The development of theory and methods of using cloud-based information and communication technologies in teaching mathematics of engineering students in the United States

Nataliia Mykhailivna Kiianovska
Department of higher mathematics, SIHE «Kryvyi Rih National University»,
11, XXII Partz'yizdu str., Kryvyi Rih, 50027, Ukraine
kiianovska.nataliia@yandex.ru

Abstract. The *purpose* of the study is the analysis of the development of the theory and methods of ICT usage while teaching higher mathematics engineering students in the United States. It was determined following *tasks*: to analyze the problem source, to identify the state of its elaboration, to identify key trends in the development of theory and methods of ICT usage while teaching higher mathematics engineering students in the United States, *the object* of study – the use of ICT in teaching engineering students, *the research methods* are: analysis of scientific, educational, technical, historical sources; systematization and classification of scientific statements on the study; specification, comparison, analysis and synthesis, historical and pedagogical analysis of the sources to establish the chronological limits and implementation of ICT usage in educational practice of U.S. technical colleges.

In article was reviewed a modern ICT tools used in learning of fundamental subjects for future engineers in the United States, shown the evolution and convergence of ICT learning tools. Discussed experience of the «best practices» using online ICT in higher engineering education at United States. Some of these are static, while others are interactive or dynamic, giving mathematics learners opportunities to develop visualization skills, explore mathematical concepts, and obtain solutions to self-selected problems.

Among ICT tools are the following: tools to transmit audio and video data, tools to collaborate on projects, tools to support object-oriented practice. The analysis leads to the following conclusion: using cloud-based tools of learning mathematic has become the leading trend today. Therefore, university professors are widely considered to implement tools to assist the process of learning mathematics such properties as mobility, continuity and adaptability.

Key words: ICT learning tools; cloud-based learning technologies; tools to support mathematical activity.

Н. М. Кіяновська. Розвиток теорії та методики використання хмарно-орієнтованих інформаційно-комунікаційних технологій у навчанні вищої математики студентів інженерних спеціальностей у Сполучених Штатах Америки

Анотація. *Мета дослідження* полягає в здійсненні аналізу процесу розвитку теорії та методики використання інформаційно-комунікаційних технологій навчання вищої математики студентів інженерних спеціальностей у Сполучених Штатах Америки. Відповідно до мети дослідження було визначено такі *завдання:* проаналізувати джерела з проблеми дослідження з метою виявлення стану її розробленості; визначити провідні тенденції розвитку теорії та методики використання ІКТ навчанні вищої математики студентів інженерних спеціальностей у Сполучених Штатах Америки. *Об'єкт дослідження* – використання інформаційно-комунікаційних технологій у процесі навчання студентів інженерних спеціальностей, *предмет дослідження* – розвиток інформаційно-комунікаційних технологій навчання вищої математики студентів інженерних спеціальностей у Сполучених Штатах Америки. Предмет, мета і завдання дослідження обумовили вибір комплексу наукових *методів дослідження:* аналіз науково-педагогічної, методичної, історичної літератури; систематизація та класифікація наукових положень з проблеми дослідження; конкретизація, порівняння, аналіз і синтез; історико-педагогічний аналіз джерел для встановлення хронологічних меж розвитку та впровадження засобів ІКТ в освітню практику технічних ВНЗ США.

У статті розглянуто засоби підтримки математичної навчальної діяльності, що були розроблені та впроваджені в процес навчання протягом останнього десятиліття. Серед них можна виділити наступні: засоби для передавання аудіо- та відеоданих; інструменти для спільної роботи над проектами; засоби підтримки предметно-орієнтованої практичної діяльності. Виокремлено особливості поточного етапу розвитку засобів ІКТ навчання вищої математики студентів інженерних спеціальностей. Проведений аналіз дає підставу зробити наступний висновок: використання хмаро орієнтованого навчання вищої математики стає провідним напрямом сьогодення. Тому викладачі ВНЗ мають широко впроваджувати розглянуті засоби для надання процесу навчання вищої математики властивостей мобільності, безперервності та адаптивності.

Ключові слова: засоби ІКТ навчання; хмарні технології навчання; засобів підтримки математичної діяльності.

Організація: Кафедра вищої математики, ДВНЗ «Криворізький національний університет», вул. ХХІІ Партз'їзду, 11, м. Кривий Ріг,

50027, Україна.
E-mail: kiianovska.nataliia@yandex.ru.

There are many different technologies available for teaching mathematics, which are based on the information technology. Some have been around for decades, while others are more recent in origin; some have already established a wide base of users, while others seem to offer greater potential in the future.

The period from 2003 to the present is associated with the development of cloud-based information and communication technologies and training in Web-environment support tools of mathematical activity.

Over the last decade it was developed and implemented in the learning process a large variety of tools for supporting mathematics learning activities. Among them there is the following:

– the tools to transmit audio and video data;

– tools for collaboration on projects;

– tools to support object-oriented practice.

Among the tools to transmit audio and video data in the most popular teachers use YouTube, Viddler, Voki, VoiceThread and others [3].

Internet service *YouTube* (2005) (*www.youtube.com*) lets to post videos. This video available for download and playback off-line, either via a computer or portable multi-media player. YouTube has become one of the most popular places to accommodate teacher training videos due to the ease of downloading and find some educational materials.

In 2005, a team of companies like RackSpace, IBM and Macromedia has developed an interactive online video platform *Viddler* (*www.viddler.com*), which is a commercial project and is designed to upload, view and comment on videos. Finished videos can be placed on websites or social networks.

Voki (*www.voki.com*) is a free educational software tool that allows users to create their own avatars who can speak voice. Symbol Voki can configure different looks, using a microphone to make audio recording, use a personal phone number to keep in touch with students to download audio files. Voki characters can be sent by e-mail, shared on social networks and embedded in websites.

Diana S. Perdue [3] notes that using Voki as a tool to support the learning process, we can provide a diverse representation of educational materials. Students are beginning to pay more attention to discipline, when they hear a voice teacher who explains stuff, not just when it is read in print.

Internet resource *VoiceThread* (*www.voicethread.com*) designed for group discussions and exchange views on any town. In VoiceThread can be done multimedia slideshow containing images, documents and videos, and provides a way for users to navigate through the pages and leave comments in any way:

memos (recording from a microphone or telephone), text, audio or video files (through web cam) [3].

Using tools to collaborate on projects, teachers can support the learning process in the distance, beyond the audience.

Using *Google Docs* (*www.google.com.ua/intl/en/docs/about/*), the teacher can create a variety of documents, work on them together with students in real time and store documents and other files on the Internet, providing access to these documents to others. Besides the opportunity to access their documents and files from any computer in any location when connected to the Internet.

The article Diana S. Perdue [3] say that Google Docs is the best tool for working with a small group of students on collaborating project and in co-write something as part of a cooperative learning group project. Using Google Docs allows to provide an interactive, dynamic, constantly accessible platform where students and teachers can achieve educational goals.

Microsoft provides such opportunities in service *Office Web Apps* (*office.microsoft.com/en-us/web-apps*): review and share files regardless of the location of users, the ability to simultaneously work with others on documents in different platforms, devices and different versions of Office and even if they have not installed Office; store documents online to share.

The cloud-based technologies *DropBox* (*www.dropbox.com*), which was developed in 2008, allows users to store their data on servers in the cloud and share them with other users online. The work is based on data synchronization.

Video-conferencing or online classrooms provide a real opportunity for students to participate in a classroom situation and to interact with a teacher and other students in ways that would not have been possible before the widespread availability of fast broadband Internet connections. Students can access live interactive tuition at flexible times and locations. *Elluminate* (*www.elluminate.com*), *iLinc* (*www.ilinc.com*), *WiZiQ* (*www.wiziq.com*) are examples of providers of video-conferencing and online classroom facilities. These resources support in organizing conduct webinars (web conferencing) in online mode or in writing. They provide an online classroom with an IWB that both teachers and students can use; facilities to up-load documents such as PowerPoint presentations, PDF, Word, Excel documents, video and audio files; lesson-recording and playback for absent students or for revision; application-sharing capability for working together with mathematical applications such as spreadsheets, dynamic geometry or graphing software. Communication happens via keyboard, via microphone and headset and through handwritten mathematics via a graphics tablet. It is possible to use the board. You can download course materials before class or during exercise. Downloaded files are placed in the cloud [2, p. 86].

There are many online resources to support interactive extracurricular

interaction: platform Piazza, Skype, Google+ and many others.

Using the platform *Piazza* (*piazza.com*) provides support learning activities of students outside the classroom. For example, on a platform Piazza class of mathematical topics are at the University Columbia – Calculus I, University of Illinois at Urbana-Champaign – Algebra, Cornell – Calculus II, University of Toronto – Advanced Engineering Mathematics, University of British Columbia – Real Variables I, New Mexico State – Trigonometry and Pre-Calculus and others [4].

Using *Skype* (*www.skype.com*) the teacher can not only maintain communication with students, but also to conduct conferences and video lessons. With MP3 Skype Recorder can record conversations to make Skype in audio format and post it as a teaching material on the Internet.

Computer support object-oriented practice is to provide the user (student or teacher) set of facilities and tools that automate and provide an opportunity to test the process of solving practical problems. Such a system must be equipped with a full set of methodological support. In mathematics it is a tutorial book of problems, guide, student workbook, a collection of examinations and tests, guidance teachers and others.

The main purpose of the development and implementation of the learning process of educational software environments support the practice of students is increasing the efficiency of high-quality training in the laboratory and the practical part of the training course for self-study research nature [6].

The choice of computer mathematics (SCM) and the support of a large installation base on the solved through the application of network technology, a user with a specialized client software addresses the server side of the SCM, where user commands are executed and the result is returned to the client software. These services are provided, in particular, MATLAB Web Server, webMathematica and SageMathCloud. Although not all of the SCM includes embedded networking tools, for those of them, which along with the visual supports command interface can create a network add-in [5].

New promising line of SCM are the mobile mathematical environment, the first representative of such systems have appeared only in the early twenty-first century. How is the SCM in a single network environment, it is the transfer application software (even the «Desktop») in the Web- environment. It is important that the use of mobile Web-environments in the learning process enables integration of classroom and extracurricular work in a continuous learning process.

Using Web-SCM can:

1) perform any calculations, both analytical (actions of algebraic expressions, solving equations, differentiation, integration, etc.) and numerical (exact – with any bit, close – with any advance given accuracy),

2) to present the results of calculations in readable form, to build two-and three-dimensional graphs of curves and surfaces, histograms, and any other images (including animated);

3) combine computing, text and graphics on a worksheet with the possibility of printing, publishing online, and collaborate on them;

4) created using the built-in programming language implementation models for educational research.

The main areas of application of Web-SCM in learning mathematics include [5]:

– graphical interpretation of mathematical models and theoretical concepts;

– automation of routine calculations;

– support for self- employment;

– organization of mathematical research.

A good representative Web-SCM is SageMathCloud, developed in 2005 by Washington University mathematician William Stein. Based on Sage constructed mathematical mobile environment that acts as an integrator of various mathematical packages by providing a common Web-based interface.

The *Wolfram Demonstrations Project* (*demonstrations.wolfram.com*) in 2007 also has many Mathematics demonstrations addressing geometric topics. The demonstrations help learners interact with three-dimensional objects, which can be difficult to visualize. It has open code. In demonstrations can provide different parameter values and conduct research objects [1, p. 297].

In 2009, *Wolfram|Alpha*, self-described as a «computational knowledge engine» began operation (*www.wolframalpha.com*). This site is a veritable goldmine for doing mathematics online. More specifically, Wolfram|Alpha delivers graphs with additional targeted information on the function or equation entered. Entering the equation yields the information that the geometric figure it is and its characteristics. As for entering a function, such as $(x - 1)(x + 2)(x - 3)(x + 4)(x - 20)$, Wolfram|Alpha, unlike other graphing calculators except Web-Graphing.com, determines function-dependent window dimensions that include essential mathematical features of the function. Typically, Wolfram|Alpha delivers two graphs, one local that includes all important points of interest and the other global that indicates the end behaviors of the function. In addition, this website provides step-by-step instructions for taking derivatives and computing indefinite integrals, including approximate values (no steps) for local maxima and minima. WebGraphing.com also delivers two graphs, both of which include all important points of interest, additionally showing asymptotes, discontinuities, and holes, in standard mathematical notation. There, the two graphs differ by color-coding; one graph shows increasing curve segments in one color and decreasing curve segments in

another color, while the other graph shows concave up curve segments in one color and concave down curve segments in another color. Also included are complete calculus solutions with both symbolic and approximate values, as well as tutorial steps for determining these values. [1, p. 286-287].

GeoGebra (*www.geogebra.org*), developed in 2010 by Markus Hohenwarter and an international team of programmers, offers an easy-to-use, interactive applet that can either be used directly in a web browser or downloaded for local use. Users are provided a blank two-dimensional plane (as either an axis or grid) on which they can place points and create lines and shapes. As the learners produce and manipulate objects by dragging points, updated information about the objects is displayed, including equations of lines, measurements of angles, and side lengths of creating polygons. There is also an open field that allows users to input their own equations to be graphed. These dynamic features allow GeoGebra to be very versatile and useful for exploring a wide range of two-dimensional plane-geometry topics. Learners can move from investigating basic geometric principles, such as reflection, congruence, and similarity of polygons, to advanced ideas including tangent lines, ellipses, vectors, and hyperbolas [1, p. 296].

Designed in 2011, TI-Nspire is a hand-held device which resembles a graphing calculator, such as the TI-84, but it has a larger screen and a redesigned keyboard. In fact it is a dedicated hand-held computer running a package called TI-Nspire which is also available as a software package for use in a Windows PC. There are two versions of both the hand-held and the software with computer algebra system (CAS) and without, plus a teacher edition of the software which includes an emulator to demonstrate the use of the hand-held. There are five pages that can be added to a TI-Nspire document:

– calculator (this includes symbolic algebra manipulation in the CAS version);

– graphs and Geometry;

– lists and Spreadsheets;

– notes;

– data and Statistics.

A particular feature of TI-Nspire is the ability to combine the different features of graphing and geometry. In this case the Geometrical feature to mark intersection points accurately has been used to find the intersection of two graphs [2, p. 63].

Thus, we can distinguish the following features of the present stage of development of ICT tools for teaching mathematics engineering students:

1) the transfer of the mathematical activities of teachers and students of computer space to use network technologies;

2) the ability to work with office applications without booting to their

workplace required software;

3) access to personal user data from any workstation;

4) the possibility of community access and correction files, regardless of the location of each.

There are a number of problems in the implementation of ICT in the sixth period:

1) the availability of necessary equipment and software to all members of the educational process in the classroom and beyond;

2) the need for continuous learning new tools and capabilities teachers and students that takes enough time;

3) the need for adequate financing for the purchase of licenses for the acquisition of commercial tools to support learning activities;

4) an opportunity to understand the students with some state variable interface Web technologies.

Thus, the emergence of new hardware or the software affects the process of teaching mathematics and creating conditions for the realization of a Thunderstorm-based learning of mathematics, which became the leading trend today.

References

1. Cherkas B. Interactive Web-based tools for learning mathematics: best practices / Barry Cherkas, Rachael M. Welder // Teaching Mathematics Online : Emergent Technologies and Methodologies / Edited by Angel A. Juan, Maria A. Huertas, Sven Trenholm, Cristina Steegmann. – Hershey : Information Science Reference, 2012. – P. 276-310.

2. Oldknow A. Teaching mathematics using ICT : third edition / Adrian Oldknow, Ron Taylor and Linda Tetlow. – New York, 2010. – 328 p.

3. Perdue D. S. Best practices for hybrid mathematics courses / Diana S. Perdue // Teaching Mathematics Online: Emergent Technologies and Methodologies / Edited by Angel A. Juan, Maria A. Huertas, Sven Trenholm, Cristina Steegmann. – Hershey : Information Science Reference, 2012. – P. 90-118.

4. Piazza • Ask. Answer. Explore. Whenever [Electronic resource] // Piazza Technologies. – Piazza Technologies, 2014. – Access mode : https://piazza.com/piazzafactsmath.html

5. Словак К. І. Мобільні математичні середовища: сучасний стан та перспективи розвитку / Словак К. І., Семеріков С. О., Триус Ю. В. // Науковий часопис Національного педагогічного університету імені М. П. Драгоманова. Серія № 2. Комп'ютерно-орієнтовані системи навчання : зб. наукових праць / Редрада. – К. : НПУ імені М. П. Драгоманова, 2012. – № 12 (19). – С. 102-109.

6. Семеріков С. О. Комбіноване навчання: проблеми і перспективи застосування в удосконаленні навчально-виховного процесу й самостійної роботи студентів / Семеріков С. О., Стрюк А. М. // Теорія і практика організації самостійної роботи студентів вищих навчальних закладів : монографія / кол. авторів ; за ред. проф. О. А. Коновала. – Кривий Ріг : Книжкове видавництво Кирєєвського, 2012. – С. 135-163.

References (translated and transliterated)

1. Cherkas B. Interactive Web-based tools for learning mathematics: best practices / Barry Cherkas, Rachael M. Welder // Teaching Mathematics Online : Emergent Technologies and Methodologies / Edited by Angel A. Juan, Maria A. Huertas, Sven Trenholm, Cristina Steegmann. – Hershey : Information Science Reference, 2012. – P. 276-310.

2. Oldknow A. Teaching mathematics using ICT : third edition / Adrian Oldknow, Ron Taylor and Linda Tetlow. – New York, 2010. – 328 p.

3. Perdue D. S. Best practices for hybrid mathematics courses / Diana S. Perdue // Teaching Mathematics Online: Emergent Technologies and Methodologies / Edited by Angel A. Juan, Maria A. Huertas, Sven Trenholm, Cristina Steegmann. – Hershey : Information Science Reference, 2012. – P. 90-118.

4. Piazza • Ask. Answer. Explore. Whenever [Electronic resource] // Piazza Technologies. – Piazza Technologies, 2013. – Access mode : https://piazza.com/piazzafactsmath.html

5. Slovak K. I. Mobilni matematychni seredovyshcha: suchasnyi stan ta perspektyvy rozvytku [Mobile mathematical environments: current state and development prospects] / Slovak K. I., Semerikov S. O., Tryus Yu. V. // Naukovyi chasopys Natsionalnoho pedahohichnoho universytetu imeni M. P. Drahomanova. Seriia # 2. Kompiuterno-oriientovani systemy navchannia : zb. naukovykh prats / Redrada. – K. : NPU imeni M. P. Drahomanova, 2012. – # 12 (19). – S. 102-109. (In Ukrainian)

6. Semerikov S. O. Kombinovane navchannia: problemy i perspektyvy zastosuvannia v udoskonalenni navchalno-vykhovnoho protsesu y samostiinoi roboty studentiv [Blended learning: problems and prospects of improvement in the educational process and students' independent work] / Semerikov S. O., Striuk A. M. // Teoriia i praktyka orhanizatsii samostiinoi roboty studentiv vyshchykh navchalnykh zakladiv : monohrafiia [Theory and practice of independent work university students: monograph] / kol. avtoriv ; za red. prof. O. A. Konovala. – Kryvyi Rih : Knyzhkove vydavnytstvo Kyrieievskoho, 2012. – S. 135-163. (In Ukrainian)