

**Adaptive Learning Software in Education**

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**Abstract**

Today, education is transforming with rapidly changing technology and learning needs, and traditional learning models are being replaced by a more flexible, customized and effective learning process. Adaptive learning software, which plays an important role in this change, stands out as a powerful tool to understand the individual needs of students and personalize their learning experience. Adaptive learning software provides a more effective and efficient learning experience by customizing learning content and methods, taking into account students' learning styles, preferences, and strengths/weaknesses. For this reason, adaptive learning software plays an important bridge role in the transformation process in education. In this article, adaptive learning software is examined, how it works, its application areas and the benefits it brings.

**INTRODUCTION**

Today, the rapid advancement of information and technology brings about transformation in the field of education. By moving away from traditional classroom settings, efforts are increasing to provide a learning experience that is better suited to students' individual needs and learning styles. In this context, adaptive learning software has a role to play in leading this change in education and emphasizing the importance of personalizing learning. Adaptive learning software monitors and analyzes students' learning processes and uses data-driven algorithms to understand their individual needs. In this way, it provides each student with a customized learning experience, increasing learning effectiveness and improving learning outcomes. Adaptive learning software is designed to identify students' individual learning needs and provide them with a customized learning experience. This software often uses artificial intelligence and data analysis techniques to help determine students' progress, strengths, and weaknesses.

In this article, adaptive learning software is examined, how it works, its application areas and the benefits it brings.

**Literature Review**

**What is Adaptive Learning?**

Adaptive learning is an approach to education or training that uses technology and data to provide students with individually customized content. This approach aims to intelligently adapt to each student's unique needs, learning styles, pace, and preferences. Adaptive learning uses data to identify students' strengths and weaknesses and personalizes the learning experience based on that information. Adaptive learning systems that track a student's learning progress and provide content

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based on their needs allow students to learn more effectively. This approach allows teachers to engage with their students more closely and guide them more effectively, while providing students with the opportunity to manage and control their own learning processes more effectively (Srivastava, 2024).

### **Adaptive Learning Definition**

Adaptive learning basically uses technology to enhance teaching and learning by providing students with individualized programs. This approach aims to provide students with the most appropriate and effective learning experience based on the data collected before and during the learning process. The best adaptive learning platforms use techniques such as data mining to put together education or training content that is optimized for the unique needs of students. These platforms continuously collect data from the student's interactions and analyze this data to determine the student's learning needs. As a result of the analysis of this data, platforms can determine which learning activities will be presented to students, through which medium, and in what order. This creates a customized learning journey for each student, allowing them to progress at their own pace and preferences (Srivastava, 2024).

### **Adaptive Learning Software**

ADOPTA (ADaptive Technology-Enhanced Platform for Education) is an authoring tool designed as part of a platform for building edutainment services. This writing tool was developed specifically for e-learning content delivery, providing adaptability to students' goals, styles, and performance. In addition, it is designed using the Java Enterprise Edition platform and is equipped with various features (Vassileva, Bontchev, Chavkova, Mitev, 2009):

1. **Object Metadata Descriptions and Inheritance Mechanisms:** ADOPTA uses object metadata descriptions to generate learning materials. This is used to define the characteristics of the content and the learning objectives. It also comes with inheritance mechanisms, which allows for the inheritance of features and structures from previous content. This allows for extensive customization of the content.
2. **Semantic Ontology Graphs and Metadata:** ADOPTA uses metadata to model the structure and relationships of content using semantic ontology graphs. This is used to better understand the meaning and context of the content. Ontology graphs are essential for visualizing and understanding the relationships between learning materials.
3. **Adaptive Courseware Integration:** ADOPTA is well-integrated with the trainer tool and provides the features needed to create adaptive courseware. This enables instructors to deliver customized and targeted educational materials to students. It also includes feedback mechanisms to monitor students' performance and adjust content as needed (Vassileva et al., 2009):

Research on the development of adaptive e-learning platforms has revealed great opportunities that allow for a radical improvement of the teaching process. These platforms aim to personalize the learning experience by enabling different educational content to be presented to different individuals or groups and different formatted sequencing of the presentation. However, there are two general problems in this area (Cordeiro et al., 2010):

1. Creation and delivery of adaptive training courses to students with different learning styles.
  2. Enabling differently formatted sequencing and presentation of training content.
- Cordeiro et al. (2010) presented two approaches to address these two problems in their study:

## 1. ADOPTA (Platform for Education developed with Adaptive technology)

This approach is implemented within a platform for building edutainment services. ADOPTA enables to create e-learning lessons in the form of storyboard graphs that are manually guided by the instructor. This approach allows the instructor to create personalized learning experiences by pre-determining and organizing learning materials. In this way, it allows instructors to create content that suits their student groups and learning styles.

## 2. Automatic Generation by Adaptive Engine

Another approach is to automatically generate content on the fly by the adaptive engine. In this approach, various factors such as students' learning styles, performances, and preferences are automatically analyzed and content is created accordingly. This approach allows for adaptability in a more dynamic way and responds more quickly to the personal needs of students. However, the downside of this approach is that in some cases, students may not fully understand their preferences or may produce unexpected results (Cordeiro et al., 2010).

The widespread use of internet technologies has enabled the vast majority of people to access education, wherever they are, and has given rise to e-learning (Troussas et al., 2019). In this way, students who share different characteristics can access the learning material. In the light of recent developments, educational software needs to offer a student-centered learning experience. In their study, Troussas et al. (2019) presented artificial intelligence dynamic clustering of learners' characteristics to maintain the learning speed of each student.

As a test setting, Troussas et al. (2019) designed and implemented an adaptive system to provide individualized mathematics instruction to elementary school students. Dynamic clustering takes various student characteristics such as pre-existing knowledge, current and previous level of knowledge, etc., as input to create homogeneous sets of students. Through dynamic clustering, the system provides students with personalized tips, group collaboration suggestions, domain knowledge distribution, and rewards to improve knowledge acquisition. The system was evaluated using an established framework, and the results showed that integrated smart techniques were able to offer individualized and adaptive learning while maintaining a high level of pedagogical relevance. This study contributes to our understanding of the transformation in education by emphasizing the impact of technology-supported education systems on student-centered approaches. AI-based techniques, such as dynamic clustering, can allow for the development of more effective and personalized learning experiences in education.

In their study, Kabassi and Virvou (2006) described how Multi-Attribute Utility Theory can be combined with adaptive techniques to improve individualized instruction in the Intelligent Learning Environment (ILE). ILE is referred to as Web F-SMILE. It works on the web and is intended to help novice users learn the basic skills of computer use. The tutoring is dynamically adapted to the individual student based on the student modeling component of the system and the Multi-Qualified Utility Theory (MAUT) used to process information about the user.

As a result, MAUT provides a way for the system to instantly select the best possible recommendation to be presented to users. The recommendation is dynamically generated based on adaptive presentation techniques, in which the adaptation is carried out at the content level, and the support for adaptive navigation, which is carried out at the connection level of the hyperspace of the tutoring system. The adaptability of learning depends on factors such as the student's habits, prior knowledge and skills, which are used as criteria for the implementation of MAUT in courseware. In this way, a

novel combination of MOUT with adaptive techniques is used for intelligent web-based teaching (Kabassi and Virvou, 2006).

In their study, Xie et al. (2019) examined the trends and developments of technology-enhanced adaptive/personalized learning and related journal articles in the last decade (i.e., from 2007 to 2017). To be more specific, they have examined many research topics such as parameters of adaptive/personalized learning, learning supports, learning outcomes, topics, participants, equipment, etc.

In addition, the study of Xie et al. (2019) reveals that personalized/adaptive learning has always been an interesting topic in this field, and personalized data sources such as students' preferences, learning achievements, profiles, and learning logs have become the main parameters of supporting personalized/adaptive learning. Moreover, they found that the majority of studies on personalized/adaptive learning still only support traditional computers or devices, while only a few studies have been conducted on wearables, smartphones, and tablet computers.

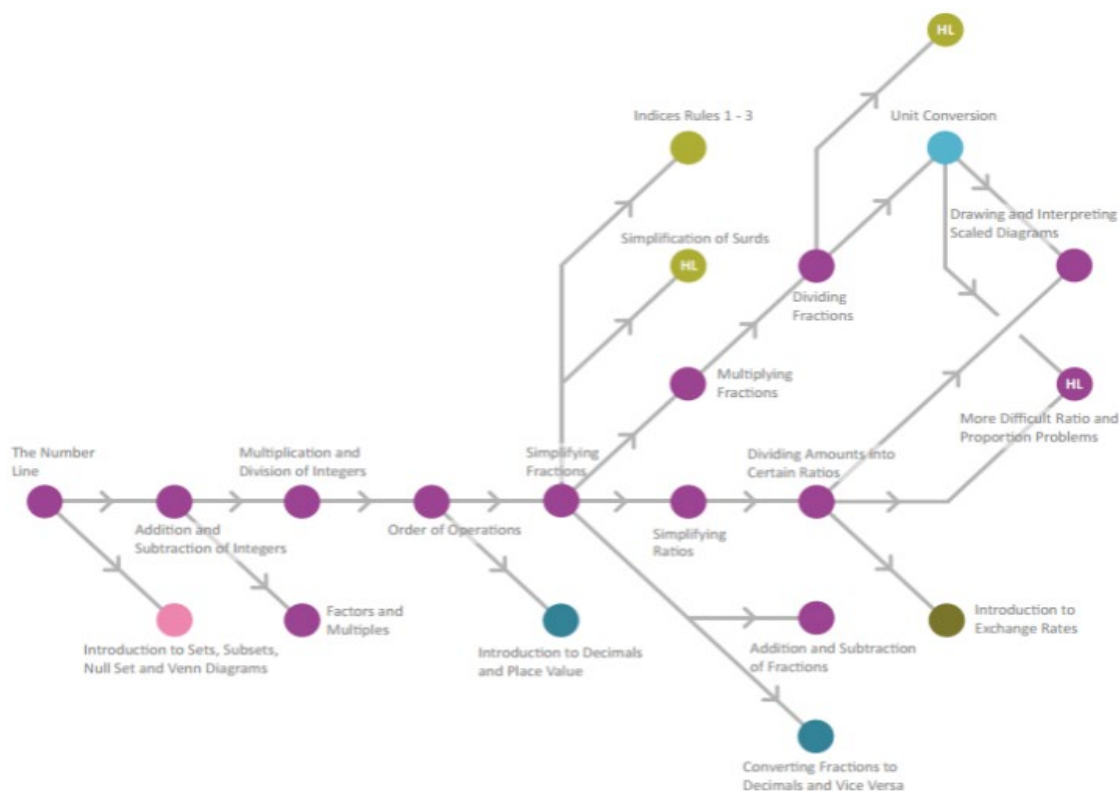
Adaptive learning software is often integrated into online education platforms and provides access to students individually. This software allows students to learn at their own pace and process material in accordance with their learning style.

Adaptive learning software continuously monitors students' performance and personalizes learning materials and activities based on this data. For example, when a student is found to be having difficulty with a particular topic, the software can support the learning process by providing more practice or additional explanations. On the other hand, when a student is skilled in a particular subject, the software can increase the student's interest and motivation by providing more advanced materials or challenge questions.

Adaptive learning software can provide many benefits in education, but to be used effectively, they must be carefully designed and sensitive to the privacy of student data. In addition, it is important for teachers to integrate this software effectively and keep track of students' learning progress.

An example of the application is Adaptemy.

The Learning Engine can be seamlessly integrated into the existing learning platform to deliver personalized learning experiences to students and teachers. Thanks to this integration, the learning processes of students and teachers can be supported more effectively. The current learning platform is designed to work in harmony with the content. This can enable them to create more powerful products and learning experiences by leveraging adaptive learning technologies. Learning processes can be made more effective by offering customized content and activities based on the needs of students and teachers (Adaptemy, 2024).



**Figure 1. Adaptemy Learning Engine**

**Source:** Adaptemy (2024), url -1

## Method

In this article, the publications scanned in the Web of Science database, including in the field of education, related to adaptive learning software were examined. Within the scope of the research, the publications in the field of education related to adaptive learning software were scanned and examined in the Web of Science database.

This review has been evaluated from various perspectives, such as the role of adaptive learning software in education, publication trends, popular topics, and leading researchers. The analysis of the data was carried out to understand the importance and development of adaptive learning software in the field of education.

The methodology of the research includes a search process in the Web of Science database using keywords related to adaptive learning software. The publications obtained as a result of this search were examined in detail, and various factors such as publication dates, publication types, authors, and number of publications were analyzed. As a result of these analyses, the characteristics and trends of publications in the field of adaptive learning software were determined and a picture of the developments in this field was drawn. The findings of the article constitute an important resource for understanding the role of adaptive learning software in education and to guide future research in this field.



**Table 1. Number of Year-Based Surveys**

Year	Number of Publications	Year	Number of Publications	Year	Number of Publications
2023	35	2010	64	1997	14
2022	53	2009	95	1996	6
2021	56	2008	80	1995	5
2020	62	2007	47	1994	7
2019	81	2006	51	1993	5
2018	61	2005	45	1992	8
2017	67	2004	48	1991	7
2016	69	2003	28	1990	4
2015	79	2002	35	1989	2
2014	79	2001	19	1988	2
2013	70	2000	11	1983	1
2012	55	1999	15		
2011	56	1998	9		

When the publications scanned in the Web of Science database are examined, it is seen that the highest number of publications related to adaptive learning software in the field of education were made in 2009 (95). Subsequently, it was concluded that 80 articles were published in 2008. The fewest publications were made in 1983 (1).

These data show that there is a certain trend in the popularity of adaptive learning software in the academic literature. The high number of publications in 2009 and 2008 indicates that there has been a significant increase in the research and development of adaptive learning software. In this period, it can be thought that developments in educational technologies and artificial intelligence have increased the interest in adaptive learning software.

However, the fact that there was only one publication in 1983 shows that adaptive learning software was just beginning to develop at that time, and researchers have done very little work on it. This may suggest that the technological infrastructure and research methods may not have been sufficiently developed at that time, or that the concept of adaptive learning was not yet fully understood.

The increase in the total number of publications highlights the potential and importance of adaptive learning software in education. This type of software is thought to have the potential to provide students with a more personalized and effective learning experience. Therefore, with the increasing interest in research in this area, it is expected that more information will be obtained about the role and impact of adaptive learning software in education.

**Table 2. Number of Publications by Publication Type**

Publication Type	Number of Publications	Publication Type	Number of Publications	Publication Type	Number of Publications
Meeting	774	Abstract	8	Editorial Material	3
Article	664	Book	6	Case Report	2
Dissertation Thesis	102	Early Access	5	Letter	1
Other	26	Clinical Trial	4	Retracted Publication	1
Review Article	21	Unspecified	4		

The highest number of publications made by publication type belongs to the paper type with 774 works. It is followed by 664 works and articles. These data show that the majority of publications on adaptive learning software are in the form of papers.

It can be thought that paper type publications are widely used so that research findings can be quickly communicated and shared with the academic community. For this reason, it is seen that studies on adaptive learning software are often presented in paper format in order to share new technological developments and findings with the academic community more quickly.

On the other hand, we see that the number of publications in the article type is also quite high. Articles provide the opportunity to present more in-depth research and detailed analysis.

In addition, the high number of publications in the form of papers may indicate that adaptive learning software is a rapidly evolving field and that researchers in this field need to share new findings and techniques quickly. However, the fact that publications in the type of articles also have a significant share shows that more in-depth research on adaptive learning software has been carried out and knowledge in this field has been shared more comprehensively.

**Table 3. Number of Publications by Author**

<b>Author</b>	<b>Number of Publications</b>
Virvou, M.	13
Bontchev, B.	10
Gwo-jen, Hwang.	9
Hwang, Gj.	9
Kloos, Cd.	9
Okamoto, T.	9
Vassileva, D.	8
Wang, H.	8
Brusilovsky, P.	7
Chen, Sp.	7
Delgado Kloos, C.	7
Gaeta, M.	7
Hatzilygeroudis, I.	7
Huang, Ym.	7

According to these data, it is seen that certain authors have a significant influence on publications related to adaptive learning software. It is noteworthy that Virvou M tops the list with 13 publications. Similarly, other authors such as Bontchev B, Gwo-jen Hwang, Hwang, Gj., Kloos, Cd., Okamoto, T., Vassileva, D., and Wang, H. have published between 7 and 10.

The high number of publications on adaptive learning software by these authors shows that they are the leading researchers in this field and have made significant contributions to studies in this field. In addition, the fact that many of these authors have signed multiple publications reveals their continued interest and contributions to adaptive learning software.

The publications of these authors may have covered various aspects of the research on adaptive learning software. For example, they may have worked on topics such as student modeling, adaptive learning strategies, and student performance evaluation methods. These publications can provide an

important resource to researchers and practitioners in the development and implementation of adaptive learning software.

## **Conclusions and Recommendations**

Adaptive learning software often uses mathematical algorithms called learning models. These models create customized learning roadmaps by taking into account factors such as students' past performance, preferences, and learning goals. Adaptive learning software can be used in a variety of application areas, from educational institutions to corporate training and individual learning. Online education platforms, in particular, can use adaptive learning software to customize it according to the needs of students.

The benefits of adaptive learning software include students achieving better learning outcomes, teachers tracking student progress more effectively, and increasing student motivation. However, the effective implementation of this technology can also face some challenges, for example, issues such as the privacy of student data and the accuracy of algorithms are important.

When the publications scanned in the Web of Science database are examined, it is seen that the highest number of publications related to adaptive learning software in the field of education were made in 2009 (95). Subsequently, it was concluded that 80 articles were published in 2008. The fewest publications were made in 1983 (1). These data show that there is a certain trend in the popularity of adaptive learning software in the academic literature.

The highest number of publications made by publication type belongs to the paper type with 774 works. It is followed by 664 works and articles. These data show that the majority of publications on adaptive learning software are in the form of papers. As a result of the analysis of publications on adaptive learning software, it is seen that the studies carried out in this field so far have a significant intensity and certain researchers are the leading figures in this field. The publications of authors such as Virvou, M., Bontchev, B., Gwo-jen Hwang, Hwang, Gj., Kloos, Cd., Okamoto, T., Vassileva, D., and Wang, H. on adaptive learning software have made significant contributions to research in this field and have led to the advancement of developments in this field.

However, it seems that the studies in the field of adaptive learning software cover various aspects and the work of these authors reflects this diversity. In addition to topics such as student modeling, adaptive learning strategies, and evaluation of student performance, significant contributions have been made in areas such as software development, event design, and user experience.

As a result, it is concluded that the studies in the field of adaptive learning software are carried out intensively by researchers in this field and these studies have made significant contributions to the advancement of the field. It is expected that studies in this field will continue in the coming periods and contribute to adaptive learning software providing a more effective and personalized learning experience.

With the developing technology, new approaches and tools come to the fore in education. In this context, adaptive learning software stands out as an important tool that personalizes learning processes and makes them more effective, taking into account the individual characteristics of students. Educational institutions and teachers can maximize the learning potential of students by taking advantage of the benefits offered by adaptive learning software. Therefore, educational institutions and teachers should be encouraged to use adaptive learning software to understand the individual needs of students and provide them with customized learning experiences. In this way, students' motivation will increase, learning outcomes will improve and the quality of education will increase even more.



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