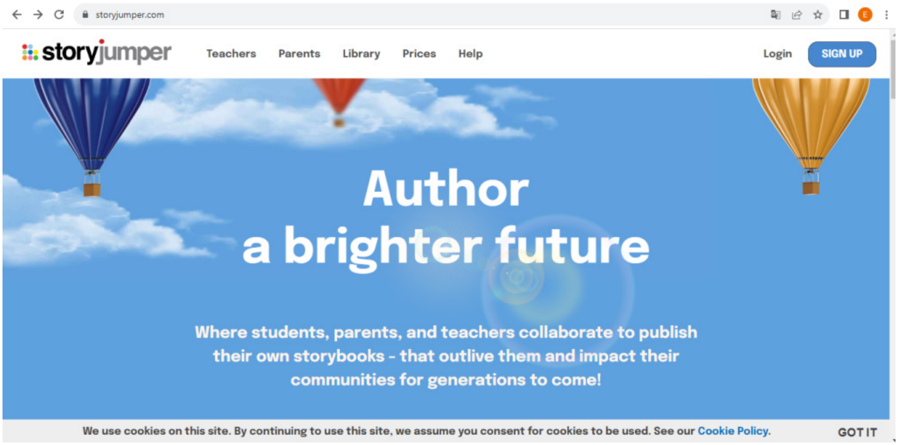

Figure 2: StoryJumper login screen (URL 2)

With StoryJumper, students can improve the use of stories for literacy and language development (Ezeh, 2020). Different types of books can be prepared in the software. You can create your own personal book with individual books, a collaborative book with group books, or a pre-designed book that you can copy and customize with template books.

The software allows a created book to be edited simultaneously by multiple people (Ezeh, 2020). Thanks to the "video chat" feature, two people editing the same book at the same time are asked if they want to video chat, making collaboration easier. The video chat box will appear in the lower right corner of the page as shown in figure 3:

Figure 3: Video chat feature (URL 2)

In order to create a digital story on the site, membership is required and it is free. Users who indicate that they are teachers during membership are given the right to create classes. Teachers can create and share a password for their students to join this class, or invite their students and other teachers.

After completing the free membership registration, click on the "createbook" option and select a template according to the type of book you want to create. Figure 4 shows the template options. After selecting the template, an instructional video appears on the screen to create a book. The language of the video is English and there are no other language options. The same applies to the site. That's why foreign languages have a big impact on this software. On the left side of the book creation screen, there are titles for text, characters, scenes, and photos you want to add from your computer. Figure 5 shows the story creation screen.

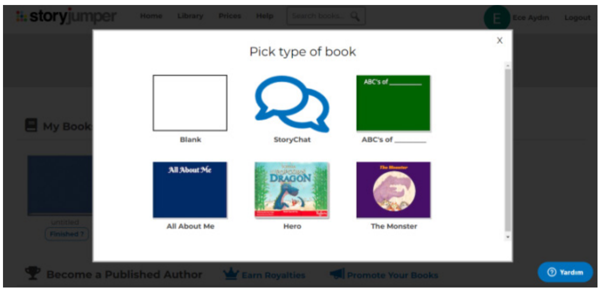

Figure 4: Template selection (URL 2)

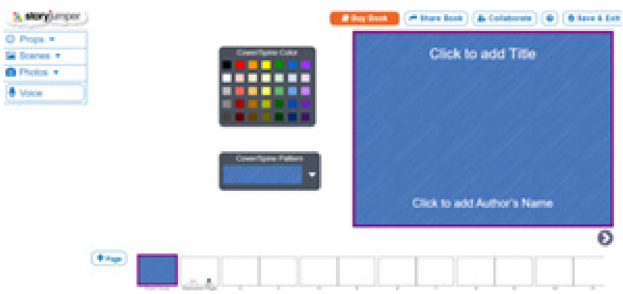

Figure 5: Story creation screen (URL 2)

While creating content, you can add sound effects, music or your own voice to the pages by clicking the "Voice" button. There is a QR code in the book. If you added your voice, users can listen to the audiobook by scanning this code. The code is shown with a red circle in figure 6 below.

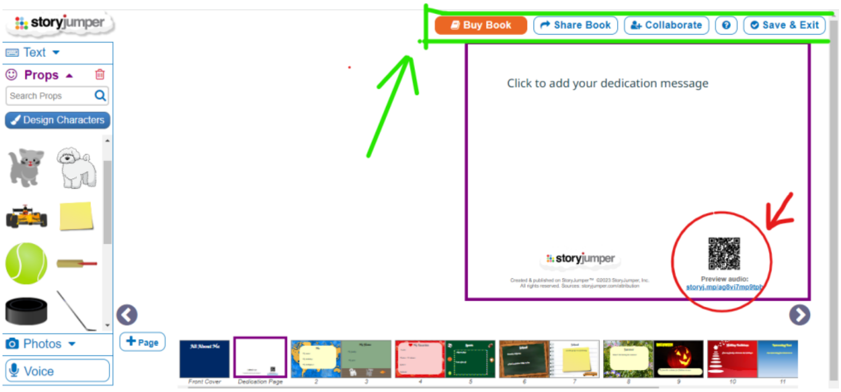

Figure 6: Audiobook and sharing options via QR code (URL 2)

After you complete your story, five options appear at the top right of the book. These options can be easily seen in the area shown in green in Figure 6 above. You can save and exit by clicking the "Save & exit" button. "?" When you click on the button, the guide prepared by the software will open and help can be requested. By clicking the "Collaborate" button, you can invite others to edit your book. To do this, you need to know the e-mail address of the person or people you want to edit your book in order to send an invitation. When the person who accepts the invitation sent via e-mail opens the book, a notification appears on the screen that he/she can use the video chat feature.

Considering all these features mentioned above with the StoryJumper tool, thanks to the option of editing the book, teachers can follow the stories created by students, make corrections and provide instant feedback. (Ünal & Çakır, 2023). Thanks to instant feedback, an interactive evaluation is made and students are allowed to correct their mistakes. In addition, the software allows teachers to give group or individual homework to their students (Ünal & Çakır, 2023). Social interaction is ensured and cooperative learning can be achieved through group assignments. Prepared digital books can be shared in the classroom environment and open to the comments of their peers, or they can be shared with users via StoryJumper or with external audiences through other media and receive feedback with their comments (Ezeh, 2020).

An Example from the Storyjumper Tool on Mathematics: "One Wish, Two Tournaments"

Considering the curriculum, "M.6.1.3.1" in the mathematics course curriculum. Understands the basic concepts about sets." A digital story has been created suitable for the acquisition. This story was prepared for the TÜBİTAK 2237-A project. Sound and effects were used on every page in the story, making the book far from ordinary and entertaining. Figure 7 shows the cover and first page of the book.

Figure 7: Cover and first page of the digital story "One Wish, Two Tournaments" (URL 1).

When the book is examined, different characters and different scenes are used depending on the script written. The pages of our digital book are turned from left to right, just like the pages of a real book. It is shown in Figure 8.

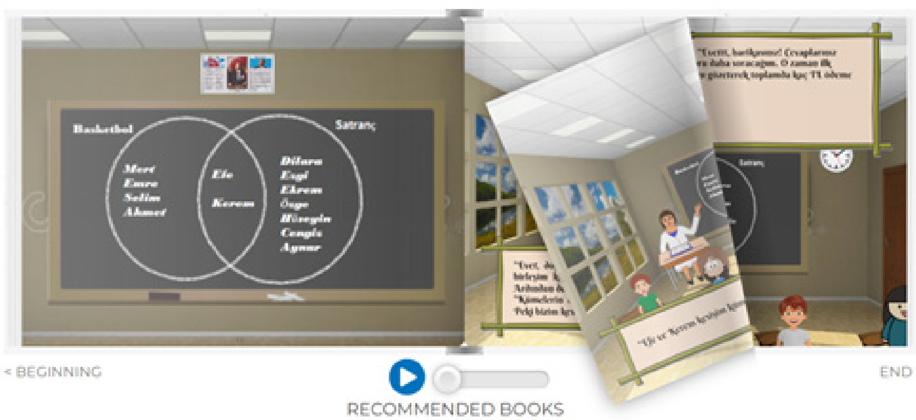

Figure 8: Reading direction of the book and page turning (URL 1).

When the scenario in the book is examined, in the first scene there is a conversation between two friends who will participate in basketball and chess tournaments in the school garden. One of these two students says that he wants to take part in both tournaments and puts his name on the lists of both teams. The bell rings and the lesson is math. Mathematics teacher Ms. Ceren shows the list of students who will participate in chess and basketball tournaments to the whole class at the beginning of the lesson. Mentioning that these two tournaments will be held for three days in another city, the number of nights they will stay at the hotel and the amount they will pay for single rooms at the hotel for one night, she poses a question to her students: “How many rooms should we reserve for the students?” After listening to the answers of her students, teacher Ceren writes two nested questions on the board. He draws a circle and writes basketball at the beginning of one of these circles and chess at the other. By talking about the definition of sets and the union and intersection sets, he carefully places the names on the list into sets together with his students in the class. Thereupon, he returns to the question he first asked and asks his students to answer it. Finally, he arouses students’ curiosity by asking which city they will go to for these tournaments.

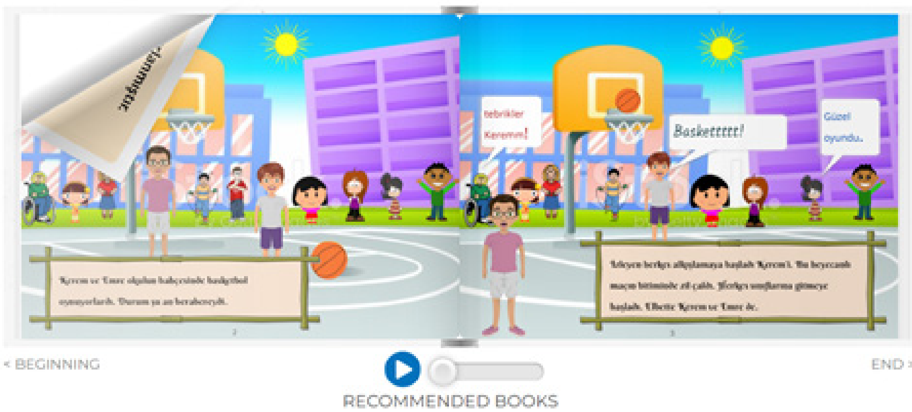

Figure 9: A scene from the digital book “One Wish, Two Tournaments” (URL 1)

Result and Suggestion

Previous research shows that digital storytelling can be an effective strategy for mathematics education and training. Using digital storytelling in mathematics lessons by providing a relevant context in line with the curriculum increases students’ interest and curiosity in the course. It has been observed that this method, which uses multimedia and is seen as unusual and interesting, increases the memorability of the subjects in mathematics teaching. StoryJumper software was researched, choosing it as one of the ever-increasing digital story tools in the digital software industry, but it turned out that studies on the software were limited. In many studies in Turkish sources, the definition of digital story, its processes and the names of digital story tools are given, and the opinions of teachers, teacher candidates or students about digital stories are taken. However, since detailed information is not provided about digital story tools in the context of mathematics education, there is a lack of research on this subject. Therefore, in this study, StoryJumper, one of the educational tools, was tried to be explained in detail. In the literature review regarding the opinions on the StoryJumper software, it was determined that most of the students had positive opinions about digital stories and found digital stories instructive and entertaining. Adding sound to stories is considered one of the most important features of this software. The software has two separate uses for teachers and students. Teachers can create their virtual classrooms and view and edit the content prepared by their students. Teachers giving feedback thanks to this feature of the software provides students with the opportunity to see and correct their mistakes. In addition to individual studies, students can also prepare interactive story books through group work and comment on other shared books, if they wish. This situation enables them to socialize and grow up as individuals who are open to criticism. However, the fact that the language of StoryJumper and many digital storytelling tools is only English creates a difficulty for users who do not speak a foreign language. In order to use these tools effectively and correctly, it is recommended to learn a foreign language.

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URL 2. https://www.storyjumper.com/

MATHEMATICAL MODELING IN MATHEMATICS EDUCATION AND ITS RELATIONSHIP WITH SOME CONCEPTS

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Abstarct

In this section, a literature review was made and the concept of "Mathematical Modeling in Mathematics Education" was explained and its relationship with realistic mathematics education, horizontal and vertical mathematization, PISA and TIMSS exams was examined. For the sake of clarity, the concepts mentioned are briefly defined and thus the information given is intended to be more descriptive. In this study, mathematical modeling was discussed only within the scope of mathematics education, and in the definitions and relations with other concepts, it was not always stated that it was in mathematics education. The process and approaches of mathematical modeling are explained and the sub-steps are shown. Finally, some studies related to mathematical modeling are presented.

Key Words: *Mathematics education, mathematical modeling, modeling process, horizontal and vertical mathematization, modeling approaches*

Introduction

Students generally perceive mathematics as a difficult subject and have a prejudiced approach to mathematics. The fact that they see mathematics as an abstract lesson has a great impact on this. In order to remove the perception that mathematics is just an abstract lesson and to warm up students to mathematics, mathematical modeling can be used when explaining mathematics to make it easier for students to understand the lesson. Mathematical modeling helps students turn abstract situations into concrete ones, thus contributing to the development of their concretization skills. By learning to establish a connection between the abstract world and the concrete world, students can easily do this in their minds after a while. Mathematical modelling; While it

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supports mathematics learning by enabling students to create concepts, it also helps students develop various competencies and attitudes and helps them understand the world better (Blum & Ferri, 2009). The student who sees the equivalent of mathematical concepts in daily life; By establishing a more comfortable connection with the world he is in, he learns to look at the world from a mathematical perspective, realizing that mathematics is not just a course and that we live intertwined with mathematics. This situation, which is a step towards gaining high-level thinking skills in the future, enables the development of problem-solving skills. Therefore, the student can visualize the problems he encounters better and approach these situations more easily. A student who gets used to mathematical modeling will not have difficulty doing this after a while, and even if he is not aware of it, he will lay the groundwork for being able to do high-level mathematics in the future.

Aim

This study was conducted to examine mathematical modeling within the scope of mathematics education and to examine the relationship between mathematical modeling and other concepts in mathematics education and to reveal this relationship.

Method

In this study, the document analysis method, one of the qualitative research methods, was used (URL 1). In this method, many documents are collected, reviewed and analyzed as the first source of research data (Sak, Sak, Şendil and Nas, 2021). Document review and literature review were conducted. In the light of the literature review, mathematical modeling in mathematics education was defined and evaluated, and different definitions in previous studies on this field were also explained. In the literature, the place of mathematical modeling in mathematics education has been tried to be determined and its contribution to mathematics education has been examined.

Data Collection Tools and Analysis

The data in this qualitative study was obtained by scanning the literature on websites where articles are published, such as Dergipark, which can be accessed through “Google Scholar”, which contains many articles from past to present. Primary and secondary sources were used. Content analysis was used to analyze the data.

What is Mathematical Modeling?

Modeling can be defined as the process of creating models by using models while interpreting the problems we encounter (Tutak and Güden, 2014). Mathematical modelling; It is a form of mathematical expression of events or situations we encounter in mathematics or outside mathematics (Tutak and Güder, 2014: 10). If we consider it in the context of mathematics course, mathematical modeling; It is about interpreting the problem faced by the student, expressing it with figures or symbols and turning it into a model. When the problem becomes a shape, it becomes easier for the student to see what is wanted and the student can reach the solution more easily.

If we talk about its historical development, the concept of mathematical modeling emerged in the early 20th century and, according to available sources, it was mentioned for the first time in the book "How Can We Teach Applications of Mathematics" written by Henry Pollak in 1969 (Uzun, Ergene and Masal, 2023).

The Relationship between Realistic Mathematics Education and Mathematical Modeling

Mathematical modeling is related to RME because it is used in the later stages of Realistic Mathematics Education (RME). Yonucuoğlu and Bindak (2021) described Realistic Mathematics Education as the learning and teaching theory in mathematics education that was first introduced and developed in the Netherlands. RME can be defined as a learning and teaching theory in mathematics teaching that was first developed by Hans Freudenthal with his colleagues at the Freudenthal Institute in the Netherlands in the 1970s. (URL 2). While Didiş Kabar (2018) examined the relationship of mathematics with daily life in her study, she said that Mosvold (2008) defined the relationship of mathematics with real life as "the bond between the mathematics taught at school and the outside world". Since GME focuses on real-life problems, mathematical modeling is used to define and analyze these problems. According to Gravemeijer (1994), GME is based on 5 basic features. These:

1. Real life problems
2. Material use
3. Students' use of their own structures
4. Intertwined learning strands

Instead of explaining these features one by one, I will only explain the parts related to mathematical modeling mentioned in this article. Material use, which is the 2nd feature, includes the use of models, diagrams and symbols in the course (URL 2). Therefore, at this stage we can see the impact of mathematical modeling.

Relationship of Mathematical Modeling to Horizontal and Vertical Mathematicization

Freudenthal (1068) briefly defined mathematization as the process of reaching the mathematical concept, that is, formal knowledge, from a real-life problem, a real model (Özdemir and Üzel 2013). Treffers (1987) named and examined realistic mathematics education in two categories: horizontal and vertical mathematization (Sönmez, 2019). Horizontal mathematization refers to putting a real-life problem into mathematical language, that is, expressing it with mathematical terms or symbols. Information is produced from real life and transferred to symbols in the mathematical language. When solving the problem, a solution is sought by trial and error. Mathematical modeling is also used at this stage. Vertical mathematization is a process in which mathematical structures are expressed with symbols. The problem situation is redesigned and translated into mathematical language with symbols. In vertical mathematization, shortcuts and equation relationships are mostly examined (Altıner, 2021). As stated by Freudenthal (1991), we can say that in vertical mathematization, one moves within the world of symbols, while in horizontal mathematization, one moves from real life to the world of symbols. We can say that if students encounter problems similar to the problem they have solved before, they use horizontal mathematization, and if the problem is more advanced, they use vertical mathematization (URL 2). If we think of horizontal mathematization as a way that can transform the real world into symbols and connect the two, we can think of vertical mathematization as a rising ladder within mathematics itself, as it establishes a relationship between symbols and concepts. Because vertical mathematization pushes the student to think at an advanced level and opens the way for him/her to do high-level mathematics (Altıner, 2021).

Mathematical Modeling Process and Approaches

According to Wikipedia, a mathematical model is defined as “the description of a system using mathematical concepts and language”, and mathematical modeling is explained as “the process of developing a mathematical model” (URL 3). Mathematical modeling in mathematics education is based on first understanding real-life problems correctly, interpreting them by mathematizing them, and presenting them in different ways such as tables, graphs, and Venn diagrams. According to Özaltun, Hıdıroğlu, Kula and Güzel (2013), the mathematical modeling process includes “display forms, written symbols, formal models or pictures, manipulative models and real-life models” (Lesh et al., 1983).

Modelings are cyclical processes (Altun, 2020). Blum and Ferri (2009) showed the cycle of the modeling process in 7 steps given below in order to help the cognitive analysis of the modeling situations they used in their own projects. In these steps, the mathematical expression of a problem and the process of solving this problem, leaving real life aside, are shown in a cyclical manner.

1. Understanding the situation (problem)
2. Simplifying / structuring
3. Mathematizing
4. Mathematical work
5. Interpretation
6. Verification
7. Presentation

Altun (2020) mentioned that different researchers divide mathematical modeling processes into various stages. These are Lingerfijard (2002), Kaiser (1995) and NCTM (1989). According to Altun (2020), if we show these step by step:

Lingefjard (2002):

1. Identifying and simplifying the givens
2. Identifying variables
3. Formulation
4. Turn it into a mathematical model
5. Graphical representation
6. Meeting vital needs in a problem situation

While stating that it consists of stages, Kaiser (1995) also divided it into 6 steps:

1. Defining and simplifying a real-life problem
2. Creating a mathematical model
3. Transforming, improving and solving the model
4. Interpreting the model
5. Validate the model
6. Using the model

NCTM (1989), which states that modeling consists of 5 non-linear stages, lists these stages as follows:

1. Defining and simplifying a real-life problem
2. Creating a mathematical model
3. Developing the model and solving the problem
4. Interpreting the model
5. Validate and use the model

(Altun, 2020).

There are multiple modeling approaches as educators offer many views on the use of modeling in mathematics education. Citing these approaches from Kaiser and Sriraman (2006), Erbaş et al. (2014) stated that the approaches are grouped under six headings. The titles are as follows:

1. Realistic or Applied modeling
2. Contextual modeling
3. Educational modeling
4. Socio-critical modeling
5. Epistemological or Theoretical modeling
6. Cognitive Modeling

Derin and Aydın (2020) explained the basic approaches of these modeling approaches in their study.

Teaching Mathematical Modeling

There is no definitive way to do this. In their study on mathematical modeling, Blum and Ferri (2009) made four different inferences on how modeling can be taught appropriately.

- The first of these includes quality teaching criteria. For quality teaching, the appropriate modeling method should be chosen. When handling modeling tasks, a balance needs to be struck between maximum and non-maximum tasks. The teacher must fulfill his/her guidance role and at the same time, the student's independence and ability to work flexibly must be ensured.
- In the second conclusion, it is important to support students' individual modeling ways and encourage them to engage in multiple modeling. Teachers must be aware of and familiar with their duties. They must have potential for solutions and be able to make custom solutions.
- In the third conclusion, teachers should be familiar with intervention methods and especially strategic interventions.
- In the fourth implication, teachers should know adequate student strategies and how to support them in order to solve students' modeling tasks.

A solution plan has been designed in which students can get help for the difficulties that may be encountered during the solution of mathematical modelling. This solution plan has 4 steps.

1. Read and understand the text fully: The situation is clearly imagined and a draft is created.
2. Creating a model: The required data are examined and assumptions are made if necessary. Mathematical relationships are sought.

3. Use of mathematics: The mathematical result is written by applying appropriate procedures.
4. Explaining the results: The result is associated with the task and the answer is written. (Blum and Ferri, 2009)

The Relationship of Mathematical Modeling with PISA and TIMSS Exams

PISA exam has been held by the Organization for Economic Co-operation and Development (OECD) every 3 years since 2000 (URL 4). TIMSS exam is held every 4 years by the International Association for the Evaluation of Educational Achievement (URL 5). These exams are held to determine the competencies of students around the world in various fields and to observe their changes over the years (Dönmez and Dede, 2020).

In the PISA exam, many characteristics of students are measured, such as their mathematical proficiency, ability to produce strategies, mathematization abilities, and ability to use mathematical tools. There are 6 proficiency levels determined by PISA in the field of mathematical literacy. At the first level, all information is given and routine operations are carried out to solve the problem. At the second level, basic rules and formulas are used. At the third level, one can interpret representations that differ from basic-level problem-solving strategies. At the fourth level, different representations are used in situations encountered and these representations are associated with real life situations. At the fifth level, he can choose and think about different strategies when faced with complex problems. At the sixth level, one can put forward new solutions for newly encountered situations and generalize (Dönmez and Dede, 2020). If we pay attention, we can see traces of mathematical modeling at the fourth level.

In the mathematics section of the TIMSS exam, questions are prepared for 3 basic cognitive areas. These cognitive domains are knowing, applying, and reasoning. It can be said that the knowing domain in the TIMSS exam corresponds to the first proficiency level that is tried to be measured in the PISA exam, the application domain corresponds to the second and third proficiency levels, and the reasoning domain corresponds to the fourth, fifth and sixth proficiency levels. Based on this, we can comment that the field of reasoning is a field that includes mathematical modeling (Dönmez and Dede, 2020).

Some Studies on Mathematical Modeling

In a study by Duran, Doruk and Kaplan (2016); In the fall semester of the 2013-2014 academic year, 41 active students who were in the final year of primary mathematics teaching at a state university in Eastern Anatolia were selected and the selected teacher candidates were asked to find a solution to the

"Turtle Paradox". The participants were specifically selected from those who had successfully passed the Calculus III course, which included the relationships between the concepts of model, modeling and mathematical modeling, and the steps to help them design activities related to mathematical modeling (Duran et al., 2016). The "Turtle Paradox" was put forward by the Greek mathematician Zenon of Elea. It is thought that Zenon originally expressed the turtle as a slow runner, but it was later changed to the expression turtle by one of the commentators. According to this paradox, Achilles, a mythological character, and the turtle will compete. Achilles gives the turtle an advance because he runs too fast (Çetin 2022). Assuming that the turtle starts 100 meters ahead of Achilles, when Achilles reaches the position where the turtle started the race, the turtle will be further than its initial position (Duran etc., 2016). Since the turtle that continues its movement started the race ahead of Achilles, even if Achilles comes to its previous position, Achilles will never be able to catch up or pass the turtle because the turtle will be further ahead at that moment. The turtle paradox problem was chosen because it is suitable for modeling. In the study, 5 steps of the modeling process were taken into account. The second of these, according to Duran et al., (2016), is the "Mathematical model creation" step. It was observed that the mathematical models produced by most of the participants at this stage were incompatible with the solution of the problem. Pre-service teachers were able to determine the mathematical concepts they should use for modelling, but they explained them incorrectly. This can be explained as pre-service teachers encountering such a paradox for the first time and having difficulty understanding the paradox. Additionally, while six teacher candidates used verbal expressions in modelling, one teacher candidate created mathematical models and used graphs and tables (Duran et al., 2016).

According to Uzun et al., (2023), in a study conducted by Boaler (2001), he divided 300 students at the primary school level into two groups and gave traditional mathematics education to one of the groups and mathematical modeling education to the other for 3 years. It was observed that the mathematical achievements of the students in the group increased and, according to the students' opinions, their thoughts about mathematics were in a positive direction.

Akgün, Çiltaş, Deniz, Çiftçi, and Işık (2013) conducted a study in which semi-structured interviews were conducted with eleven primary mathematics teachers whose participants were determined on a voluntary basis and whose service period varied, and classroom observation was conducted with four of them, in order to determine the awareness of primary school mathematics teachers about mathematical modeling. they did. In order to increase the reliability of the study, the determined categories were also examined by the researcher, an expert in the field of qualitative research, and a field educator who had done a doctoral study on mathematical modeling. It was observed whether teachers used mathematical models and mathematical modeling methods in their classes; Teacher opinions were taken regarding the concepts of model, modeling, mathematical model and mathematical modeling. It was concluded that the teachers who participated in the study were not sufficiently knowledgeable about mathematical modeling, confused the concepts just mentioned, and did not include mathematical modeling in their lessons as much as necessary. Participating teachers expressed their opinions that they use mathematical modeling to visualize concepts and make the lesson better understood and the learning more permanent. In this study, which also touches upon the difficulties experienced by teachers in the mathematical modeling process, teachers; They mentioned that they had difficulty accessing mathematical models and using the models in the classroom environment, that mathematical modeling took time, and that they had time constraints due to the intensity of the curriculum.

Result and Suggestion

In this study, mathematical modeling in mathematics education and its relationship with some concepts in mathematics are examined; It is very important to use mathematical modeling in education so that students can easily understand that mathematics is not disconnected from real life situations, but is actually part of life, and so that they can embrace this situation. Nowadays, when traditional methods are far behind, this concept has become an indispensable part of new generation mathematics. A student who understands and comprehends events and situations better through mathematical modeling will be able to solve the problems he encounters more easily because he will be able to better visualize the events he encounters with mathematical modeling and mathematize the models. The relationship between horizontal and vertical mathematization and mathematical modeling is explained. This lays the groundwork for higher-level thinking skills in the future and enables him to do higher-level mathematics. In PISA and TIMSS exams, where students' proficiencies in many subjects are measured, their ability to relate the representations they encounter to real life situations is also measured, and this skill is based on the ability to do mathematical modeling. However, it should not be forgotten that this ability of the student depends on the competence of the teacher in this regard and his ability to convey this to the students. When a study conducted to determine the awareness of mathematics teachers about mathematical modeling was examined, it was seen that the teachers' competencies in mathematical modeling while providing mathematics education were not at the desired level. In fact, it has been observed that there are teachers who cannot clearly distinguish between model, mathematical model, mathematical modeling and mathematical modeling concepts in mathematics education when asked to explain them. Although there are teachers who know the meanings of the concepts, they have limited time to convey mathematical modeling to students accurately and effectively, and even if there is time, participating teachers stated that they have difficulty accessing mathematical modeling tools. In order to increase the competencies of teachers in this regard, necessary training can be given to teachers who are not new generation. Students studying at the faculty of education should encounter this issue from their first year, and the concept definitions and how students will be educated to acquire this skill should be explained and this should be emphasized. Necessary training should be given to teachers and teacher candidates to understand the importance of mathematical modeling education, which should be given to students so that they can better understand the world and the possible problems they encounter and find solutions more easily.

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THE FUTURE OF THE INTERNET: AVAILABILITY OF WEB 3.0 TECHNOLOGY IN MATHEMATICS EDUCATION

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Abstract

The aim of this study is to explain the development of web technologies, their versions, and how these versions can be used in mathematics education at what stages since the day they entered our lives. At the same time, the aim is to determine the advantages of web 3.0 technology and artificial intelligence, which are the latest versions of web technologies, over previous versions and to examine their contributions to mathematics education. In this study, articles related to web technologies and their use in mathematics education in Dergipark and Web of Science databases were examined, a case study, one of the qualitative research methods, was used and the data was analyzed with the content analysis method. In the study, what the web versions are, the features of these versions, their advantages over each other, and how web technologies are used in mathematics education are explained. As a result, the web 3.0 version, in which the concept of personalization comes to the fore, can make significant contributions to mathematics education, can detect each user's shortcomings, misconceptions, and application difficulties by filtering and personalizing separately for each user, and provides a three-dimensional mathematics learning environment suitable for each user in a virtual environment. It is stated that it can be prepared. At the same time, it has been stated that it is not possible to detect these misconceptions and errors in real life in the classroom environment for every student at the same time, and that creating the appropriate environment to eliminate the detected misconceptions requires serious time and cost, and by using web 3.0 technologies and artificial intelligence, we can do all these at the same time for every student. It has been determined that it is possible to do this and that a significant saving in time and cost can be achieved.

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Keywords: *Web technologies, web 1.0, web 2.0, web 3.0, artificial intelligence, mathematics education*

Introduction

Today, where technological developments continue unabated, web technologies continue to gain different dimensions. The project, which started as Web 1.0 and had only one-way transfer, did not allow user interaction. Web 2.0, which entered our lives as the second generation internet and is a new dimension of web 1.0, emerged as technologies that allow user interaction (Safran et al., 2007). These technologies offered their users the opportunity to produce content and build a collaborative digital system by sharing this content. Web 3.0 technologies, which are more advanced and have gained a new dimension, have gone beyond web 2.0. This period, when information began to be processed with artificial intelligence, initiated the transition of web evolution to the next stage (Koçak, 2023).

In Web 3.0 technologies, the web 3.0 network is also called a semantic network due to features such as artificial intelligence processing data, storing this data according to certain characteristics, classifying it and presenting it to users (Rubens et al., 2011). That is, the semantic network. The fact that artificial intelligence can perform the tasks and transactions performed by users using Web 2.0 technologies and present them to the user with Web 3.0 technologies has been effective in the use of this nomenclature (Berners-Lee, Hendler & Lasilla, 2001).

Web 2.0 technologies were developed for human use and have a centralized structure. In other words, users' data is stored in certain applications and multiple user access to the data is provided through these applications. Web 3.0 uses cloud technologies and has a decentralized structure (Grider, 2021). In other words, users' data is stored over the internet through certain software, not in applications. This means increased data security. Web 3.0 brings the concept of personalization to the fore (Anderson, 2004). Artificial intelligence offers content and information to users in line with their preferences and tastes. These contents are accessed from users' activities on the network, such as searches, messages, preferences, likes, comments and photos (Fırat, 2020). In other words, it can be said that artificial intelligence makes the mentioned user personalizations by making use of web 2.0 applications. When a user wants to make a trip plan, web 3.0 technologies and artificial intelligence filter the user's personal characteristics and favorite settlement styles and create travel routes for the user (Yılmaz, 2021).

There is another concept that entered our lives with Web 3.0 technology; metaverse The word metaverse; It was formed by the combination of the words universe and meta, that is, universe and beyond. (Arvas, 2022). The term “transuniversal” refers to a virtual world beyond the real world we live in. That is, virtual reality and augmented reality (Nesbo, 2021). The way that takes users to this virtual world is web 3.0 technologies. In other words, metaverse and web 3.0 are complementary to each other and are indispensable parts of a whole (Tarakçı, 2021). Metaverses enable users to do activities together in a 3D virtual environment, organize activities and participate in organized activities through the avatars they have chosen (Güler, 2022). Web 3.0 technologies and artificial intelligence can provide suggestions based on personalized data about users and direct them to activities that suit their needs, tastes and characters in a 3D virtual environment (Silva et al., 2018). This is where the education-related part of the meta universe and web 3.0 technologies begins. Data personalized for each user, personalized recommended programs based on this data, and 3D virtual environments where these programs can be applied (Damar, 2021). It seems like everything a user would need for the training they want to receive on a particular subject is readily available. If we specialize this situation in the field of mathematics education, it can be said that artificial intelligence can detect the mathematical difficulty experienced by the user and make suggestions to overcome this difficulty. It can even be considered that it can present the application or training program it has prepared in a 3D virtual environment to the user in order to overcome the existing difficulty.

Aim

The aim of this study is to examine the development of web technologies to date in different dimensions, to make inferences about the usability of web 3.0 technology in the field of mathematics education and at what stages it can be used, and to analyze and present the contributions of using these technologies to mathematics education.

Method

In this research, a case study, which is a type of qualitative research, was used because it was aimed to interpret the development of web technologies over time, their usability in the field of education, and the usability of web 3.0 technologies in the field of mathematics education. Case study; It is a qualitative research approach in which one or more situations are examined in depth with the help of data collection tools such as documents and reports containing multiple sources (Subaşı, Okumuş, 2017), and the subjects or themes investigated are defined (Creswell, 2007). The data obtained in the study were analyzed using the content analysis method.

Findings

In this part of the research, the versions of web tools since their inception, the features of these versions, and how they are used at which stages in mathematics education are mentioned.

1. Web 1.0

It is known that when web technologies first emerged, there was a one-way flow of information and did not allow user interaction. In other words, users could not intervene in the information, they could only read the information. Information accessibility was also limited only to what the administrator allowed (Park & Kim, 2022). This version of the web, called Web 1.0, is considered a read-only web with very little interaction on websites (Dominic, Francis and Pilomenraj, 2014). The use of web 1.0 technologies in mathematics education is limited to summarizing the subjects or writing the features of a subject (Tutak, Nayıroğlu, Süzen, 2023). Since users are in the reader position, they only have the opportunity to read the administrator's work as much as the administrator allows.

2. Web 2.0

The transition from web 1.0 to web 2.0 can be considered as a transition from a read-only form to a read-write version (Nayıroğlu, Tutak, 2023). With this new version, users who only act as readers have gained the ability to both read and change data. In other words, users moved from the reader role to the author role. The concept of collaboration comes to the fore in web 2.0 technologies that allow user interaction (Hussain, 2012). Because in this version, users have the opportunity to create content and work collaboratively by sharing the created content online (Grosseck, 2009). Integrating Web 2.0 technologies into mathematics education is one of the best ways to ensure understanding of mathematical terms and concepts. According to NCTM, technology is one of the basic principles of mathematics education, and the use of appropriate technologies improves students' ability to make sense and provides opportunities for problem solving and reasoning. At the same time, technology helps students develop their mathematical ways of thinking (Keong, Horani, & Daniel, 2005) and mathematical ideas (Wachira & Keengwe, 2011), and helps them take responsibility for mathematical learning (Buteau & Muller, 2006).

Various course activities can be prepared using Web 2.0 technologies and these activities can be applied at all stages of the course. Activities can be prepared in accordance with the attention-grabbing phase, deepening phase, application phase and evaluation phase of the course. Virtual classroom environments can be created using Web 2.0 tools and students can work collaboratively in these environments. This contributes to the development of students' mathematical meaning skills.

3. Web 3.0

Web 3.0 technology is also called semantic network (Naik and Shivalingaiah, 2008). With Web 3.0 technologies, artificial intelligence can define the meaning of the queries made by users and what the user's goals and needs are according to these queries. In other words, in this technology, artificial intelligence has the ability to make sense like a human. For this reason, it is called semantic network (Baz & Meral, 2021). The prominent features of Web 3.0 technologies are; personalization, interoperability and three-dimensional virtualization environments. Situations such as cost, time and labor, which are the benefits of real models, can be minimized in models developed in three-dimensional virtual environments (Ünalır, 2016). With Web 3.0 technologies, the concepts of virtual reality and augmented reality have emerged. Virtual reality is the creation of a three-dimensional environment and images developed in a computer environment by designing them in the human mind with technological materials such as VR glasses, giving a feeling of reality (Çavaş, Huyugüzel-Çavaş and Taşkın-Can, 2004). Web 3.0 technologies can be used at all stages in mathematics teaching. Augmented reality can be used to draw attention to mathematical issues or provide information about the subject (Giannakos & Lapatas, 2010). Activities that are difficult to make sense of and model mathematically, such as the view of objects from different directions, can be modeled in a virtual environment with web 3.0 technologies and presented to students. During the evaluation phase, students may be asked to create a mathematical modeling in a three-dimensional virtual environment through collaborative work. In this way, students will not only create an active learning environment by working together, but also will have a meaningful learning process by concretizing abstract subjects for themselves through virtual modeling.

Result

Developments in web technologies and all other technological developments are undeniable facts of our lives. These developments are not limited to each other but affect all areas and even change some areas and take others to new dimensions. It is up to educators to follow all these developments and integrate them appropriately into educational environments. Time has shown that providing an educational environment that is unaware of these developments will result in nothing but stagnation. The more educational environments are diversified, the more people can be reached (İnce, 2020). In other words, technological developments reveal different learning styles and prepare learning environments suitable for these styles. In this period when individual differences come to the fore, it is artificial intelligence, not humans, that analyzes and reveals differences. The semantic network, which entered our lives with Web 3.0 technologies, follows people through data and reveals their individual differences by filtering this data (McIlraith et al., 2001). With the introduction of web 2.0 technologies that allow user interaction, data can be easily found by artificial intelligence through web 2.0 tools. In other words, we leave a footprint on web networks with every interaction we make on the web. Artificial intelligence also finds these traces and combines them to make personalized interpretations (Altunal, 2022). So, can artificial intelligence follow the mathematical footprints of users, personalize those footprints for each user and offer appropriate mathematical environments for them? The answer to this question will undoubtedly be yes. For example, when a question like the following is sent to the user over the web in order to check the achievements regarding algebraic expressions;

Since the value of the algebraic expression 3x+2 is 20, what is the value of the variable in this expression?

In this case, the user has two possible answers;

1- If the expression 3x+2 is equal to 20, the expression 3x is equal to 18. In this case, the value of x, the variable, is 6.

2- The expression 3x+2 is equal to 5x. If the expression 5x is equal to 20, then the value of x, that is, the variable, is 4.

If the user answers 6 when both of the specified options are presented to the user, artificial intelligence processes that the user does not have a misconception on this issue and his way of thinking is correct. However, if the user answers 4, the artificial intelligence processes that the user has a misconception in this regard and that the sum of a variable and an integer is expressed as a single variable. Just like in the example above, thinking that the sum of the expression 3x and the integer 2 is equal to the expression 5x. In this case, artificial intelligence can create a model in a three-dimensional virtual environment to eliminate this misconception of the user. The sample model prepared by artificial intelligence could be as follows; To model the expression 3x, three boxes are created on a table, without showing how many sticks they contain, and it is stated that there are an equal number of sticks in each box. To model the integer 2, two sticks are created and placed on the same table. To show that the total number of sticks available is equal to 20, a second table is created and 20 sticks are placed on this table. In this case, the value of the variable will be how many bars are in a box. With the help of this modeling, when you open and look at each box, the user will see that there are 6 sticks. In order to show the user's mistake and eliminate misconceptions, when 5 of the same boxes are created and the total number of bars is determined, it will be seen that there are 32 bars.

The example mentioned is only about a misconception regarding a subject, and as can be seen, artificial intelligence has prepared and implemented all stages. This application, which would have taken a long time and been costly if done in real life, could be offered to the user immediately thanks to web 3.0 technology. At the same time, instant feedback was given and when the user gave the wrong answer, artificial intelligence understood the existing misconception and instantly prepared the appropriate model in the three-dimensional virtual environment to eliminate it and directed the user to this environment. In real life, both preparation and implementation of this require a long process. Another superior aspect of these technologies is the ability to create personal models for each user. Thanks to Web 3.0 technology, artificial intelligence can identify different misconceptions of users who give different answers to the same question at the same time, prepare different models for each user, and direct each user to different three-dimensional virtual environments at the same time to apply these models. It is not even possible to do this at the same time in a classroom environment.

As a result, web 3.0 technologies; It can be used to determine students' learning styles, misconceptions and errors and to offer customized educational environments accordingly. These technologies have great potential to identify students' strengths and weaknesses and create personalized learning plans for them. Additionally, artificial intelligence-supported learning environments offer interactive mathematics experiences to students. Mathematics games, three-dimensional applications and simulations prepared in virtual environments help students understand abstract concepts in a concrete way.

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A LOOK AT MATHEMATICS IN THE GREAT SELCUK PERIOD

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Abstract

Mathematics education has been as important as mathematics as a branch of science for centuries (Bayraktar, Aydoğdu, Tutak, 2022). It has been determined that the order in mathematics will be very effective in understanding the order between the universe and the events in the environment (Kükey, Tutak, 2019). Turkish scientists have always played an important role in the development of education, especially the development of mathematics, from a historical perspective. Over time, while taking their place in the history page with different state names, they have contributed innovations in many areas of education and mathematics. In this study, the contributions made to mathematics during the Great Seljuk Empire are mentioned. When we look at history, it is obvious that scientists from every state played an important role in the development of science. However, when viewed from this perspective, the contributions of Turkish scientists to science in many stages of history are of great value. For example, when we look at Omar Khayyam in the pages of history, Omar Khayyam is the person who classified equations systematically for the first time in the history of mathematics (Baki, 2014). This classification is still used today. He divided simple and compound, and compound ones according to their coefficient numbers. He gave 25 forms of the first, second and third degree equations and showed with examples how each of them was solved. This and similar ones are presented in more detail in the rest of the study.

Keywords: *Great Selcuk Period, History of Mathematics*

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Introduction

Aslan (2021) stated that he focused on the civilizations that directly contributed to the birth of modern science in the history of mathematics. Bidwell (1993) stated that the history of mathematics is a branch of science that deals with the development processes of mathematics, the lives and works of people who contributed to mathematics, and the social and cultural dimensions of mathematics. The history of mathematics is a science that provides a useful resource for understanding how mathematical thinking occurs and provides some insight into how positive attitudes towards the subject can be developed. According to Fried (2001), the history of mathematics is a result of human activities that contribute to the meaning of mathematics, make mathematics different and remarkable, and make the invisible aspects of problems understandable. Farmaki, Klaudatos and Paschos (2004) describe the basic roles of the history of mathematics as a scientific discipline; It reveals the origins of mathematics, its uses, and its relationships with society and other fields of science. When we look at the history of mathematics, there are various periods. When we look at the Turks, there are various periods. These; While we can examine it as before and after Islam, it can be examined as the Great Seljuk period, the Ottoman period and other periods. In this study, the Great Seljuk period was examined. An attempt has been made to explain the mathematicians who lived during the Great Seljuk period and their contributions to science.

Purpose of the Research

The aim of this research is to examine the development of mathematics during the Great Seljuk period.

Method of research

This study was prepared to examine the development of mathematics during the Great Seljuk period in the light of literature. In this study, a literature review was conducted. In this study, the data in the literature are described and evaluated in detail.

Data Collection Tools

In this study, the development of mathematics during the Great Seljuk period was examined. For this purpose, academic studies on the subject were examined. In order to identify these studies, DergiPark, Google Scholar, Wiley Online Library, Science Direct, ACM Digital Library, ERIC (Education Resources Information Center) and YÖK National Thesis Center academic journal databases were scanned.

Analysis of Data

Literature review is the process of examining existing sources and documents and collecting data from these documents. This process contributes to the identification and understanding of the problem in the research (Karasar, 2005). For this reason, a literature review was conducted in this study. The data obtained as a result of the literature review has been tried to be organized and interpreted in a way that the reader can understand.

Great Selcuk State and Mathematics

The Great Seljuk State is a Turkish state founded in 1037 by the Kınık tribe of the Oghuz Turks in the Middle Ages. The capital of the state, which is affiliated with the Turkish-Iranian tradition, is the city of Nishapur. While the official language of the Great Seljuk state is Persian, the language of the army is Turkish. Arabic is also among the widely spoken languages. The Seljuks, who ruled over a wide geography for many years, were effective in bringing Iranian culture to Anatolia and trained very important scientists who contributed to world history. Especially during the reign of Sultans Alparslan and Melikşah, great importance was given to education and training, and educational activities were generally carried out in madrasahs. They have carried out important studies in the fields of medicine, astronomy, physics, chemistry and mathematics (TDV Islamic Encyclopedia). The first name that comes to our mind with his works in the field of mathematics is undoubtedly Omer Khayyam. Sultan Alparslan and vizier Nizamülmülk's view of positive sciences is of great importance in Ömer Khayyam's contribution to mathematics. Nizamülmülk, the Vizier of Alparslan and Melih Shah, gave 10,000 dinars to Ömer Hayyam to continue his mathematical studies (Tekeli, 1996). This support did not go in vain and eventually "El Cebir vel Mukabale", the most important algebra book of its time worldwide, was published (Baki, 2014). As a matter of fact, in a geometry book he wrote before entering the service of Melik Shah, Omer Khayyam stated that rational sciences other than astronomy and medicine were not evaluated during his time. Omer Khayyam, who devoted his life to the study of mathematics and astronomy, is better known as a poet. He was not pleased to serve in the palaces of the Seljuk sultans and the vizier Nizam al-Mulk and preferred a quiet life for scientific research; He preferred to travel and live in science and art centers such as Samarkand, Bukhara, Balkh and Isfahan. Ömer Khayyam is the first person in the history of mathematics to classify equations systematically (Baki, 2014). This classification is still used today. He divided simple and compound, and compound ones according to their coefficient numbers. He gave 25 forms of the first, second and third degree equations and showed with examples how each of them was solved. He solved various groups of second degree equations. He benefited from geometry while making these solutions because, according to Ömer Khayyam, if the geometric proof is known, the arithmetic solution can be better understood. He managed to solve 13 types of third degree equations. He says that the solutions of third degree equations can be solved by using the intersection of conic sections, but the same method cannot be applied to higher than third degree equations because the space is three-dimensional. This is a great development for the science of mathematics. According to Ömer Hayyam, although we cannot express length numerically, we can think of it as a number, and here we encounter the concept of "x" (Tekeli, 1996). He accepted positive roots in equation solutions and rejected negative roots. If the equation has no positive and real roots, it says that the equation is unsolvable. The reason for this is that he generally worked on half parabola and half hyperbola (Vakar Ahmed Rızvî, 1998). As can be understood from here, Ömer Hayyam tried to build a bridge between analytical geometry and algebra. It was known by Euclid that the formula (a+b)n in the binomial expansion should be n = 2, and the calculation of higher values of n was first made by Ömer Hayyam. He is the first mathematician to point out Pascal's triangle. We see this in his works (Dilgan, ibid., p. 7). Ömer Hayyam discovered the methods of geometrical extraction of square roots, cube roots, four, five and higher order roots and gave their proofs (Tekeli, 1996). He also worked on Euclid's axioms. As an astronomer, Ömer Khayyam prepared a new calendar (Jalali Calendar) based on observations and measurements, and calculated the length of a solar year as 365.24219858156 days. Let us now state that a known year has 365.242190 days and the 6th digit after the comma changes every 70 years (Ülger, 2017). In the Great Seljuk state, progress was made in the field of mathematics during the reign of Sultan Sencer. He gathered around him many scientists such as Hazini, Enverî, Mui'zzi, Savî, İlâkî. Among these, Hazini has studies in the fields of physics and astronomy. He wrote a "zic" for Sultan Sencer, based on his own observations, under the name "Ez-Zîc el-Mu'teber el-Sencerî el-Sultanıi". The part that concerns mathematics is the trigonometric studies it deals with. He gave sine and cotangent tables of each degree down to the second. He gave the nodal movement of the Moon as fractions extending to 7 or more digits. He determined the coordinates of 530 stars at the latitude of Merv for the years 1135-1136 and measured the inclination of the ecliptic in Isfahan (Tekeli, 1996). Nizameddin's Nişabüri is one of the important names of the period. His book titled "er-Risâletü'ş-Şemsiyye fi'l-ḥisâb" is a treatise on the basic principles and applications of mathematics (Fidan, 2016). El-Nesevi is one of the mathematicians who worked in the same period. He made studies on Indian arithmetic and the works of Archimedes. In his work titled El Mukni, he developed approximate formulas that give the square and cube roots of natural numbers. He solved the problem of dividing the angle into three, which had been discussed for many years, with a new method. He taught geometry, mathematics and medicine in Simnan. In the history of mathematics, he is one of the leading mathematicians who know the concept of decimal based on Indian mathematics well. First of all, he applied Indian mathematical techniques to the

Hisâbi mind's understanding of unit fractions. On the other hand, he establishes the sexagesimal system according to Indian numbers and integrates it into the basic arithmetic operations performed with this base (İhsan Fazlıoğlu, Nesevi, TDV İslam Ensiklopedisi; Yılmaz). Another mathematician about whom we have very little information is Kuşyar bin Lebban. He treated Indian number systems and sexagesimal number systems in an orderly manner. He transferred the numbers and methods of Indian mathematics to the astronomical calculation system for the first time. He successfully applied both Indian and sexagesimal number systems to square and cube root calculations. In some division and square root operations, the fact that the result is continuous indicates that it approaches the decimal fraction system. In geometry, he studied planar and spherical trigonometric functions. He gave the sine, cotangent, tangent, versed-sine tables with the differences between them. El Esfezari is one of Omar Khayyam's colleagues and the information we have about him is limited. It is known that he carried out studies on Euclidean geometry (TDV Islamic Encyclopedia). Al Baghdadi is another colleague of Omar Khayyam. He dealt with Euclidean geometry. Ghazali, one of the well-known names of the period, created a lot of controversy with his philosophical comments. Their approach that divine truth is superior to rational truth and that those who deal with arithmetic, geometry and astronomy will admire the sophistication in these sciences and want the same thing from all sciences was misinterpreted by Muslim circles and, since it was very popular, it kind of hindered the progress of eastern mathematics and positive sciences (Sarton, 2018).

Results

It has been determined that mathematics affects the development of other sciences and enables students to be successful in other courses (Kükey, Tutak, 2019). A teacher should not have difficulty in transferring mathematics to real life (Işık, Tutak, Kalkan, 2020). When we look at the pre-Islamic development of mathematics in the Turks; Because societies are nomadic, theoretical knowledge in terms of mathematics is scarce. However, it is seen that mathematics is used in practice in terms of decorative art and depictions of nature. In this respect, Huns and Kök Turks are the societies that used the most common decorative art. The most important work of the Köktürks is the Turkish Calendar with 12 Animals. Uyghurs, on the other hand, have benefited from mathematics by settling down and building water channels, building stone buildings, and establishing formal education. Later, the Karakhanids, the first state to accept Islam, developed the decimal system in the military. In another period, the Islamic period, we encounter the Ghaznavids. Biruni, the greatest scholar of the Ghaznavids, worked with trigonometric functions and introduced terms such as tangent, cotangent and cosecant. At the same time, Biruni is the first scientist to calculate the diameter of the world. Another state is Tolunoğulları. Tolunids minted gold coins in mints and opened new water channels. This proves that they can perform mathematical operations. If we examine the Great Seljuk Period, there are scientists who made a name for themselves here. These are Ömer Khayyam, El Nesevi, Nizameddin En Nişaburi, Kuşyar Bin Lebnan. Omar Khayyam's greatest contribution to mathematics is his discovery of the triangle known as 'Pascal's Triangle'. The origin of this is the 'Khayyam Triangle.' Khayyam is also the first scientist to find the binomial expansion. He was interested in algebra. He also holds the title of being the first scientist to know his date of birth. This is because he has mastered the calendar calculation. Kuşyar bin Lebnan made trigonometric calculations based on Biruni's knowledge. In the Golden Age of Islam, there were Yusuf Has Hacip, Farabi and Ibn Sina. Although Ibn Sina is known as a medical doctor, he divided the science of mathematics into four headings and divided these headings into sub-headings. When Farabi is mentioned, we think of his classification of mathematics and his book of geometry. Yusuf Has Hacip, on the other hand, did not try to prove the existence of Allah in his book Kutadgu Bilig, but categorized it. This categorization will appear as the Peano axioms 800 years later.

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MATHEMATICIANS IN THE OTTOMAN PERIOD AND THE REPUBLICAN PERIOD

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Abstract

The purpose of this research is to portray the scientists and their contributions that shaped mathematics in the Ottoman and Republican periods. We had many famous mathematicians both during the Ottoman period and the Republic period. These mathematicians have made many developments since the time they lived in. Mathematicians living in the Ottoman period made many innovations. Mathematicians living in the Republican period both continued these developments and gave importance to institutionalization. Books about mathematics were written by mathematicians living in both the Ottoman period and the Republic period. In addition, these scientific studies were further institutionalized during the Republic period. Master's and doctoral studies in the field of science started during the Republic period. For the development of countries, innovations in education must be constantly made. Mathematics education has been as important as mathematics as a branch of science for centuries (Bayraktar, Aydoğdu, Tutak, 2022). It has been determined that the order in mathematics will be very effective in understanding the order between the universe and the events in the environment (Kükey, Tutak, 2019). It is essential that the development of mathematics, one of the most important dimensions of education, be continuous. It is very important to know its historical development in order to ensure continuous development. In addition, this development process must be transferred to new generations through studies.

Keywords: *Mathematicians, History of Mathematicians, History of Mathematics*

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Introduction

According to Fried (2001), the history of mathematics is a result of human activities that contribute to the meaning of mathematics, make mathematics different and remarkable, and make the invisible aspects of problems understandable. Farmaki, Klaudatos and Paschos (2004) describe the basic roles of the history of mathematics as a scientific discipline; It reveals the origins of mathematics, its uses, and its relationships with society and other fields of science. Bidwell (1993) stated that the history of mathematics is a branch of science that deals with the development processes of mathematics, the lives and works of people who contributed to mathematics, and the social and cultural dimensions of mathematics. In this study, we tried to portray the mathematicians who contributed to mathematics in the Ottoman period and the Republic period and their works. Looking at the Ottoman period, Gelenbevi İsmail Efendi was the first person to bring logarithm to Turkey. Hoca İshak Efendi is considered among the pioneers who established modern science in Turkey. He also carried out studies in the fields of mathematics, astronomy, metallurgy and geology. Hüseyin Tevfik Pasha was sent to the USA in 1872 with the task of checking the production of rifles ordered by the Ottoman Empire to American arms factories and whether the specifications were complied with. He stayed in Rhode Island, USA, until 1878, during which time he dealt with mathematics; He wrote his English book Linear Algebra at this time and found a way to apply the multiplication proposed by Argand in his theory of complex numbers to three-dimensional space. Matrahçı Nasuk prepared tables showing length measurements and led those who came after him in this regard. When we look at the mathematicians of the Ottoman period and the Republic period, we witness these and many similar studies and innovations.

Purpose of the Research

The aim of this research is to examine mathematicians and their important contributions in the Ottoman and Republican periods.

Method of research

In this study, a literature review was conducted. In this study, the data in the literature are described and evaluated in detail.

Data Collection Tools

In this research, mathematicians and their important contributions in the Ottoman and Republican periods were examined. For this purpose, academic studies on the subject were examined. In order to identify these studies, DergiPark, Google Scholar, Wiley Online Library, Science Direct, ACM Digital Library, ERIC (Education Resources Information Center) and YÖK National Thesis Center academic journal databases were scanned.

Analysis of Data

Literature review is the process of examining existing sources and documents and collecting data from these documents. This process contributes to the identification and understanding of the problem in the research (Karasar, 2005). For this reason, a literature review was conducted in this study. The data obtained as a result of the literature review has been tried to be organized and interpreted in a way that the reader can understand.

Gelenbevi İsmail Efendi

Gelenbevi İsmail Efendi, born in 1730 in Gelenbe town of present-day Manisa, is one of the mathematicians of the Ottoman Empire. His real name is İsmail. Since he was born in the town of Gelenbe, his second name comes from the town where he was born. It became famous mostly under the name Gelenbevi. Gelenbevi is the last Ottoman mathematician who solved problems with the old method. Upon the requests of Grand Vizier Halil Hamid Pasha and Admiral Algerian Hasan Pasha, he was appointed as a mathematics teacher at the Mühendislikhane-i Bahrî-i Hümâyûn, opened in Kasımpaşa, with a salary of sixty kuruş. This appointment brought him financial comfort. A story is told about him as follows: ‘Some weapons did not hit the target, sultan III. He angered Selim and then called Gelenbevi to his presence and gave him a warning. Thereupon, Gelenbevi estimated the distances to the target, made the necessary corrections in the weapons and ensured that the cannons hit the target. This success of Gelenbevi attracted the attention of the sultan and he was rewarded by the sultan. Gelenbevi left more than 30 works in Turkish and Arabic. Gelenbevi İsmail Efendi was the first to introduce logarithm to Turkey. There is also Gelenbevi Anatolian High School named after him in Fatih, Istanbul (Abdulkuddüs, 1988).

Hoca İshak Efendi

He is considered among the pioneers who established modern science in Turkey. He first became a riyaziye (mathematics) teacher at Mühendislikhane-i Berr-i Hümayun, and then “başhoca” (school principal) between 1830 and 1836. He worked in mathematics, astronomy, metallurgy and geology. His extensive and rapid translations played an important role in Ottoman scientific and educational life before the Tanzimat period. His most important work is “Mecmua-i Ulum-Riyaziyye” (Mathematical Sciences Selection), which consists of four volumes. Science terms derived from Arabic terms have been used in Turkey for a long time (Çuluk, 2021). His most important work is called “Mecmua-i Ulum-Riyaziyye” (Selection of Mathematical Sciences). In Ottoman science literature; It is the first book that brings together the published Turkish texts of many natural and mathematical sciences such as mathematics, physics, chemistry, astronomy, biology, botany, zoology and mineralogy

(Seyitdanlıoğlu, 2021). As the printing of each volume was completed at the Mühendislikhane Printing House, it was announced through the Takvim-i Vekayi; II. It was met with Mahmut's appreciation and praise. It is understood that this encyclopedic work was compiled from French sources published approximately 45-50 years ago. After Mecmua-i Ulûm-ı Riyaziye, Hoca İshak played an important role in the transition from madrasah education to modern science in Turkey by translating ten separate scientific books, totaling 13 volumes, one after the other between 1826 and 1834. All of his published books were taught as textbooks at Mühendislikhâne-i Berrî-i Hûmâyun after him (İhsanoğlu, 2021).

Vidinli Hüseyin Tevfik Pasha

With his talent in mathematics lessons at the Military Academy, he attracted the attention of his mathematics teacher Tahir Pasha, who graduated from Cambridge University, and Tahir Pasha gave him private lessons. After graduating, he started giving algebra lessons at the Military Academy. When Tahir Pasha died, his mathematics lessons were left to Hüseyin Tevfik Pasha. While he was still teaching at the Military Academy, he was appointed to the Tophane Experience and Examination Commission. In 1868, he was sent to Mekteb-i Osmanî in Paris as assistant director and was also assigned to conduct studies on ballistics and rifle manufacturing. Meanwhile, he attended university in Paris to improve his mathematical knowledge and published articles and attended scientific meetings during his two years in Paris (Çeçen, 1988). Hüseyin Tevfik Pasha was sent to the USA in 1872 with the task of checking the production of rifles ordered by the Ottoman Empire to American arms factories and whether the specifications were complied with. He stayed in Rhode Island, USA, until 1878, during which time he dealt with mathematics; He wrote his English book Linear Algebra at this time and found a way to apply the multiplication proposed by Argand in his theory of complex numbers to three-dimensional space. A facsimile edition of the work named "Linear Algebra", which was published in two different times, including both editions, was made by Kazım Çeçen under the name "Hüseyin Tevfik Paşa and Linear Algebra" (İTÜ, 2009).

Matrakçı Nasuh

Matrakçı Nasuh, born in the Bosnian town of Visoko, was a talented Janissary who passed through both the Infantry and Devshirme systems, a swordsman and a sniper known for his intelligence (Ayduz, 2015). He prepared tables showing length measurements and led those who came after him in this regard. He wrote his two books on mathematics, Cemâlü'l-Küttâb and Kemalü'l-Hisâb and Umdetü'l-Hisâb, during the reign of Selim I (Yavuz) and dedicated them to the sultan. In these works, that Matrakçı Nasuh presented to

Yavuz Sultan Selim, it is clear that he discovered the multiplication methods known as Naiper and modern mathematics teaching fifty years before Napier. This method, which is practically used for multiplication, division and square root operations, was published by Scottish mathematician John Napier in Edinburgh, Scotland, in 1617, fifty years after Matrakçı Nasuh, in his work called "Rabdology". In this book, Matrakçı Nasuh not only shows the triangle method he developed for multiplication, but also presents mathematical problems taken from real life to explain algebraic thinking examples and methods (İnalcık, 1993).

Mirim Çelebi and Mathematics

He is a scientist who is considered the greatest authority of his time in the fields of mathematics and astronomy in the Ottoman Empire. He solved this problem with the help of mathematics in his study, in which he examined the part of Kadızâde's work called Şerḥu'l-Mülaẖẖaṣ fî ʿilmi'l-heyʾe, which deals with the subject of "tedârîs" (the ratio of the highest mountain in the world to the diameter of the earth). He showed five different solutions with examples to calculate the sine of a 1-degree arc. In this work, he was also particularly interested in the values of trigonometric expressions and came to original conclusions (Tekeli, 1982).

Takiyüddin and Mathematics

Ottoman Turk, hezârfen, astronomer, engineer, mathematician and mechanical scientist. Takiyüddin gave the definitions of sine, cosine, tangent and cotangent, made their proofs and prepared their tables. Takiyüddin showed the fractions of trigonometric functions with decimal fractions for the first time and prepared sine and tangent tables calculated from 1 degree to 90 degrees with one-degree intervals. Since there were no logarithm tables or calculators in this period, trigonometric calculations were made using either these tables or a simple tool called rub, that is, "trigonometric quarter". Takiyüddin's works in the field of arithmetic are also very important. He developed his own practical numbering system and began to use decimal fractions instead of the sexagesimal fractions that had been used for a long time. Takiyüddin examined decimal fractions theoretically and showed with examples how to perform four operations with them. According to Takiyüddin, who learned decimal fractions from the work Miftahü'l-Hisab (The Key to Arithmetic, 1427) by Gıyasüddin Cemşid el-Kaşi, who was the director of Ulugh Beg's Samarkand Observatory, al-Kashi's knowledge on this subject was based on fractional fractions. It is limited to the operations of numbers; However, decimal fractions need to be generalized by applying them to other branches of science such as trigonometry and astronomy (Koca, 2002). Takiyüddin, in his very valuable work called Bugyetü't-Tüllab min İlmi'l-Hisab (What We Expect from Arithmetic), which he wrote with the aim of introducing the calculation methods used by the Ottomans, namely the decimal method called Hind Calculation and the sexagesimal method called Müneccim Calculation, showed decimal fractions as an alternative to sexagesimal fractions. In this work, he explained with examples how to double and halves decimal fraction numbers, add, subtract, multiply, divide, take the square root, and convert sexagesimal fractions to decimal fractions and decimal fractions to sexagesimal fractions. However, it seems that Takiyüddin did not use or develop a symbol to distinguish the whole number from its fraction; For example, he merely expressed the number 532,876 verbally as “5 Hundreds 3 Tens 2 Ones 8 Tenths 7 Hundredths 6 Thousandths” or as “532876 Thousandths”. In addition, he prepared a table to easily rank fractional numbers between the hundreds-thousandths and the hundred-thousandths place, that is, to separate the whole and fraction parts from each other (Demir, 2000). Takiyüddin said that the sexagesimal method used in determining celestial positions was not convenient in terms of calculation. Because in the sexagesimal method, multiplying and dividing numbers with many fractional digits is a time-consuming, tedious and daunting task; Even the sexagesimal square table, which is similar to the ten level table we use today, is not sufficient to overcome this difficulty. However, in the decimal method, no matter how many fractional digits there are, multiplication and division operations can be easily done, so it shows the movements of Mercury, Venus, Mars, Jupiter and Saturn in the sky, which are visible to the eye, as well as the Moon and the Sun. Takiyüddin, who aimed to solve one of the most important difficulties of astronomers with this suggestion, realized that while representing angles or arcs with decimal fractions, he could not represent their trigonometric functions with sexagesimal fractions, and used Sidretü’l-Müntehai’l-Efkar fi Melekuti’l-Feleki’d-Devvar to apply decimal fractions to trigonometry. In his work (The Limit of Knowledge of the Heavens), he showed the fractions as decimal fractions after taking the radius of the unit circle as 10 instead of 60 or 1 (Unat, 2002). In another work called Ceridetü’d-Dürer ve Haridetü’l-Fiker (The Society of Pearls and the Pearl of Opinions), which he completed in Istanbul in 1584, Takiyüddin took the last step and created a sine by taking the radius of the unit circle as 10 units and showing the fractions as decimal fractions. - He calculated the Cosine Table and a Tangent - Cotangent Table and made them available to mathematicians and astronomers. If Takiyüddin had adopted the unit length as 1 unit instead of 10 units while preparing these tables, he would have reached the system we use today. Takiyüddin was also interested in algebra and followed the arithmetic method in solving second degree equations (Unat, 2002).

Kadızade Rumi

He was a mathematician and astronomer who lived in Iran and Central Asia in the early fifteenth century. He is one of the leading scientists of the founding period of Samarkand University, which is located in Uzbekistan today and is considered one of the most respected universities in the world. His real name was Selahaddin Musa. He was born in Bursa as the son of a family from the ulema class. He is known by the forename Kadızade because his father and grandfather were judges of Bursa. The word "Rumi" meaning "Anatolia" was added to his name later. Kadızade Rumi completed his primary education in Bursa madrasas. Subsequently, he went to Khorasan and Transoxiana regions, one of the most famous science centers of the age, to improve his existing knowledge on mathematics and astronomy (Fazlıoğlu, 2018). Samarkand is one of the cultural centers that are important in the formation of the Ottoman scientific tradition. Ulugh Beg made Samarkand the capital and revitalized it intellectually. The basis of the Samarkand tradition of thought was mathematical sciences, namely mathematics and astronomy. Ulugh Beg invited Kadızade Rumi to give lectures at Samarkand University. Rumi became a leading astronomer here. Today, many historians define Kadızade Rumi as the second Ptolemy, referring to the Greek astronomer Ptolemy (Kahya, 2018). Kadızade Rumi suggested to his students to go to the Ottoman country; Ali Kuşçu and Fethullah Eş-Şirvani, who went to Anatolia with his guidance, brought the knowledge of the Samarkand mathematics-astronomy school to Anatolia. In this commentary, which is his most important work in terms of theoretical geometry, Kadızâde showed a different approach from Samarkandî at many points and in his explanations he compared Nasîrüddîn-i Tûsî's Taḥrîrü'l-uṣûl fî ʿilmi'l-hendese and Esîrüddin el-Ebherî's Iṣlâḥu'. He benefited from l-Euclides. The most important feature of Şerḥu Eşkâli't-teʾsîs in terms of Ottoman mathematics history is that it was taught as an intermediate level geometry textbook in madrasahs for many years (TDV, 2016).

Ali Kuşçu

His real name is Alaeddin Ali; his father's name is Muhammed. Although his birthplace and date are not exactly known, he was born in the 15th century. It is estimated that he was born in Samarkand at the beginning of the century. He was nicknamed "the birdman" because his father was Ulugh Beg's chief falconer. Ulugh Beg, who was himself a great scholar and protected scholars, knew Ali Kuşçu either directly through his father or through Kadızâde-i Rûmî, who was originally from Bursa and went to Transoxiana for education, and gave him lessons. Therefore, he received basic knowledge in mathematics and astronomy from Uluğ Bey, Kadızâde-i Rûmî and Gıyâseddin Cemşîd in Samarkand. Kuşçu wrote two important works in the fields of astronomy and mathematics. One of these is the astronomy book called "Fethiye" because it was finished during the Battle of Otlukbeli and presented to Fatih after the victory. The work consists of three parts. In the first part, the spheres of the planets are discussed and the movements of the planets are mentioned. The second part is about the shape of the Earth and the seven climates. In the last chapter, Ali Kuşçu gives the measurements of the Earth and the distances of the planets. This astronomy work, which was very influential in its time, is in the nature of a small handbook and was written for the teaching of astronomy in madrasahs rather than revealing new findings. Another important work of Ali Kuşçu is the mathematics book he named Muhammediye, after Fatih the Conqueror (Kütahya Dumlupınar University, 2005).

Levon Agababyan Effendi

He was born in 1887 in Bağeş (modern-day Bitlis) of the Vilayet-ı Sitte and graduated from the famous Sanasaryan College. From 1908 to 1914, he became first a teacher and then a principal at Akşehir and Kütahya national colleges. He was a mathematics teacher and opened a private school in Kütahya, which worked for only three years.

Tezkireci Köse İbrahim Efendi

There is no information about his birth and education. He is originally from Zigetvar. In the following years, he settled in Istanbul and became interested in astronomy. Ibrahim Efendi, whose profession is understood to be a biographer, is a bureaucrat scholar living in Istanbul. Tezkireci İbrahim Efendi is the pioneer of the first translation studies from Latin to Turkish in the field of astronomy in the Ottoman Empire. Later, İbrahim Müteferrika started to introduce the new sources of modern astronomy to a wide audience with his addition to Kâtib Çelebi's work called Cihannümâ, and Erzurumlu İbrahim Hakkı also wrote his work called Mârifetnâme. In the middle of the 19th century, the first work based on the new astronomy, which replaced the old astronomy, was Tezkireci Köse İbrâhim Efendi's work titled Secencel el-Eflâk fî Gâyet el-İdrâk (Mirror of the Feleks and the Purpose of Idrâkin). This work is originally a translation of French Astronomer Noel Duret's work. According to what the biographer Köse İbrahim explains in the introduction of the work, he brought the original of this work and translated it into Arabic. Then, he prepared a calendar according to this zici and applied it to Ulugh Beg Zîci. Tezkireci participated in the Uyvar Campaign alongside Köprülü Fâzıl Ahmed Pasha in 1663. Meanwhile, he reworked the work and added his own studies and formulas he developed to the work. Compiled on the Paris meridian with the sexagesimal system, zīci revised the tables and shortened them and rearranged them according to the zodiac signs. Later, he translated the introduction of the work from Arabic into Turkish and gave the work its final form. It is stated by İbrahim Efendi that he has two more works on astronomy and international calendars. He is one of the influential names in the introduction of modern astronomy to the Ottoman scientific world in the second half of the 17th century, when new astronomy studies developed in Europe began to be followed. With his translation of a work written in Latin on astronomical tables, the concepts of Copernican astronomy and modern astronomy entered the Ottoman science literature for the first time. This work is the first work to mention the Copernican system in the Ottoman scientific literature and includes the first diagram depicting this system (Gurur, 2021).

Riyaziyeci Mehmet Nadir Bey

He is an important mathematician who grew up in the last stages of the Ottoman mathematical history. Successful work and publications in number theory; There are original published solutions to the Diophantine equations; He is considered the first Turkish mathematician whose research was published in journals abroad. He is the person who discovered and trained Salih Zeki, who made significant contributions to Turkish scientific life. He is the founder of Numune-i Terakki Mektebi, which forms the basis of Istanbul High School. He is the first person to translate Hamlet into Turkish (Gökdoğan, 2022). He was born in 1856 as a child of a poor family on the island of Chios. He was raised in Istanbul under the protection of a ship captain. After completing his primary and secondary education at the military school in Bursa, he continued his education at Kuleli High School in Istanbul and then at Mekteb-I Bahriye. He learned French and English. He completed his education as a marine staff first lieutenant. Following his graduation, he worked as an engineer on a ship for 3 months and was appointed as a secretary at the Divanhane Naval Council Presidency. Upon the request of Eşref Bey, the mathematics teacher at the Naval Academy in Heybeliada, he was appointed as an assistant teacher at this school. After a while, Mehmet Nadir Bey, who was assigned to teach at Darüşşafaka, became the teacher of Salih Zeki, who would become a famous mathematician in the future, at this school and worked hard for him (Paksoy, 2021). In 1882, he founded the Şems-ül-maarif School together with Abdi Kamil Bey from Thessaloniki; seating students at desks in this school; He tried innovations such as hanging multiplication tables and maps in the classroom. After two years of experience in this school, he founded a private school in Sulaymaniyah. The name of this school, which forms the basis of today's Istanbul High School, is Numune-i Terakki Mektebi. The school, which initially consisted of primary and secondary sections and served boys, also added a girls' section and a high school section. He opened a second branch in Edirne (this branch closed within 2 years). The number of students in the school to which aristocratic families in Istanbul sent their children reached 600 in 5-6 years. Mehmet Nadir earned a very high income from this school; He lived a luxurious life. He became disinterested in school administration and over time, the school's former success disappeared. Mehmet Nadir Bey was busy with mathematical research during the five-year period he served as the director of the Tribal School, and his first articles began to be published in the magazine "L'Intermediaire der Mathematiciens'". He was particularly interested in the solution of the Diophantine Equation. When he was not given a job as a civil servant in Istanbul, he lived in poverty for a long time. He gave accounting lessons at Darüşşafaka for a while. In 1915, he was appointed as an instructor of higher accounting courses at Darülfünun. When his student Salih Zeki became the rector of Darülfünun, he founded the "Nazariye-i adad" (Number Theory) department and Mehmet Nadir Bey was appointed as the head of this department. Mehmet Nadir Bey, who remained at this chair until the end of his life, wrote twelve articles in the Darülfünun Science Faculty Magazine and published the book "Hesabı-ı Nazariye", which he wrote for senior high school students, in 1926. The work also includes its own "general rule of divisibility". He died in his home in Bebek on December 13, 1927. His life and works were compiled into a book by Erdal İnönü in 1997 under the name "Mehmet Nadir is an Education and Science Pioneer" (Istanbul High School, 2021)

Tolunoğulları and Mathematics

The Tolunoğulları State is a Turkish State that left deep traces in Turkish, Islamic, Egyptian and world history. Although it was short-lived, it was a state that made a name for itself in political, military, social, economic, scientific, cultural and architectural fields, and was praised by all Islamic historians. The Tolunoğulları State, which was founded in Egypt and spread over a wide geography from Berka to the Euphrates River, especially important regions and cities such as Syria, Palestine and Tarsus, was the first independent state established by the Turks after embracing Islam. According to the unanimous record of Islamic historical sources and researchers, Tolunoğulları was the first state to establish an independent state in Egypt after the Pharaohs and to make its people live in prosperity. During this period, Egypt experienced its happiest years in every aspect. Tolunoğulları, who set an example for the İhşidîs established after him, was governed with the understanding of the Turkish State Tradition and the state organization established by Hz. Ömer. In the political instability of the period, especially the lack of foresight of those who came to power after Humâraveyh, and the destructive activities of both its own commanders and the Turkish commanders acting on behalf of the Abbasids, the Tolunoğulları State was defeated by Muhammed b., who was also a Turk. It was destroyed by the Abbasid army under the command of Süleyman el-Kâtibi and took its place in history, leaving deep but positive traces that cannot be erased. The two most important works from the Tolunoğulları period are; Ulu Mosque and Tolunoğlu Mosque. During this period, Egypt experienced a bright period economically (establishment of control on the Spice Road, zoning and public works activities, agricultural works, etc.) Tolunoğulları built hospitals called Maristan (Encyclopedia of Islam, 2022)

Ghaznavids and Mathematics

The founder of the Ghazni State is Alp Tigin. He was the Herat Governor of the Samanids State (955). Later, Alp Tigin, who broke up with the Samanids, went to the city of Ghazni and founded a state. Because of the name of the city, this state was called Ghazni State. The greatest ruler of the Ghazni State was Sultan Mahmud of Ghazni, the son of Sebük Tigin. Mahmud (997-1030), who dethroned his brother Ismail, who ascended the throne in place of his father, captured a large part of its territory with the collapse of the Samanids State in 999. He made 17 major expeditions to India. He played a role in the spread of Islam to the banks of the Ganges River. He fought with Khwarezmshah and Karakhanids. Oghuz Yabgu had Arslan Yabgu, the son of Seljuk, brought to him by deception, arrested and imprisoned in Kalincar Castle. Thus, he was able to fend off the Oghuz danger for a while. In its time, the city of Ghazni became a major scientific and cultural center (Erdoğan, 1991). After Sultan Mahmud's death (1030), his son Mes'ud took over. Sultan Mes'ud, who was not a ruler like his father, suffered a heavy defeat against the Oghuz army under the command of Çağrı and Tuğrul Beys in a place called Dandanakan on May 23, 1040. After this defeat, the state could never recover. Ghurids captured Ghazni. Although the rulers of Ghazni retreated to the city of Lahore, the Ghurids captured this place in 1187 and put an end to the Ghazni State (Erdogan, 2007). Ghaznavid scientist Birunu, who worked in the field of science and mathematics. For Sultan Mahmud Biruni, "It is the most valuable treasure of my palace." he said.

Al Biruni and Mathematics:

Biruni was born in Khwarezm, a historical region in Central Asia. He lost his father at a young age. He was protected by the Afrigoğulları (Âl-i Irak) dynasty in Khwarezm and studied mathematics and astrology in the palace. His teachers here are Ibn-i Iraq and Abdussamed bin Hakim. During this period, he wrote his first book when he was only 17 years old. When Khwarezm came under the rule of the Ma'munid dynasty, Biruni also went to Iran and lived there for a while. Later, it started to be protected by the Ziyâris. He wrote his book El Âsâr'ul Bâkiye in the palace of the Ziyâris. After working here for two years, he returned to his hometown and started studying astronomy and astrology with Ebu'l Vefâ. Biruni's mathematician aspect is his best-known aspect. Biruni, the greatest mathematician of the century he lived in, was the first person to suggest that the radius be accepted as a unit in trigonometric functions, and he added secant, cosecant and cotangent functions to functions such as sine and cosine. This aspect of Biruni was discovered and used by the western world only two centuries later. Biruni measured the height of a mountain using trigonometry and then calculated the length of the arc of the meridian 4 Hunutlu, 2020 by measuring the angle of horizon depression from this point, knowing its elevation, is also an important work in terms of geometry. It is a common proof that the length of the meridian arc was first discovered by Biruni using this method. However, Biruni stated that he took this method from another scholar.

Republican Era and Mathematics

Modern mathematics and mathematical analysis education, which Emin Pasha and Tahir Pasha started in the mid-19th century at Mühendislikhane-i Berri-i Hümayun after studying in Cambridge, continued after Vidinli Tevfik Pasha, Mehmet Nadir and Salih Zeki towards the end of the same century. It is represented by the belt. Later, Hüsnü Hamid (Treasurer) and Kerim Erim became the pioneers of the new generation of mathematicians. It is obvious that with the 1993 university reform, Mehmet Nadir, Kerim Erim and Hüsnü Hamdi Beyler personally engaged in research activities in addition to their educational duties. These mathematicians have international papers or articles. However, with the university reform, a mathematics research institute was established for the first time within Istanbul University. With the establishment of this institute, mathematical research has begun to gain an institutional character. In the 15 years between 1933 and 1948, in our country, Kerim Erim, Ratip Berker, Cahit Arf, Lütfi Biran, Orhan Alisbah, Mustafa İnan, Nazım Terzioğlu, Ali Yar, Ferruh Şemin, Orhan Ş. An important generation of mathematicians, consisting of İçen and others, was in office (İnönü, 1973). İbrahim Hakkı from Erzurum, who also worked on differentials, also worked on Astronomy. Kerim Erim pioneered the provision of differential and integral calculus and mathematical analysis methods training in our country. He was not satisfied with just educational studies in these areas, he also started mathematical research. He is the first scientist to direct a mathematics doctorate in our country, and his doctorate is on algebra (Erdoğan, 2019). Vidinli Hüseyin Tevfik Pasha has a Linear Algebra book. This book is an analytical geometry book using vectors in today's sense. It talks about a 3-dimensional algebra that includes complex numbers and their applications in geometry (Wikipedia, 2022). Nazım Terzioğlu completed his doctorate on real and complex functions. He is the founding rector of Karadeniz Technical University (Şenkon, 1999). Ali Yar returned home from Paris, where he was sent for training, in 1908 as our country's first and the world's third aeronautical engineer. During the last period of the Ottoman Empire, he taught physics and mathematics at Galatasaray Sultani and Istanbul Darülfünun.

Ali Yar translated a total of six algebra books, one from French and five from German, into Turkish in order to nourish the mathematical thinking in the country. While these works were selected for translation, it was aimed to transfer all the subjects of modern algebra into Turkish. Ali Yar's three books on trigonometry, translated from French for high schools, are works with a strong pedagogical aspect. During his duties in these institutions, he worked with important mathematicians of the period such as Hüsnü Hamid, Salih Zeki and Mehmet Nadir. Ali Yar, one of the three Turkish faculty members who remained on the staff and was promoted to Ordinary Professor after the 1933 University reform, also served as the Dean of the Faculty of Science at Istanbul University for a while after Kerim Erim (Erdoğan, 2019). Cahit Arf coined terms such as Arf constant, Arf rings and Arf closures, which emerged in the classification of objects. He showed that synthetic geometry problems can be solved with the help of rulers and compasses. He is famous for his work on algebra (Bilhan, 1994). The subject of Ferruh Şemin's PhD study is the differential geometry of ruled levels. He completed his doctorate on this subject. He was found in America for advanced research on deformation and differential geometry of surfaces. There are translated books (İnönü, 1973). Ratip Berker studied Ordinary Differential Equations and Partial Differential Equations at undergraduate level at Boğaziçi University until 1979; Ratip Berker, who continued to teach special functions in mathematical physics, Advanced Ordinary Differential Equations and Advanced Partial Differential Equations at the master's level, ended his duty here at the age of seventy by handing over the Head of the Department of Mathematics to Fikret Kortel. He died in Istanbul in November 1997 (Wikipedia, 2022). By writing this geometry book, Mustafa Kemal Atatürk expressed his desire to bring more understandable new terms to mathematics in a geometry class he attended in Sivas. Atatürk went to Sivas on 13 November 1937 and took a geometry (Hendese) class in the high school building where the Sivas Congress was held in 1919 (Şenkon, 1999).

Result

In this study, mathematicians living in the Ottoman and Republican periods and their efforts are mentioned. Gelenbevi İsmail Efendi was the first person to bring logarithm to Turkey. Hoca İshak Efendi is considered among the pioneers who established modern science in Turkey. He also carried out studies in the fields of mathematics, astronomy, metallurgy and geology. Hüseyin Tevfik Pasha was sent to the USA in 1872 with the task of checking the production of rifles ordered by the Ottoman Empire to American arms factories and whether the specifications were complied with. He stayed in Rhode Island, USA, until 1878, during which time he dealt with mathematics; He wrote his English book Linear Algebra at this time and found a way to apply the multiplication proposed by Argand in his theory of complex numbers to three-dimensional space. Matrahçı Nasuk prepared tables showing length measurements and led those who came after him in this regard. When we look at the mathematicians of the Ottoman period and the Republic period, we witness these and many similar studies and innovations. Mirim Çelebi is a scientist who is considered the greatest authority of his time in the fields of mathematics and astronomy in the Ottoman Empire. He showed five different solutions with examples to calculate the sine of a 1-degree arc. Takiyüddin gave the definitions of sine, cosine, tangent and cotangent, made their proofs and prepared their tables. Takiyüddin showed the fractions of trigonometric functions with decimal fractions for the first time and prepared sine and tangent tables calculated from 1 degree to 90 degrees with one-degree intervals. Ali Kuşçu has two important works written in the fields of astronomy and mathematics. One of these is the astronomy book called "Fethiye" because it was finished during the Battle of Otlukbeli and presented to Fatih after the victory. The work consists of three parts. In the first part, the spheres of the planets are discussed and the movements of the planets are mentioned. The second part is about the shape of the Earth and the seven climates. In the last chapter, Ali Kuşçu gives the measurements of the Earth and the distances of the planets. This astronomy work, which was very influential in its time, is in the nature of a small handbook and was written for the teaching of astronomy in madrasahs rather than revealing new findings. Another important work of Ali Kuşçu is the mathematics book he named Muhammediye, after Fatih the Conqueror (Kütahya Dumlupınar University, 2005). Tezkireci İbrahim Efendi is the pioneer of the first translation studies from Latin to Turkish in the field of astronomy in the Ottoman Empire. Later, İbrahim Müteferrika started to introduce the new sources of modern astronomy to a wide audience with his addition to Kâtib Çelebi's work called Cihannümâ, and Erzurumlu İbrahim Hakkı also wrote his work called Mârifetnâme. Riyaziyeci Mehmet is an important mathematician who grew up in the last stages of the Ottoman mathematical history. Successful work and publications in number theory; There are original published solutions to the Diophantine equations; He is considered the first Turkish mathematician whose research was published in journals abroad. It has been determined that mathematics affects the development of other sciences and enables students to be successful in other courses (Kükey, Tutak, 2019). A teacher should not have difficulty in transferring mathematics to real life (Işık, Tutak, Kalkan, 2020). He is the person who discovered and trained Salih Zeki, who made significant contributions to Turkish scientific life. He is the founder of Numune-i Terakki Mektebi, which forms the basis of Istanbul High School. He is the first person to translate Hamlet into Turkish (Gökdoğan, 2022). Modern mathematics and mathematical analysis education, which Emin Pasha and Tahir Pasha started in the mid-19th century at Mühendislikhane-i

Berri-i Hümayun after studying in Cambridge, continued after Vidinli Tevfik Pasha, Mehmet Nadir and Salih Zeki towards the end of the same century. It is represented by the belt. Later, Hüsnü Hamid (Treasurer) and Kerim Erim became the pioneers of the new generation of mathematicians. It is obvious that with the 1993 university reform, Mehmet Nadir, Kerim Erim and Hüsnü Hamdi Beyler personally engaged in research activities in addition to their educational duties. Ali Yar, one of the three Turkish faculty members who remained on the staff and was promoted to Ordinary Professor after the 1933 University reform, also served as the Dean of the Faculty of Science at Istanbul University for a while after Kerim Erim (Erdoğan, 2019). Cahit Arf coined terms such as Arf constant, Arf rings and Arf closures, which emerged in the classification of objects. He showed that synthetic geometry problems can be solved with the help of rulers and compasses. He is famous for his work on algebra (Bilhan, 1994). The subject of Ferruh Şemin's PhD study is the differential geometry of ruled levels. He completed his doctorate on this subject. He was found in America for advanced research on surface deformation and differential geometry, and he also has translation books (İnönü, 1973).

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MATHEMATICS WITH FARABI AND IBN-I SINA

İbrahim ÖĞMEN[1], Nadir SÖNMEZ[2], Hatice Melike AKÇAY[3]

Abstract

Mathematics, generally defined as the language of numbers, is a branch of science that has existed since the existence of humanity until today and is constantly evolving. Therefore, when we look at the history of world mathematics, it has continued its continuous development under different civilizations at many different times. World history of mathematics, Prehistoric Mathematics, Babylonian Mathematics, Egyptian Mathematics, Greek Mathematics. They can be listed as Roman Mathematics, Chinese Mathematics, Indian Mathematics, Islamic Mathematics, Mayan Mathematics, Medieval European Mathematics, Renaissance Mathematics, Mathematics During the Scientific Revolution (17-18th Century) and Modern Mathematics. In this study, the intense efforts of Farabi and Ibn Sina, who made great contributions to this development process of mathematics, are mentioned. Farabi and Ibn Sina made great efforts especially for the classification of sciences. For the classification of Ibn Sina's sciences, his treatise named Risâle fî Aksâmi'l-'Ulûmi'l-'Akliyye was taken into consideration. According to Ibn Sina, wisdom is divided into abstract, theoretical and practical parts. The aim of theoretical wisdom is right, and the aim of practical wisdom is good. The subject of theoretical wisdom is those whose existence is independent of human action; The subject of practical wisdom is human actions (Akkanat, 2008). This and similar information are included in detail in the study.

Keywords: *History of Mathematics, Farabi, İbn-i Sina*

Introduction

The science of mathematics has made progress by mathematicians from past to present, and all this period from past to present is considered and examined as the history of mathematics. Often the history of mathematics is explained in

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connection with the general history of science. Mathematics education has been as important as mathematics as a branch of science for centuries (Bayraktar, Aydoğdu, Tutak, 2022). It has been determined that the order in mathematics will be very effective in understanding the order between the universe and the events in the environment (Kükey, Tutak, 2019). From this perspective, it can be said that mathematics has formed the basis of every field. Today physics, chemistry, biology, engineering, etc. All fields use mathematics. From here it can be said that the development of all sciences owes to mathematics. Aslan (2021) stated that he focused on the civilizations that directly contributed to the birth of modern science in the history of mathematics. Bidwell (1993) stated that the history of mathematics is a branch of science that deals with the development processes of mathematics, the lives and works of people who contributed to mathematics, and the social and cultural dimensions of mathematics. The history of mathematics is a science that provides a useful resource for understanding how mathematical thinking occurs and provides some insight into how positive attitudes towards the subject can be developed. According to Fried (2001), the history of mathematics is a result of human activities that contribute to the meaning of mathematics, make mathematics different and remarkable, and make the invisible aspects of problems understandable. Farmaki, Klaudatos and Paschos (2004) describe the basic roles of the history of mathematics as a scientific discipline; It reveals the origins of mathematics, its uses, and its relationships with society and other fields of science. It is very important to know and learn about the mathematicians who worked hard for the development of mathematics, which is so important in our lives. In this study, the important contributions of Farabi and Ibn Sina to mathematics during their time are mentioned.

Purpose of the Research

The purpose of this research is to examine the contributions of Farabi and Ibn Sina to mathematics.

Method of research

This study was prepared to examine the contributions of Farabi and Ibn Sina to mathematics in the light of the literature. In this study, a literature review was conducted. In this study, the data in the literature are described and evaluated in detail.

Data Collection Tools

In this study, the contributions of Farabi and Ibn Sina to mathematics were examined. For this purpose, academic studies on the subject were examined. In order to identify these studies, DergiPark, Google Scholar, Wiley Online Library, Science Direct, ACM Digital Library, ERIC (Education Resources

Information Center) and YÖK National Thesis Center academic journal databases were scanned.

Analysis of Data

Literature review is the process of examining existing sources and documents and collecting data from these documents. This process contributes to the identification and understanding of the problem in the research (Karasar, 2005). For this reason, a literature review was conducted in this study. The data obtained as a result of the literature review has been tried to be organized and interpreted in a way that the reader can understand.

Karahans and Mathematics

The rulers of the first Muslim Turkish dynasties who dominated Eastern and Western Turkestan were named Karakhanids because they widely used the title ‘kara’, meaning ‘strong’. This first Muslim Turkish community was formed by the Yagmas, a branch of the Uyghurs. Bilge Kül Kadir Khan is the first Karakhanid ruler (Öztürk, 2007). All institutions that emerged among the ancient Turks as a result of settled life; It has witnessed a great change from architecture to art, from education to science and politics. Ibn-i Sina, Farabi, Ulugh Beg, Kaşgarlı Mahmut are important Turkish scientists and thinkers who maintain their importance today. Realizing the great importance that Islam attaches to education, Turkish communities have attempted to improve education in all areas by engaging in various educational activities (Doğan, 2010).

Farabi and Mathematics

10-13. In the 19th century, scientific studies in the Turkish-Islamic world moved to a very advanced level. Science and scientists were highly valued by the rulers. In addition, the scientists who grew up in this period deeply influenced Europe. Farabi, who has 160 works on physics, mathematics, astronomy and logic, was called the second teacher because he explained Aristotle’s ideas very well. In the Western world, he became famous under the name “Al-Pharabius” and many of his works were translated into Latin and used as textbooks in colleges (Kafesoğlu, 1997). We learn about Farabi’s views on mathematics from his work titled Commentary on the Beginning of the Fifth Book of Euclid (Şerh-i Sadr el-Makale el-Hâmise). Here, Farabi reconciled Aristotle’s view of “description = close genus + distinction” with Euclid’s descriptions in geometry and sought an epistemological basis for Euclid’s geometry. He managed to reach some geometric concepts by describing Euclid’s undefined terms. Farabi also claimed that by examining mathematical objects, one becomes inclined to acquire knowledge about God. In his work titled İhsa’ül-Ulum (1990) for the classification of Farabi’s sciences, Farabi first divided the sciences into five large sections:

- Linguistics,
- The science of logic
- Science of mathematics
- Metaphysics and physics (Polat, 2015)
- Politics, fiqh and kalam (morality and civilization).

Then he listed the sciences within them separately and in an orderly manner. As a method, Farabi started from the general sciences to the special sciences and sub-branches.

He listed the mathematical sciences, which he called educational sciences, as follows:

- Numbers (account),
- Hendese (geometry),
- Menâzır science (optics),
- Nucum (stars) science,
- The science of music,
- Cerr-i eskal (weights) science
- The science of precautions (tricks).

Farabi made separate classifications as practical and theoretical for each of these seven departments, which he listed under the title of mathematical sciences. He described the practical part of the science of number as determining the numbers of things that need to be counted. He states that the theoretical part examines numbers absolutely, isolated from objects and things counted in the mind. The theoretical science of number examines the properties of numbers theoretically, and according to Farabi, this is the part that should be considered as the real science. He stated that in the practical part of the science of geometry (geometry), people such as carpenters, blacksmiths, architects and engineers who use geometry in practice are interested in the shapes of material objects in their field, but in theoretical engineering, lines, surfaces and volumes are handled theoretically, independently of the objects. He also stated that, just like the science of numbers, what is accepted as the real science is theoretical mathematics.

Farabi did not separate the science of Menâzır (optics) into practical and theoretical. He stated that although the science of optics is included in the subject of geometry, it needs to be considered as a separate science since it is related to the appearance of objects and vision. He divided this science into two parts, which examine objects viewed with straight light and objects viewed with non-flat light, as well as the science of mirrors. The science of Nücûm (stars); He examined it in two groups: the science of judgments derived from stars and the science of positive stars. He stated that the first one was only related to subjects such as fortune-telling and dream interpretation, and therefore only the second one could be considered among the real sciences. The subject of the science of positive stars is; He explained it as the investigation of issues such as the shapes, postures, positions, movements of objects in the sky, solar eclipses, day and night, the formation of climates, settlement areas on earth, and the length of night and day there.

He divides the science of music into two parts: practical and theoretical music. Practical music is about creating tunes and melodies on natural or artificial musical instruments. Theoretical music, on the other hand, is the science of melodies and tunes, regardless of the instrument or object, and examines the reasons for their formation. He also divides the science of Cerr-i eskal (weights) into two groups. The first one is about the determination of weights, that is, scales. The second is about the weights that are moved or used to move them, that is, the tools used to lift and carry. The seventh science, which he named the science of measures (tricks), seems to be a combination of the application areas of the other six mathematical sciences, although it mostly includes mechanics and engineering subjects. He defines this science as the measures taken to ensure that the things whose existence is demonstrated by proof in mathematical sciences and the objects in nature are in harmony with each other. Algebra and correspondence are common to the science of number and geometry, and the ratios of numbers are the same as the ratios of magnitudes; Thus, he stated that rational and irrational numbers can be represented by magnitudes. Farabi also includes geometry measures; He listed measures such as building construction, measuring objects, preparing stargazing instruments, musical instruments, weapons and bows. Enabling distant objects to be seen (lenses) and mirrors are measures related to optics. Building construction, making tools, carpentry, and measuring measures were listed among the measures (tricks) of applied crafts in cities (Pattabanoğlu, 2017).

İbn-i Sina and Mathematics

For the classification of Ibn Sina's sciences, his treatise named Risâle fî Aksâmi'l-'Ulûmi'l-'Akliyye was taken into consideration. According to Ibn Sina, wisdom is divided into abstract, theoretical and practical parts. The aim of theoretical wisdom is right, and the aim of practical wisdom is good. The subject of theoretical wisdom is those whose existence is independent of human action; The subject of practical wisdom is human actions (Akkanat, 2008). The parts of theoretical wisdom are three; the lowest science is physics, the middle science is mathematics, and the higher science is metaphysics. Such a ranking is not related to the importance of the sciences, but is due to the relations of the sciences with matter. The things that are the subject of physics cannot be isolated from matter, neither in the outside world nor in the mind. Those who are the subject of mathematics can be abstracted from matter in the mind, but not in the outside world. Those that are the subject of metaphysics are not related to matter, neither in the outside world nor in the mind (Akkanat, 2008). After dividing theoretical and practical wisdom into sections, Ibn Sina explained the basic branches of science and sub-branches of science of each wisdom. Mathematics has been considered among theoretical wisdom because it deals with entities whose existence is independent of human actions. The existence of mathematics is related to matter and motion, but its definition is independent of matter. For example; In a rectangular object, the shape of the object is considered independently of itself (Unat, 2020).

There are four basic branches of mathematics; arithmetic, geometry, astronomy, music. In arithmetic; Number types, their properties and the relationship between them are examined. In geometry; Lines, surfaces, volumes, their dimensions and proportions are discussed. The topics of geometry include the topics in Euclid's book Method. Astronomy; It is about the states of the parts of the universe, their positions relative to others, their measurements, dimensions, and the movements of the heavens and stars. The subjects of astronomy are the subjects found in the book al-Majasti (Akkanat, 2008). Following the basic science branches of mathematics, separate sub-science branches are given for each basic science branch. Sub-branches of arithmetic; These are the Indian operations of addition, division and algebra. Sub-branches of geometry are surface area, mechanics, levers, weights and scales, precision instruments, optics and mirrors, and water transportation (Akkanat, 2008).

Yusuf Has Hacip and Mathematics

In Kutadgu Bilig, the importance and necessity of arithmetic (calculus), algebra and engineering (geometry) sciences, which are the sub-branches of mathematics, are emphasized. Many examples are given from different branches of mathematics. Kalafat identified 40 terms related to the concept of accounting in Kutadgu Bilig. These terms are: heavy (expensive), purchase (debt, anything borrowed); purchase unit (shopping, debt settlement, payment), altun (gold), artuk (more, rather, more), asıg (profit, benefit, gain), asıgçı (usurer, utilitarian, profiteer, usurer), copper (copper, money), bıçuk (half), unit (debt, to give), bitig (letter, account book), bitigçi (printer, clerk, accountant), elig sakış (four transactions, black sentence), eksük (incomplete), kaznak / Kıznak (treasury), Kız (expensive, expensive), Izmir (come and go), Kumaru (inheritance), Kümüş (silver), Mün (capital), Orunç (bribe), sa- (count), san (number, counting).), sakış (counting, counting), sakışçı (calculator, accountant), sat- (to sell), satıg (selling, selling, trade), satıgçı (merchant, seller), tavar (goods, property), tabig (buying). giving), cheap (worthless), ülüg (share, share), ülüş (share, share, share), half, mourning (damage), yulug (a type of tax, sacrifice, ransom).

Since the concept of account is a common subject area of accounting and mathematics, accounting terms are also included in the aforementioned study. Among these terms, the words artuk, bıçuk, eksük, half are not used as mathematical terms in Kutadgu Bilig. Turkish terms directly related to mathematics; sa-, san, sakış, sakışçı, elig sakış. In the work, the word sakış is used for arithmetic and algebra. In Kashgarli, the verb sak- (to count, accept) is given. Sakış is not just a simple counting or counting knowledge. In one aspect, it is the science of arithmetic. This science is the window of mathematics to daily life. In the work, statements about the importance of mathematics are given through Ögdülmiş's mouth. While explaining how a person who will become a vizier should be, Ögdülmiş mentions the importance of knowing the science of calculation. Knowing Sakish is as necessary as reading all kinds of documents and documents. It is necessary to read all kinds of documents and make calculations in the payment of workers' rights in the state administration (Erdem, 2019). While Ögdülmiş explains to the ruler how a treasurer should be, he emphasizes that the treasurer must know sakış (accounting). Sakış (account) registration must be done correctly. In this case, mathematics integrates with the recording system of accounting science. In the work, the name sakış is combined with other words to form different mathematical terms. Elig sakış, which is referred to as black sentence in Arat's translation, is one of these terms. What is meant by this term is not a simple four operations. It is a mathematical tradition belonging to the Turkish-Islamic tradition. It is a calculation process performed by using knuckles, fingers and hands for mental calculations. It is a mathematical term defined for four operations in Hesab-ı Hevâî. Expressions such as elle dut- (to hold in hand), elde diyü (by saying in hand) and nowadays in hand var, which have been used in arithmetic operations since the Ottoman period, are reflections of the idiom elig sakışı. In Kutadgu Bilig, the word saḳış is saḳış tut- (to calculate-calculate), saḳış artanı. It is also used in the expressions (to spoil the account, to miscalculate).

In Kutadgu Bilig, the branches of mathematics such as arithmetic (number and calculation) and algebra (generalization of numerical operations by substituting signs instead of numbers) are given directly with the Turkish word sakış, while the science of geometry is covered with the Arabic word hendese. When learning mathematics, hendese saḳışı tut- (doing geometry calculations) is the next stage after elig saḳış. In the work, hendese, yinçge are described as saḳış (fine calculation). Thanks to Hendese, complex calculations (ir root sa-) regarding the earth and the sky can be made.

Yusuf Has Hâcib is interested in many areas of mathematics and knows well that these areas are not independent of each other. The Alexandrian mathematician Euclid, who lived between 330-275 BC, is also important for Yusuf Has Hâcib. Euclid is the mathematician whose name is most associated with geometry. According to Yusuf Has Hâcib, Euclid should also be known thoroughly. Hâcib sees Euclid as a door. He says that the advanced knowledge of geometry hidden behind this door can be achieved by studying algebra. Kalafat brings a different interpretation to the expression cebr ü muḳabel(u) in this couplet. According to that; Even though this phrase reminds us of Harezmî's work called "Kitabü'l-Muhtasar fi Hisabi'lCebr ve'l-Mukabele", it is not appropriate in terms of meaning. This expression involves analyzing a complex set of equations. In the light of the valuable information given by Kalafat about cebr ü muḳabel(u), the following comment can be made: Yusuf Has Hâcib used the expression ceb ü muḳabel(u) with interpretation. He preferred this term for complex equations and also referred to the work of Harezmi. Hâcib presents the works and information that need to be learned about arithmetic and algebra before moving on to hedese. Then he directs it to the hendese again. The gate of the hendese is Euclid. Although Has Hâcib regards Euclid as a gateway to geometry, he also alludes to a historical event. Euclid studied at the Plato school. On the door of this school, it is written: "Those who do not know geometry cannot enter (Those who do not understand mathematics cannot enter). The philosophical basis of this saying is the desire to learn the true secret of the universe. This request was emphasized by Hâcib with the expression "yime oḳlidis ḳapġı yetrü toḳı". This secret, based on calculation and mathematics, is also the basis of worldly and 'uḳbi affairs. Hâcib used mathematical logic at the very beginning of his work. In the chapter titled "Ten {gri 'azze ve celle ögdisin ayur" he tries to prove the existence of the number 1 almost logically. These determinations were mathematically proven by Peano only eight centuries after Kutadgu Bilig. In his proof, Peano accepts the existence of the number 1 and the existence of the next number of each number. In the couplet below, Yusuf Has Hâcib gives a theory of mathematical logic that was tried to be proven centuries after him. The expression "Törimiş two one tanuḳ" briefly means that if there are two, there is also one.

Results

Because pre-Islamic societies were nomadic, theoretical knowledge in terms of mathematics was scarce. However, it is seen that mathematics is used in practice in terms of decorative art and depictions of nature. In this respect, Huns and Kök Turks are the societies that used the most common decorative art. The most important work of the Köktürks is the Turkish Calendar with 12 Animals. Uyghurs, on the other hand, have benefited from mathematics by settling down and building water channels, building stone buildings, and establishing formal education. Later, the Karakhanids, the first state to accept Islam, developed the decimal system in the military. It has been determined that mathematics affects the development of other sciences and enables students to be successful in other courses (Kükey, Tutak, 2019). A teacher should not have difficulty in transferring mathematics to real life (Işık, Tutak, Kalkan, 2020). In another period, the Islamic period, we encounter the Ghaznavids. Biruni, the greatest scholar of the Ghaznavids, worked with trigonometric functions and introduced terms such as tangent, cotangent and cosecant. At the same time, Biruni is the first scientist to calculate the diameter of the world. Another state is Tolunoğulları. Tolunids minted gold coins in mints and opened new water channels. This proves that they can perform mathematical operations. If we examine the Great Seljuk Period, there are scientists who made a name for themselves here. These are Ömer Khayyam, El Nesevi, Nizameddin En Nişaburi, Kuşyar Bin Lebnan. Omar Khayyam's greatest contribution to mathematics is his discovery of the triangle known as 'Pascal's Triangle'. The origin of this is the 'Khayyam Triangle.' Khayyam is also the first scientist to find the binomial expansion. He was interested in algebra. He also has the title of being the first scientist whose birth date is known. This is because he has mastered the calendar calculation. Kuşyar bin Lebnan made trigonometric calculations based on Biruni's knowledge. In the Golden Age of Islam, there were Yusuf Has Hacip, Farabi and Ibn Sina. Although Ibn Sina is known as a medical doctor, he divided the science of mathematics into four headings and divided these headings into sub-headings. When Farabi is mentioned, we think of his classification of mathematics and his book of geometry. Yusuf Has Hacip, on the other hand, did not try to prove the existence of Allah in his book Kutadgu Bilig, but categorized it. This categorization will appear as the Peano axioms 800 years later. When we come to the Ottoman Period, we will be greeted by Gelenbevi İsmail Efendi, Hoca İshak Efendi, Vidinli Hüseyin Tevfik, Matrakçı Nasuh, Mirim Çelebi, Takiyüddin, Riyaziyeci Mehmet Nadir Bey and Ali Kuşçu. Gelenbevi İsmail Efendi was the last mathematician who solved problems with the old method and introduced logarithm to our mathematics. Hoca İshak Efendi is one of the founders of modern science. Vidinli Hüseyin Tevfik wrote an English book called Linear Algebra. He synthesized the information on the trigonometric information left by Takiyüddin Biruni, the scientist who left the most information of this period. He made astronomical calculations in his own observatory. If he had used 1 unit instead of 10 units, he would have reached our current system. Riyaziyeci Mehmet Nadir Bey holds the title of being the first Mathematician to be published in a magazine abroad. When we come to the Republic Era, Ataturk will undoubtedly welcome us. He is not only a leader but also a scientist. He introduced many concepts of

Turkish mathematics in his book titled Geometry, which he wrote with his own hand. During this period, Kerim Erim was also the first scientist to manage a mathematics doctorate in our country and worked on differential equations. Ali Yar translated many mathematical works into Turkish upon Ataturk's request. Another name of this period is Cahit Arf. This mathematician, who contributed to our mathematics with Arf Rings and Arf Constant, solved synthetic geometry problems with the help of ruler and compass. Other important names of this period are Ferruh Şemin and Ratip Berker. Today, mathematical studies are still continuing and we hope that Turkish scientists will contribute to these studies at the highest level.

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TURKS AND MATHEMATICS BEFORE ISLAMIC

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Abstract

The purpose of this research is to learn the relationship and development of Turks and mathematics before Islam. For this purpose, an extensive literature review was conducted. As a result of the literature review, data about Huns and mathematics, Gokturks and mathematics, and Uyghurs and mathematics were obtained. The data obtained was evaluated and converted into a report. It is essential for countries to progress in the field of education in order to develop. In order to develop in the field of education, it is necessary to know the history of education well. If countries know the stages they have gone through in the field of education better, they can create the right education policies in that direction towards the future. Therefore, this study is in the form of a research that provides a general picture of mathematical developments about Huns and mathematics, Gokturks and mathematics, and Uyghurs and mathematics. Conducting such studies in depth is very important for the development of education.

Keywords: *Mathematics, History, Number*

Introduction

The origin and historical development of the word "mathematics", which we encounter almost everywhere in our lives, has been one of the discussed topics. Mathematics, derived from the Greek word "Mathema" meaning science, knowledge and learning, was used in the first inscriptions to indicate any field of teaching or study (Burton, 2017). The science of mathematics has made progress by mathematicians from past to present, and all this period from past to present is considered and examined as the history of mathematics. Often the history of mathematics is explained in connection with the general history

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of science. Aslan (2021) stated that he focused on the civilizations that directly contributed to the birth of modern science in the history of mathematics. Bidwell (1993) stated that the history of mathematics is a branch of science that deals with the development processes of mathematics, the lives and works of people who contributed to mathematics, and the social and cultural dimensions of mathematics. Mathematics education has been as important as mathematics as a branch of science for centuries (Bayraktar, Aydoğdu, Tutak, 2022). It has been determined that the order in mathematics will be very effective in understanding the order between the universe and the events in the environment (Kükey, Tutak, 2019). The history of mathematics is a science that provides a useful resource for understanding how mathematical thinking occurs and provides some insight into how positive attitudes towards the subject can be developed. According to Fried (2001), the history of mathematics is a result of human activities that contribute to the meaning of mathematics, make mathematics different and remarkable, and make the invisible aspects of problems understandable. Farmaki, Klaudatos and Paschos (2004) describe the basic roles of the history of mathematics as a scientific discipline; It reveals the origins of mathematics, its uses, and its relationships with society and other fields of science.

The purpose of this research is to learn the relationship and development of Turks and mathematics before Islam. For this purpose, an extensive literature review was conducted. As a result of the literature review, data about Huns and mathematics, Gokturks and mathematics, and Uyghurs and mathematics were obtained. The data obtained was evaluated and converted into a report.

Purpose of the Research

The aim of this research is to examine the relationship between Turks and mathematics before Islam and its development according to periods.

Method of research

This study was prepared to examine the relationship between Turks and mathematics before Islam and its development according to periods in the light of the literature. A literature review was conducted to determine these. In this study, the data in the literature are described and evaluated in detail.

Data Collection Tools

In this study, the relationship between Turks and mathematics before Islam and its development according to periods were examined. For this purpose, academic studies on the subject were examined. In order to identify these studies, DergiPark, Google Scholar, Wiley Online Library, Science Direct, ACM Digital Library, ERIC (Education Resources Information Center) and YÖK National Thesis Center academic journal databases were scanned.

Analysis of Data

Literature review is the process of examining existing sources and documents and collecting data from these documents. This process contributes to the identification and understanding of the problem in the research (Karasar, 2005). For this reason, a literature review was conducted in this study. The data obtained as a result of the literature review has been tried to be organized and interpreted in a way that the reader can understand.

Huns and Mathematics

Huns, 4-6 AD. They are a nomadic people who lived in Central Asia, the Caucasus and Eastern Europe for centuries. They are thought to have first lived east of the Volga River, in an area that was then part of Scythia. By 370 AD, the Huns reached the Volga region, and by 430, they had established a broad, albeit short-lived, dominance in Europe. He conquered the Goths and many other Germanic people living outside Roman borders, causing others to flee into Roman territory. The Huns made frequent and devastating raids on the Eastern Roman Empire, especially during the reign of Attila. In 451 the Huns invaded the Western Roman province of Gaul, where they fought a combined army of Romans and Visigoths in the Battle of the Fields of Catalonia, and in 452 they invaded Italy. After the death of Attila in 453, the Huns ceased to be a major threat to Rome and they lost most of their empire after the Battle of Nedao. Variants of the name Hun are recorded in the Caucasus as far back as the early 8th century (URL 1).

Decoration is an action that also requires mathematical knowledge. The Hun Turks were not satisfied with the aesthetic dimensions of the works they created, they also processed them. They imitated and depicted nature (Argun, 2020).

Gokturks and Mathematics

Gokturks are the first state in history founded with the name Turk. After the weakening and disintegration of the Hun Empire, the Gokturk State was established in 552 by establishing dominance among the Turkish tribes. In 745, the Gokturk state collapsed when the Uyghurs defeated the Second Eastern Gokturk (Kutluk) Khaganate. Information about the Göktürk period can be obtained from the Orkhon monuments erected in the Orkhon-Yenisey valley from the same period and written using the Göktürk alphabet (URL 2).

All activities requiring science, which the Turks who lived before them, continued to develop and revise during this period (Argun, 2020). Turkish Calendar with 12 Animals was used. In order to use this calendar, it is necessary to know the world, solar and lunar periods. They were able to calculate seasons, years, and the length of nights and days. In a large sense, this calendar requires chronology. The calendar is solar based. It was also used in Egyptian-Mesopotamian civilizations, and a year was calculated as 365 days, 50 minutes and 47 seconds. A year is divided into six weeks. The fourth of February has been designated as New Year's Eve (Argun, 2020).

Uyghurs and Mathematics

They built stone buildings and surrounded their cities with walls. Cities are settlements built on information. Calculating the architecture of the city requires mathematical knowledge. Kariz Water Channels in the Turfan region are a gift of the Turks to the world civilization. It is the Turkish miracle under the desert (Argun, 2020). Kariz Canals collected the water from the Tanrı Mountains, passed it 60 km under the desert, and carried it to the settlements in Turfan, and the agricultural areas were irrigated. The channels were opened approximately 100 meters underground. Its total length is 5000 km. The system works entirely with the force of gravity (Argun, 2020). In order to do this 2500 year ago, approximately 500 BC; Knowledge of slope, angle, water flow, mathematics, physics and engineering is required (Argun, 2020).

It is known that the Turks, who have used the base ten (decimal) system since the early dates, used stick numerals at an early date. We can say that they still used stick numerals during the time of the Huns. They also performed various arithmetic operations with this system. This system operated based on additive principles (Kahya, 2017). The basic sciences used were addition and subtraction; Multiplication and division operations were performed by reducing addition and subtraction (Kahya, 2017). We see that in addition to operations with whole numbers, there are also operations with fractions. These mathematical operations are mostly simple operations. Here, fractions with a denominator of 1 are primarily used (Kahya, 2017). We see that some weight, length and currency units have been shaped in Turks over time (Kahya, 2 017).

For example, it is stated in a legal text: 'When a person named Terbiş or Derviş needed money, he sold 100 pillows of a vineyard, which he inherited from his father and on which 16 workers worked, to 'il Yangıç' or el-Yangıç (in accordance with local laws).) sells. Terpiş, his older and younger siblings, his nephew and his uncle will not object to the sale. If he objects, he will give 'a golden pillow to the Great Army, a silver pillow to the Internal Treasury, and a riding horse to each of the begs as punishment.' (Kahya, 2017). As can be understood from this text, some measures had already been formed during the Uyghur Period. The scale called pillow here was 50 liang or 1 T'ing according to Chinese measurements. Gold was often used together with gold. It is not known exactly how much Liang is worth. Chao was a currency used during the Yuan dynasty. Again, from this quote, we see that gold and silver are used as money (Kahya, 2017). We learn their weight measurement units from some documents dating back to the Uyghur Era, in which some sales-related issues are recorded (Kahya, 2017).

Results

The geographical location of the Turks before Islam caused them to gain a warrior identity due to strategic and political reasons. The struggles of us Turks, who have a high spirit of freedom, without falling under the hegemony of any country, lasted for many years. In recent years, with the domestication of horses, a nomadic lifestyle was adopted. There was an understanding of customs that was frequently seen in nomadic societies. We can say that societies where mathematics and positive sciences are developed are generally settled and have educational institutions. It can be said that the relatively late transition to settled life among us Turks caused the studies in mathematics to start correspondingly late. After the acceptance of Islam, many studies were carried out in the field of mathematics. Although not directly in the field of mathematics, there are some studies used and carried out using mathematics in this period.

The adventure of Turks in mathematics is examined in four separate sections. These are the period before Islam, the Islamic period, the Ottoman Period and the Republican Period. In this study, the period of the Turks before Islam is discussed. Because pre-Islamic societies were nomadic, theoretical knowledge in terms of mathematics was scarce. However, it is seen that mathematics is used in practice in terms of decorative art and depictions of nature. In this respect, Huns and Kök Turks are the societies that used the most common decorative art. The most important work of the Göktürks is the Turkish Calendar with 12 Animals. Uyghurs, on the other hand, have benefited from mathematics by settling down and building water channels, building stone buildings, and establishing formal education. Mathematics is a branch of science that has existed since the beginning of the world and is constantly evolving. It has been determined that mathematics affects the development of other sciences and enables students to be successful in other courses (Kükey, Tutak, 2019). A teacher should not have difficulty in transferring mathematics to real life (Işık, Tutak, Kalkan, 2020). Mathematics existed at the beginning of life and will continue forever. Because mathematics is literally life itself. Therefore, it is very important to measure and know every aspect of the history and development of mathematics. Looking at the history of mathematics, sometimes people used one-to-one correspondences and sometimes numbers instead of counting. Sometimes people called it non-existence because there was no zero, but when the time came and zero was found, they expanded their number systems. Mathematics has undergone constant change and development over time. So much so that if we follow these developments and follow today's life, we can easily see how much mathematics has developed. While the expression "absence" was once used instead of zero, today the use of zero serves many purposes in human life. For example, we can give the following example: The computers on which we perform most of our operations today generally work with programs based on zeros. Therefore, knowing the history and development of mathematics is important in every aspect. Providing this information in appropriate steps is very important for mathematics education and should be provided.

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DNR BASED INSTRUCTION

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Introduction

DNR is an approach that argues that in order to learn mathematics, students must first have a mental need, they must acquire mathematical ideas and practices, and they must internalize, organize and reorganize the mathematics they have learned (Harel, 2008c).

DNR-based teaching appears to be based on the ideas of cognitive and social constructivism. Constructivism is a philosophical approach that explains how learning occurs. Therefore, DNR can be considered as a framework that explains how individuals learn mathematics and offers ways for more effective mathematics teaching (Oflaz, 2017).

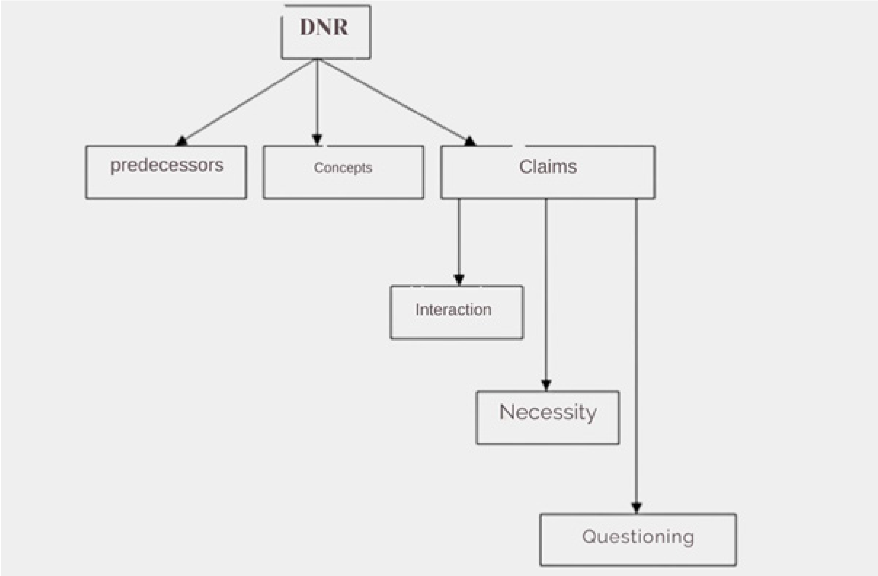

Figure 1. DNR Structure (Harel, 2008b)

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Opinions of the DNR

Harel discussed the premises of DNR in his study (2008, p. 893) and said that it consists of eight premises. These eight premises are discussed in four classes.

- Mathematics: Mathematics can be considered as the combination of two complementary sets. The first of these is a set of structures consisting of axioms, definitions, theorems, problems and their solutions. This set includes the desired ways of understanding that have been put forward throughout the history of mathematics. The second cluster consists of ways of thinking that include the characteristics of mental actions belonging to the products that make up the first cluster (Harel, 2008a). Since mathematical knowledge consists of ways of understanding and thinking, the development of both ways of thinking and understanding should be aimed in teaching mathematics.
- Learning: When faced with new information, the individual tries to incorporate this information into the cognitive structures existing in his mind. This process, which ensures the adaptation of the cognitive structure in the individual's mind to its environment, is called assimilation. However, the new information/event encountered may not fit the existing cognitive structure. In this case, the person needs to reshape the cognitive structure in his mind in order to explain the new situation. This process is also called the editing process. If the schemas in the individual's mind are sufficient to explain the new situation, assimilation occurs. If it is not sufficient, then learning occurs through the process of rearranging the schemas (Bacanlı, 2009; Senemoğlu, 2005). All people have the capacity to desire to learn and carry out mental actions (Harel, 2008b).
- Teaching: According to Vygotsky (1980), mathematical knowledge is acquired through experiences and culture. The teacher's duty is to direct the knowledge gained by the student through his own experiences to become more scientific and to achieve conceptual understanding in the student. According to Vygotsky's theory, the individual learns better than someone who is an expert on that subject.
- Ontology:

  Subjectivity: The observations that individuals think they make vary according to their perspective and the meanings attributed to the environment.

Commitment: Worldviews are the mechanism that initiates and controls human actions.

But worldviews also arise as a result of actions. While creating these premises, existing theories were used or based on these theories. In short, the term epistemophilia originates from Aristotle (LawsonTancred, 1998); The basis of Piaget's theory of balance consists of the term harmony (Piaget & Inhelder, 1967); The learning-knowing relationship was also taken from Piaget, and it is compatible with Brousseau's (1997) claim that "For every piece of knowledge, there is a basic situation that gives it appropriate meaning."

Basic Principles of DNR-Based Instruction

DNR's principles can be examined under three headings. These; interaction principle, necessity principle and reasoning principle.

1. Interaction

According to Hiebert and Lefevre (1986), conceptual knowledge can be thought of as a network of interconnected information. Conceptual knowledge, which is associated with many pieces of information in the mind, is created by establishing relationships between the parts that make up the knowledge.

Procedural knowledge consists of the rules, algorithms, operations and symbols that make up mathematics used to solve mathematical problems. Procedural knowledge also includes the strategies necessary to solve problems. In order to create mathematical knowledge, these two pieces of information must be given in a way that complements each other (Oflaz, 2017).

In DNR, conceptual and procedural knowledge are expressed as ways of thinking and ways of understanding. While pointing out products such as ways of understanding, definitions, theorems, proofs, problems and solutions; Ways of thinking point to the characteristics of the process carried out to create these products. Mathematics consists of all of these two types of knowledge. Ways of understanding are affected by ways of thinking, and ways of thinking are affected by ways of understanding. According to DNR, interaction means the development of ways of thinking through the production of ways of understanding, and conversely, the ways of understanding produced are affected by ways of thinking (Harel, 2013).

2. Necessity

According to Harel (1998, 2008b), students are more likely to learn if they have a mental need for what they will learn. Intellectual need means the student's desire to learn any mathematical concept.

According to DNR, in order for learning to occur, imbalance must occur in the mind. In this way, the student can go beyond his existing structure and create a new structure (Piaget, 1978).

When a student encounters a problem that he cannot solve with his existing knowledge, he will be eager to solve that problem and will change the knowledge in his mind and create new knowledge. According to DNR, mental confusion occurs when the individual's mental needs and psychological needs are met. If an individual obtains new information by using his existing knowledge when faced with a problem situation, his mental need is met. On the other hand, when a person encounters a problem situation, that problem should be interesting for the person, the person should be willing and persevere to solve the problem. These constitute the psychological need dimension (Harel, 2008b).

3. Reasoning

Students need to reason and internalize the ways of understanding and thinking they have created. Students form and internalize their mathematical knowledge better with the help of experience and practice, rather than being taught directly (Cooper, 1991). According to DNR, practices and experiences provide reinforcement of desired ways of understanding and thinking. The mentioned practices should not be considered merely as exercises or solutions to routine problems (Harel, 2008b). The problem situations to be created here should be considered as problems in which students will apply, internalize and reorganize their knowledge.

Concepts of DNR

The concepts of DNR are examined under three headings: mental actions, ways of understanding and ways of thinking.

1. Mental Actions

Mental actions such as interpreting, predicting, inferring, proving, explaining, generalizing, applying, predicting, classifying, researching and problem solving that constitute mathematical thinking are frequently performed. All kinds of actions that occur in our minds are called mental actions (Harel 2008c).

2. Ways of Thinking and Ways of Understanding

The cognitive characteristics of the product of a person's mental action, that is, the way of understanding, also constitute the ways of thinking. Accordingly, the solution of a problem or a proof constitutes the ways of understanding problem solving and proving activities. The way of thinking is the cognitive feature of that action (Harel, 2007).

Proof Schemes in DNR-Based Instruction

In DNR, special importance is given to the issue of proof. Harel and Sowder (2007) define proving as the mental action of a person (or a group) to eliminate doubts about the accuracy of a claim. While proof is a cognitive product of the act of proving, that is, a way of understanding, the proof scheme is the cognitive characteristic of this product, that is, a way of thinking (Harel, 2008a). In the classification put forward by Harel and Sowder (1998), three types of proof schemes are mentioned. These are: external, empirical and analytical schemes.

Figure 2. Summary of Harel and Sowder proof schemes (Ursavaş & Çimer, 2015, p. 272).

1. External Proof Schemes

Verifications made according to external proof schemes; (a) If it is based on an authority such as a teacher or a book, it is called an authoritarian proof scheme, (b) If it is based strictly on the appearance of the argument, it is called a habitual proof scheme, (c) If it is based on symbols or practices that do not have a meaningful basis in the context, it is called a symbolic proof scheme (Harel and Sowder, 1998).

1.1 Authoritarian Proof Schemes

The authoritarian proof scheme is both widely used and difficult to abandon. Because the most frequently asked question by students is "how" rather than "why". Additionally, students see the teacher as the only source for answers and believe that the teacher is responsible for telling them the necessary information. (Harel and Sowder, 1998).

1.2 Habitual Proof Schemes

It is stated that when the form and appearance of the argument affects the student more than the accuracy of the argument, it shows the characteristics of the habitual proof scheme (Martin & Harel, 1989).

1.3 Symbolic Proof Schemes

The existence of a symbolic proof scheme can be said in cases where symbols are evaluated separately from their meanings and without associating them with their representations in the problem. In other words, it can be stated that the source of mental action here is outside (Harel & Sowder, 1998).

2. Experimental Proof Schemes

Students who show the characteristics of this proof scheme use the method of proof or invalidate the condition by getting help from tangible evidence or sensory experiences while justifying the situations. (Harel & Sowder, 1998).

2.1 Example-Based Proof Schemes

If students convince themselves and others of the truth of an assumption by making quantitative evaluations of one or more examples, they can be said to have an example-based proof scheme. (Yıldız, 2016)

2.2 Intuitive Proof Schemes

When it comes to the existence of this proof scheme, while intuitive justifications can be presented about the truth or falsehood of the argument, it is difficult to find a strong basis for this situation (Tall & Ramos-Mejia, 2006).

3. Analytical Proof Schemes

It is when one proves the claim based on the results of the previous steps.

3.1 Transformational Proof Schemes

All transformational proof schemes share three basic characteristics: generality, operational consideration, and logical inference. It describes the acceptance of the "for all" argument in its generality and that no exceptions and isolated cases to this situation can be accepted. The existence of operational thinking can be mentioned when the individual sets goals and the main goal and begins to foresee the possible consequences of his inferences during the proof process. Finally, logical inference comes into play when the individual understands that mathematical proof must ultimately be based on the rules of logical inference. Although mathematical proofs are based on rules of logical inference, cases where these rules alone are used are extremely rare. Inductive and purely discursive reasoning are integral parts of this proof process. In addition to proving arguments, mental processes are applied to transform images from one state of knowledge to another when generating hypotheses.

These applied transformations and elements are a part of the mathematical reality mentioned (Harel, 2008).

3.2 Axiomatic Proof Schemes

The axiomatic proof scheme is in the second category of analytic schemes and is an epistemological development of the transformational proof scheme that includes awareness of important formal development (Harel and Sowder, 1998). That is, when a person understands that basically any proof process must start from undefined terms and axioms and that these axioms determine mathematical reality, he begins to use the axiomatic proof scheme (Harel, 2008a).

As a result, although proof schemes are not hierarchical, the process that begins with the individual's dependence on external and empirical schemes develops step by step towards analytical schemes. Although authoritarian and experimental proof schemes are valuable, the necessity and importance of the analytical proof scheme, especially in the field of mathematics, is indisputable. Because analytical proof schemes express the creation and transformation of general mental images for a context, and these transformations are always made through logical inferences (Harel and Sowder, 1998).

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