Half-Century of Application of Information Technology in Mathematics Education: from Web-Based Learning to Cloud-Based Learning

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ABSTRACT

Today, information technology plays an important role in education. Information technology has made a significant contribution to education in general, and mathematics education in particular. It enables the training of an unlimited number of students at any given time and location, regardless of skin color, ethnicity, or geographical location. In addition, information technology enables result prediction, solution discovery, testing, automatic scoring, and a variety of other necessary features. In this article, we analyze the history of formation and development from Web-based Learning, E-learning, Mobile Learning, Blended Learning to Cloud-based Learning for Maths (CBLM). The study was carried out mainly by means of literature review. The end result is a new CBLM teaching model as well as practical examples of CBLM. The goal of the outcome is to develop a new method of teaching based on CBLM in the context of the Fourth Industrial Revolution, which is currently accelerating.

Keywords: Cloud computing, Internet, CBLM, WBL, E-learning.

1. OVERVIEW

Because of the Internet, the teaching and learning processes have changed dramatically. It is now easier to find information and materials. The Internet functions similarly to a virtual library, providing users with various types of information. As a result, everyone, including teachers and students, can easily and quickly access information. The use of websites has become an indispensable component of the learning process. Web-based Learning (WBL) is a method of learning in a constructive and collaborative learning environment using web means. Web-based learning (WBL) allows people to follow sessions openly and freely without having to adhere to a timetable or attend classes. WBL enables students to communicate across time and geography (Abd Rashid et al., 2016). Today, most universities have a web-based learning system to keep a large number of course resources in the higher education process (Peng et al., 2013).

Following Web-based Learning is a teaching method known as E-learning. E-Learning is a teaching method that focuses on an online learning environment. Activities and instructional strategies that are tailored to individual differences and tailored to each student's competencies can help students achieve higher levels of learning (K. H. Wang et al., 2006). E-learning is becoming increasingly popular. E-Learning provides content through all electronic means, including the Internet, intranet, peripheral networks, satellite broadcasting, audio and video cassettes, interactive televisions and CD-ROMs (Gerhard & Mayr, 2002). Therefore, it is a teaching method that facilitates the implementation of personalized learning and interpersonal interaction on a large scale (Nicholson, 2007).

Mobile Learning (M-learning) is the next teaching method to emerge after E-learning. Alan Kay's (1972) vision of DynaBook, a proposal for laptops specifically designed for children to explore, create, share, and communicate using computers, can be traced back to the origins of mobile learning. (Smith, 2014) This is a new educational model that serves as the foundation for the new learning environment. Students can access learning resources at any time and from any location, making the learning process more holistic and encouraging continuous education and training throughout their lives. (Rashevska & Tkachuk, 2015) Mobile learning is regarded as a distinct type of distance education (Keegan, 2005). Overall, M-Learning offers a fresh perspective by allowing teachers to deliver lectures at any time and from any location. Mobile devices such as PDAs, smartphones, iPads, and tablets have become important tools for teachers and students to support teaching and learning activities since their invention and innovation. M-Learning addresses the time constraints that students and teachers face when learning. (Taharim et al., 2016)

Following M-learning is a teaching method known as B-learning. Blended learning emerged as one of the most popular teaching terms in the early 2000s. Many studies

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have shown that blended learning is highly effective (Güzer & Caner, 2014). This teaching method is both appealing and practical because it combines a traditional classroom approach with an online learning model (BakarNordin & Alias, 2013). It is an effective teaching method that combines various teaching modes, teaching models, and learning styles (Bryan & Volchenkova, 2016). At least four most commonly used interpretations in blended learning: (i) to combine modes of web-based technology to accomplish an educational goal, (ii) to combine several pedagogical methods to produce optimal learning outcomes with or without instructional technology, (iii) to combine any form of instructional technology with face-to-face instructor-led training, and (iv) to combine instructional technology with actual job tasks in order to create a harmonious effect of learning and working (Ossiannilsson, 2017).

The use of cloud computing is an important factor in increasing access to teaching and research. Cloud-based learning extends learning beyond the classroom. The technology known as "Virtual Desktop Infrastructure" is used to store and process data stored in a data center. Furthermore, cloud application via an Internet browser is no different for users than using software installed on a user's personal computer screen (Shyshkina et al., 2018). Cloud computing provides computing resources, software and hardware, and its flexible configuration to meet the needs of the user (Shyshkina et al., 2017). The cloud-based learning environment is a new step in the development of the open education system (Glazunova & Shyshkina, 2018). Cloud-based learning is currently one of the leading teaching methods because of its greater adaptability and mobility, as well as comprehensive interoperability, free network access, and shared use of a unified infrastructure (Shyshkina, 2015). In other words, cloud-based learning tools have the potential to interact with other systems. (Hernández Rizzardini et al., 2013)

A major advantage of cloud-based learning is that schools benefit directly from the conversion of a large number of legacy computers into fully functional virtual computers. The school does not need to purchase or upgrade hardware, nor does it need to update the installed software. The old computers in use are reused by acquiring powerful processing capabilities and the most recent software from cloud computing servers. As a result, teachers and students can more effectively implement the teaching process. They only concentrate on learning tasks and activities, not on infrastructure maintenance, software updates, or hardware upgrades (Saad & Ehsan Rana, 2014)

2. RESEARCH CONTENT

The role of teachers in cloud-based learning

First, teachers are responsible for attracting students to learning, as well as planning teaching activities, coping and processing knowledge, and selecting communication styles in cloud-based learning. The cloud-based learning environment should be designed to improve student learning performance, equality, and self-esteem and confidence (Atabekova et al., 2015**;** Wang et al., 2021)

Second, teachers should provide students with a questionnaire before starting cloud-based learning in order to capture learners' views regarding this technology. Teachers must consider students' cultural backgrounds in order to provide learning tasks based on their diverse social backgrounds and learning experiences (Atabekova et al., 2015)**.**

Third, teachers design teaching phases based on their students' strengths, weaknesses, interests, and learning styles. The teaching method should be developed with the goal of improving skills related to future professional activities in specific professional environments. Teachers devote a lot of time to individual counseling. Teachers should closely monitor learners' omnidirectional communication to ensure that they are not underestimating or exaggerating their assigned tasks. Teachers should pay attention to potential differences in learner attitudes and behavior due to cultural and social backgrounds (Atabekova et al., 2015)**.**

Fourth, teachers should make each student feel like they are a part of the learning community. Teachers develop a learning environment in which all students embrace and devote time to individual reflection on the learning process (Atabekova et al., 2015).

The role of students in cloud-based learning

First, students act as explorers and learners in cloud-based learning. Students ask questions, find answers for themselves, or seek assistance from teachers. Students actively, rather than passively, participate in the learning tasks assigned by teachers. Students use the Internet to learn more about lesson topics and software and tools to complete lesson topics.

Second, students respond to the questions on the learning sheet provided by the teacher. They look for ways to delve into, develop questions, and address related issues.

Third, students from various cultural backgrounds and personalities can demonstrate their social backgrounds and learning styles to teachers, allowing teachers to adapt to individualized learning.

Fourth, students must always see themselves as members of the learning community. They then contribute to and promote the most effective community learning methods. Students share their knowledge understanding as well as their learning strengths with other students.

Classification of cloud computing services

There are numerous ways to categorize cloud computing services. Services can be classified based on the type of service implementation or the type of service provided.

Classification by type of service deployment

The first is private cloud. A private cloud is defined as the creation of an infrastructure dedicated to the client and accessible via a secure network for a limited number of users (learners, teachers, tutors etc.). As a result, either the client or a trusted provider manages the infrastructure directly. There are two aspects to the private cloud. On the customer side, private cloud deployment is the virtualization and automation of internal infrastructure in order to provide simpler, faster, and on-demand resources and services. On the provider side, private cloud is reflected in the fact that it provides a set of resources to the customer that are accessible via a secure network (Panoutsopoulos et al., 2015)**.**

The second is public cloud. A public cloud is an external infrastructure for an organization that is accessible via the Internet and is managed by the infrastructure's owner, with resources shared across multiple organizations. Because the infrastructure can be sold to any type of buyer, it can be shared with an almost infinite number of users on the same platform. A common problem in public clouds is that the location of resources is unknown, but the advantage is that you can "rent" resources and only pay for what your customers use (Panoutsopoulos et al., 2015)**.**

The third is hybrid cloud. In hybrid cloud, the company uses a combination of both a private cloud and a public cloud. This type is often used in cases of scalability problems. In this case, it is critical to connect the private or internal cloud to the public cloud in order for the two infrastructures to communicate (Panoutsopoulos et al., 2015)**.**

The fourth is community cloud. A community cloud expands the reach of cloud computing by enabling synergy and collaboration beyond the boundaries of an organization. A community cloud is a solution designed for a specific professional community, an association, or a government cloud that has similar needs and interests (same type of applications, security requirements, etc.). It can host a general and highly specialized business application, but it is also general for the community (Panoutsopoulos et al., 2015)**.**

Classification by type of service provided

Cloud computing services can be summarized as a pyramid with three main layers, namely application, platform and infrastructure. Depending on the needs of the customer, service providers may offer various service packages, such as IaaS as Infrastructure package, PaaS as Platform package, or SaaS as Service package. The most popular service model in cloud computing is the SaaS package. (Fasihuddin et al., 2012)

The first is the IaaS (Infrastructure as a Service) package, which stands for infrastructure as a service. This is the cloud infrastructure, where customers rent CPUs, memory, storage, and so on, and the costs are directly related to the fill rate. IaaS has several advantages. The client has complete control and can install any type of teaching software. This package allows for package expansion, quick implementation, and payment based on intended use (Siewert, 2011; Guatemala, 2012).

The second is the PaaS (Platform as a Service) package which provides a flexible, distributed and virtualized platform managed by an external provider in order to develop and deploy applications and services. These are actually the tools (such as databases and studios provided as Web solutions) and infrastructure needed to host the services. PaaS is built on IaaS's flexible architecture, making it easier to design, test, deploy, and host applications. PaaS has several benefits. The education unit will concentrate on development rather than infrastructure. Following application development, implementation is fully automated, with no additional software to buy or install. (Siewert, 2011)

The third is the SaaS (Software as a Service) package. This package is the most well-known cloud computing service model, which stands for software as a service. This is an application deployment model in which the provider leases the application as a service to its customers (whether corporate or individual) instead of a paid license. This model converts software budgets into variable expenditures rather than fixed expenditures. SaaS offers a number of advantages. It is not required to perform the installation or update; the provider will do so. The next advantage is the flexibility and ease of implementation, payment for use, and the ability to easily test new software. Devices with minimal hardware requirements (e.g. mobile phones) can be successfully used as cloud clients (Siewert, 2011)**.**

Research methods and results

Research methods

We employ the literature review methodology to examine previously published relevant studies in order to create a new model for the application of information and communication technology to mathematics education.

Our model was designed and commissioned to teach mathematics to high school students in Vietnam. Simultaneously, we use in-depth interviews and expert methods to gather feedback on the model's pedagogical

and technological compatibility, data flow, and interoperability.

The system automatically saves the interaction activities of users (teachers, students) on the system, and we conduct analysis, statistics, and matching to adjust the model and optimize performance.

Cloud-based learning for Maths

In this article, by reference to the model of cloud-based learning of Nguyen Viet Dung, (2020), we propose a model of Cloud-based learning for Maths (CBLM) as follows:

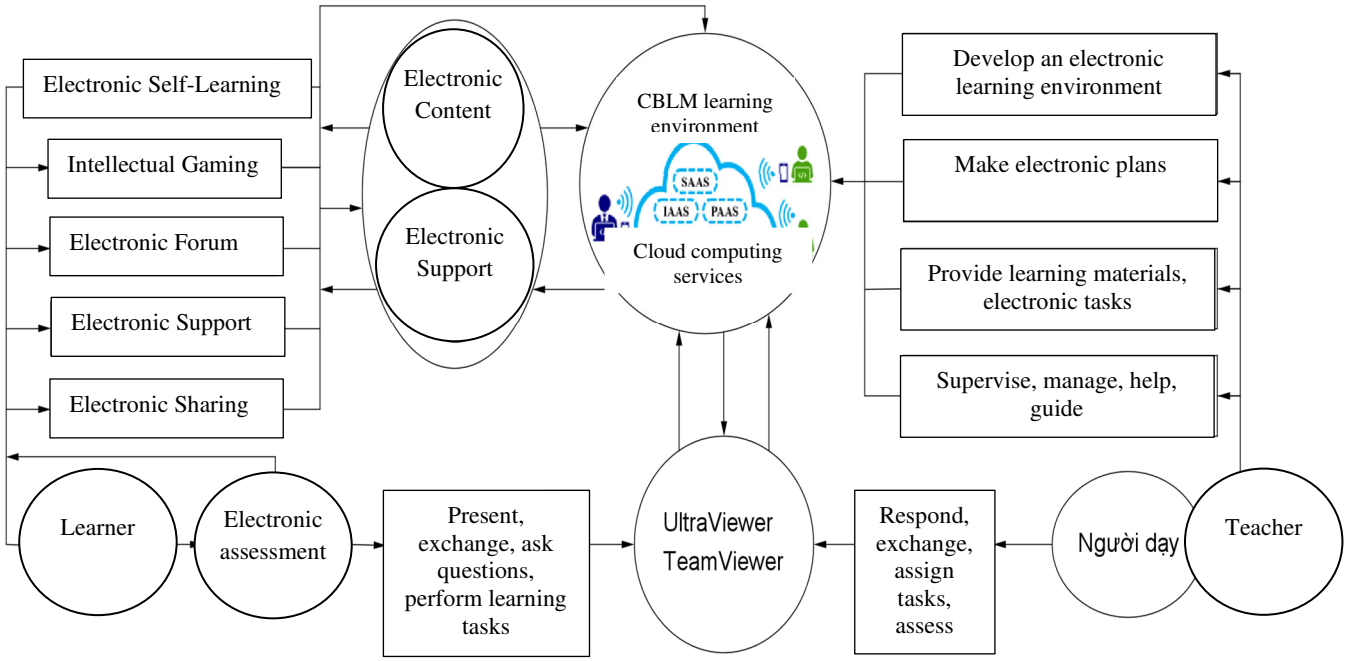


Figure 2. *Cloud-based learning for Maths*
(Source: Tran Trung, Nguyen Ngoc Giang)

The provider or teacher provides *Electronic Content* for learning mathematics using cloud products and services. Mathematics knowledge is contained in *Electronic Content* for the purpose of learning in the direction of discovery and knowledge creation. For students to understand concepts, properties, and theorems, they must be described in a dynamic state. *Electronic Content* and *Electronic Support* are two inseparable features. With *Electronic Support,* students can describe concepts, move pictures, find immutable quantities, verify and predict results. Students can interact with *Electronic Content* to gain new knowledge. Students can also insert images and text to help with the learning process. The interface of *Electronic Content* is divided into teaching phases that are appropriate for each student. Students with good academic performance receive a different dose than those with fair, satisfactory, or unsatisfactory academic performance. Students at the low level will be given guiding questions to help them understand the problem, while students at the high level will be given questions to help them dig deeper into the problem.

Illustrative example

For example, when designing an axial symmetry teaching dose, the cloud computing service may provide the teaching dose with *Electronic Content* as follows.

Example 1 *(Axial Symmetrical Movement)*
Look at the two entrance doors of a supermarket, consider the position of the two points M, M' *relative to the vertical line in the middle of the entrance?*

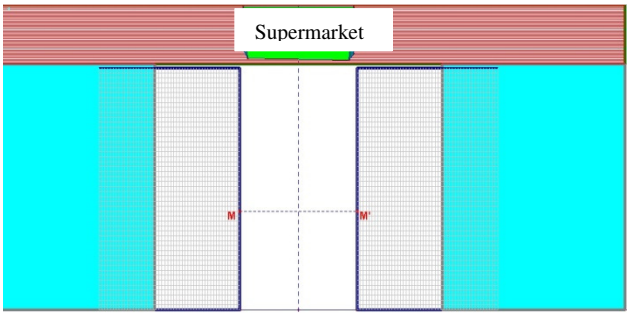


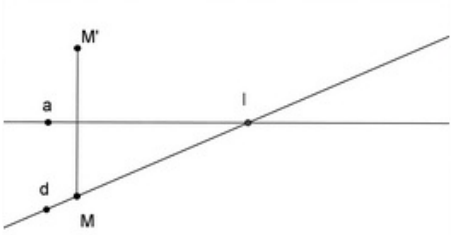
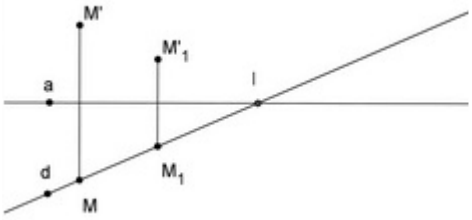
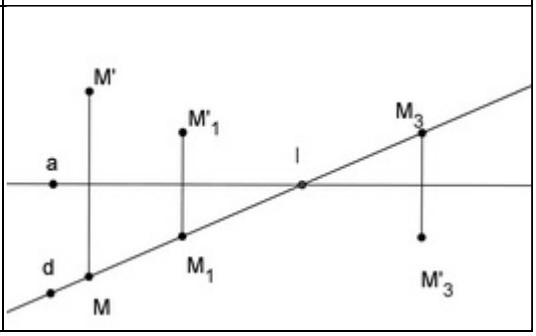
Figure 3. *Entrance of a supermarket (Source: Nguyen Ngoc Giang (2016))*

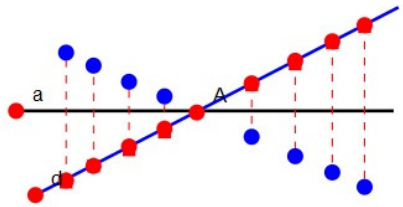
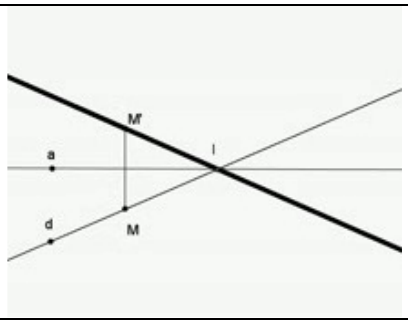
- When observing the entrance doors of the supermarket on the screen, all students at all levels answered the question of Example 1 correctly. This is a teaching dose for every student. This is the level of recognition, which is the lowest level on Bloom's scale.

Electronic Content provides learning doses automatically.

Students interact with *Electronic Content* to complete the lesson.

Example 2. *Two lines* a *and* d *intersect at* I *. For each point* M *of line* d *, draw the point* M' *which is symmetrical with* M *through line* a *. Consider where the point* M' *is when the point* M *is moving on line* d *.*

The level of disclosure of information about the solution of the problem in the ascending direction	**The learning level corresponds to the answer given**	**Content of the question**	**Corresponding drawing**
1	Very good	Consider where the point M' is when the point M is on line d ?	
		Consider where the point M' is when the point M is in other positions on the line d ?	
2	Good	Consider where the point M' is when the point M is in other positions on the line d ?	

3	Satisfactory	Activate the **Interaction** button to predict the locus! What is the shape of point M' locus?	
4	Unsatisfactory	What is the shape of point M' locus?	

(Nguyen Ngoc Giang, (2016))

The *Electronic Content* section's content and knowledge are designed so that students can interact with the cloud computing service to gain new knowledge for themselves. At level 3 for satisfactory students, for example, students can interact with electronic content production by taking finite points of motion, and the cloud computing service creates the corresponding traces. Electronic content in cloud services must be designed to encourage interaction and feedback while promoting the benefits and overcoming student limitations.

In addition to *Electronic Content*, cloud computing services provide other important features such as *Electronic Support, Electronic Forum, Electronic Self-Learning, Intellectual Gaming, Electronic Dictionary, Electronic Documents*, *Electronic Reviews*. In addition to the same uses as traditional names, these features provide appropriate teaching phases, integrate sound and voice, assist in searching, storing, and checking dictionaries, provide self-study materials, and so on. Furthermore, cloud computing enables automated, accurate, and quick assessments.

3. CONCLUSION

Teachers in CBLM are responsible for supervising, managing, assisting, guiding, and accompanying students. Students and teachers do not need to interact face to face in CBLM. Students with questions who want to present, exchange, and perform learning tasks can use cloud services to exchange information, and teachers will respond via SAAS services such as UltraViewer, TeamViewer,... Teachers are those who assess the outcomes of knowledge, skills, and attitudes in the development of competence. In the context of the Covid epidemic, non-face-to-face teaching becomes critical. As a result, the CBLM model described above is highly practical and should be replicated and applied.

Today, CBLM is a new teaching model. Because of its interoperability and electronic nature, as well as how cloud computing resources are used, this teaching model has many advantages. CBLM focuses on two elements. Firstly, the cloud computing operating model can be used to optimize hardware resources. Cloud services eliminate the need to replace old, poorly configured computers. Secondly, teachers create electronic learning materials that are tailored to each student's abilities. The supporting materials and tools must be in electronic forms such as video, audio, interactive drawings, etc. These features make CBLM adaptable and responsive to practical requirements. Students are allowed to operate in a virtual environment so that they are not self-deprecating or afraid of making mistakes during the learning process. Especially with CBLM, students become extremely self-conscious. Students investigate, research, delve into, and gain self-awareness. CBLM is distinguished by the fact that students learn each appropriate teaching phase in the nearest development zone in order to gain their own knowledge. Students will be more enthusiastic, remember lessons longer, and develop their information technology skills to the greatest extent possible. As a result, their learning outcomes will improve. Another important consideration is that students' academic achievements during natural disasters and epidemics are unaffected by complete online learning rather than face-to-face learning.

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