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Flipped Learning for Teaching Ukrainian IT Students

Abstract

The paper is devoted to utilisation of flipped learning for improving educational quality for IT students. The article discusses the advantages and disadvantages of flipped learning, the obstacles for its adoption are also described. The modification of educational functions, roles, actions, and interconnections of the participants during implementation of flipped learning is shown. Flipped learning implementation algorithm is proposed for a university discipline. Uniform architecture for flipped course which consists of face-to-face and online parts is provided. Forms and requirements for e-content are described. Approaches and technologies for implementing the online part of flipped learning are also discussed. Innovative educational technologies which may be useful at the stages of meaning realisation and knowledge reflection as well as for creating professional students' skills are proposed. The proposed solutions are uniform and formed by generalisation of the knowledge about the data domain, they can be utilised at Ukrainian universities.

K e y w o r d s: flipped learning, blending learning, distance learning, IT-students teaching

Introduction

Some disadvantageous changes taking place in Ukrainian higher education system, decrease in public funding and the resulting reduction of classroom hours, moral aging of educational equipment, and increased requirements for university graduates in the Ukrainian labour market, all of those have inevitably lead to searching for new educational methodologies, tools, and technologies. The process of training skilled professionals, creative and efficient graduates is a complex one. For today's specialists whose main aim is to acquire practical skills, the problem of implementing and effective use of innovative pedagogical approaches, modern information and communication technologies (ICTs), globally successful pedagogical practices becomes a priority task (Koshechko, 2015). Application of ICT in education allows its modernisation, activation of innovative potential, development and introduction of advanced pedagogical methodologies.

The process of mastering new knowledge and competences within the course of education discipline includes the following: comprehension of theoretical lecture material, arrangement of acquiring practical skills and abilities, managing student's self-study, and examining how the new knowledge is acquired. The variety of forms and methods for combining ICT with traditional education shows that searching for methods of modernising the education system and making it up-to-date according to the requirements of the labour market is highly relevant and important. Today, one can say that the Ukrainian higher education mostly uses blending learning technology, which means, the traditional education system is to some extent supplemented by means of ICT (Korotun, 2016). IT education faces the crucial task of effective development of practical skills and abilities for future professionals involved in software development, maintenance, and quality assurance. At each stage of education, information and computer technology can provide effective tools for maintaining high level of presentation of educational materials, as well as for motivating the students to learning activities. Flipped learning methodology is analysed in the present article as a potential strategy to improve professional skills by decreasing class hours intended for theoretical material and utilising them for solution of practical problems.

The main research focus is to analyse the flipped learning technology in terms of its possible implementation as an effective tool for improving the educational process and professional competences of IT students.

General Background of the Research

A multitude of Ukrainian and foreign scholars have showcased their interest in arrangement and effective implementation of electronic, blended and distant learning in modernisation of traditional education. The approaches and methodologies for introducing the modern ICT into educational process are described, among others, in research papers by the following authors: Buhaichuk (2016), Korotun (2016), Kademiia (2016), Koziar (2015), Morze (2017), Kukharenko, and others.

Involved in development of methodologies and technologies of electronic, blended, or distant learning are the following representatives of foreign academic schools: K. Shpanagel (Germany); professors D. Bergam, A. Samson (USA); professor E. Smyrnova-Trybulska (Poland); professor C. D. Sixto (Spain); M. Capay, M. Drlik (Slovak Republic); professor P. Kommers (Netherlands), and others.

The prospects, problems, methodological principles of utilising flipped learning in Ukrainian universities in general and for teaching certain disciplines are, among others, studied in papers by Didukh (2015), Prykhodkina (2015), Romanych (2015), Popadiuk and Skurativska (2017), Chopovska, Piankovska , Yevdokymova-Lysohor, and Buhaichuk (2016). The Ukrainian project Prometheus creates online courses for launching a blended-learning project, while flipped learning model is used by teachers at the National Technical University of Ukraine (Igor Sikorsky Kyiv Polytechnic Institute) and National Technical University (Kharkiv Polytechnic Institute), Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, etc. (Buhaichuk, 2016). In 2010, Clintondale High School in Detroit (USA) became the first "flipped school" that completely switched to flipped learning concept (Didukh, 2015).

The patterns, purposes, advantages, and disadvantages of flipped learning are studied by Aaron Sams, Jonathan Bergman, Salman Khan, Kari M. Arfstrom and other researchers at different universities and in various countries. According to a 2014 survey conducted at Lesley University (Cambridge, Massachusetts), 78% of teachers said they had flipped lesson, and 96% of those who tried it said they would recommend it to other educators. Awidi and Paynter (2019) report on evaluation of the impact of a flipped classroom approach on the learning experience of students undertaking an undergraduate biology course. The results of the study by Karagol and Esen (2019) reveal that there is a positive effect of the flipped learning in academic achievement compared to traditional learning approach. The study financed by the University of Zaragoza and devoted to the analysis of flipped learning as an active learning approach is presented in Blazquez, Masluk, Gascon et al. (2019).

A variety and the number of the academic works devoted to flipped learning demonstrate the topicality and prospects of this pedagogical and learning approach.

Identification of the Research Goals

Despite the diversity and number of scholarly articles, the problem of maintaining a sufficiently professional level of teaching in higher education institutions, as well as creating useful competences in graduates remains a relevant academic and practical task and requires further research and development.

The main purpose of the study is to carry out a comparative analysis of traditional and flipped learning in the context of training IT-students. The authors defined the following objectives of the research:

1. Definition of "flipped learning", analysis of history and the preconditions for its creation, analysis of global and Ukrainian practices for its implementation at universities.
2. Determining the advantages and disadvantages of flipped learning, identifying difficulties in introducing flipped learning into education process for IT students. Determining its role and place in traditional education.
3. Presentation of "traditional learning – flipped learning" transformation scheme, description of how the roles, functions, and responsibilities of education process of participants might change.
4. Description of the generalised architecture for a lesson held in accordance with the flipped-learning model: definition of online and face-to-face learning components.
5. Description of requirements for educational e-content for a flipped lesson.

The Research Results

Introduction of ITCs into education process generated a number of definitions regarding this phenomenon:

– e-learning is an education system that provides for the availability of electronic learning content and means of communication;
– online (distance) learning is a type of e-learning, where the source of knowledge and the student are separated by distance;

– blended learning is an education technology that combines e-learning with traditional face-to-face learning. Depending on the scope and methods of applying ICTs in the traditional education system, the following types of blended learning are distinguished (Buhaichuk, 2016): rotation model assumes cyclic nature of working with teaching materials; flipped learning is an educational method which assumes that students first get acquainted with the theoretical materials using online learning tools, and then actively master the acquired skills in a classroom under the supervision of a teacher; self-blended model is a model assuming that the students can add several online courses to the main regulated curriculum;
– mobile learning (m-learning) means knowledge transmission using mobile devices with WAP and GPRS technologies (Koziar & Kademiia, 2015);
– ubiquitous learning is a phenomenon of continuous education with the use of ICTs in all areas of life and in life-long terms.

The Main Features of Flipped Learning

The inventors of flipped learning are American chemistry teachers, Aaron Sams and Jonathan Bergman, who in 2008 created lecture presentations and then recorded video collection of chemistry lessons for self-study by students (Kademiia, 2016). The rapid development of flipped learning idea is associated with another American, Salman Khan, who created the Open Educational Resources Academy in the form of video lectures (Bergmann & Sams, 2012).

The origins of flipped learning include the need to stimulate students to self-directed educational activities, modification of traditional lectures, when all educational material has to be analysed in parallel with listening or annotation, while development of practical skills and abilities is mainly delegated to off-classroom self-reliant work (Prykhodkina, 2015).

Two concepts constitute the basis of flipped learning model:

1) psychological concept: due to visualisation of the content, the educational material can be better comprehended and retained in memory for a longer period;
2) pedagogical concept: the in-classroom time would be spent more efficiently on active cognitive tasks through discussions, solution of practical problems, consolidation of theoretical knowledge, reproduction of example problems, etc.

Currently, the educational programmes for higher education students, curricula and course programmes in Ukraine regulate the ratio of classroom work vs self-study as one hour of classroom activities to three hours of self-dependent work, therefore, increasing students' motivation to self-study and self-develop-

ment of professional competences is extremely relevant problem, particularly for IT-education. The flipped learning assumes that theoretical material is studied by the students off-classroom, utilising ICTs, for example, using video lectures. Thus, the main source of theoretical knowledge is not the teacher in the classroom, but the digital materials provided remotely. The self-reliant homework and classroom work switch places: the consolidation of the educational material in classroom combines with self-reliant study of the theory. The roles and functions of the teacher and students also change. The generalised transformations during transition from the traditional education system to the flipped learning are provided in Table 1.

Table 1.
Expected transformations of the traditional education system

Problem domain	Traditional education	Flipped learning
Student	"Listen – remember – reproduce" scheme	Key role in cognitive activity (learner-centred approach). Increased responsibility for acquiring the theoretical material.
Teacher	Acting as a primary source of information (teacher-centred approach). Functions: learning process supervision and monitoring; development of learning materials for the discipline	Functions: counseling, direction and motivation to self-reliant cognitive activity; learning process coordination and monitoring; developing of interactive learning materials along with managing the e-content.
Self-study	Consolidation of theoretical knowledge, solving individual practical tasks, project development.	Prior study of theoretical material, project development.
Classroom study	Writing abstracts of theoretical material; solving practical or laboratory tasks; examining the acquired knowledge.	Consolidation of self-learned theoretical material. Obtaining practical skills and abilities. Examining the acquired knowledge.
Educational material acquisition from	Passive: from teacher to student	Active
interaction between the participants of education process	Synchronous	Synchronous during classroom lectures. Asynchronous using ICT.
Knowledge transfer methods	Interactive technologies, face-to-face learning	Interactive technologies utilising ICTs, combination of face-to-face and online learning, person-oriented approach, cooperation pedagogy

S o u r c e: own work.

According to a study by the Center for Digital Education and Sonic Foundry, among the members of Educational Exchange online community half of the US university lecturers have already used flipped learning in classrooms (Markova & Shmatok, 2018). As for introduction of flipped learning in Ukrainian universities, the consecutive steps from the lecturer's point of view are presented in Figure 1.

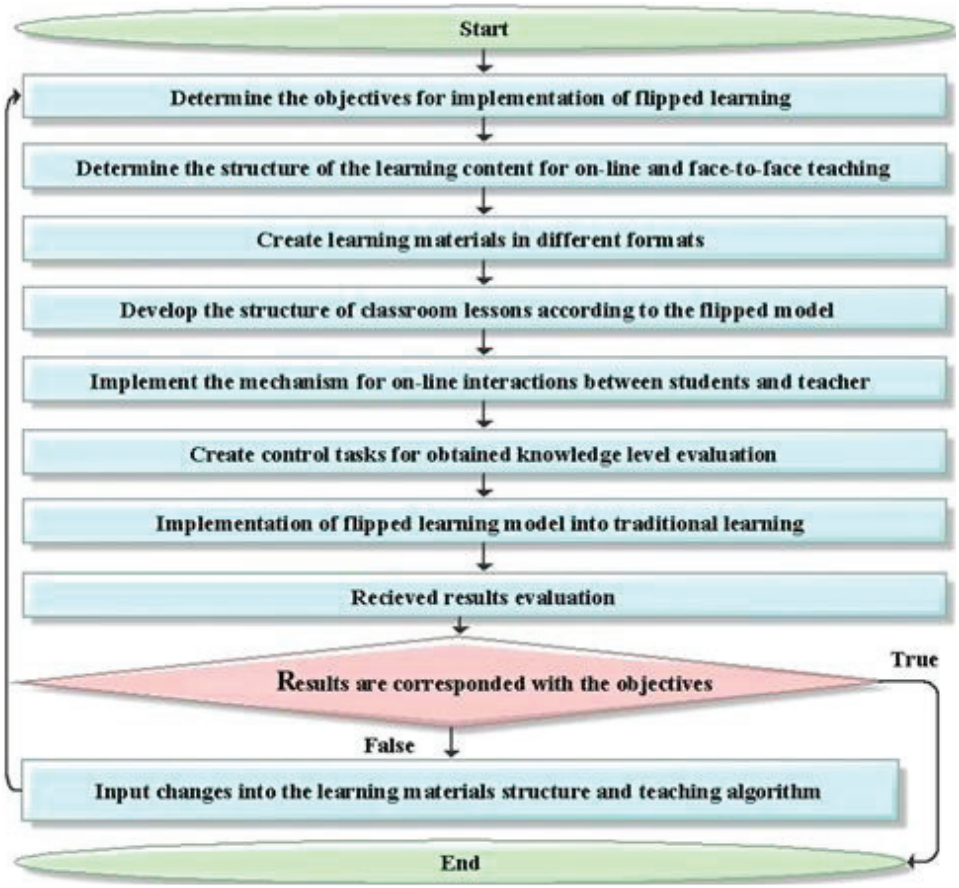

Figure 1. Flipped learning implementation algorithm
Source: own work.

To create a course using flipped learning technology, the teacher has to solve the following problems:

1. Determine the objectives for implementation of flipped learning into the selected subject.
2. Determine the amount, composition, and structure of the necessary teaching materials, namely, how to divide them into online and classroom portions.

3. Create e-learning materials, video lectures, podcasts, animations, infographics.
4. Develop the structure of classroom lessons, giving higher priorities to mastering practical skills, while using advanced pedagogical technologies.
5. Develop or apply mechanisms for interactions between the students, the e-learning materials, and the teacher by means of ICT and the Internet. Provide access to e-learning content and arrange for feedback.
6. Develop mechanisms for assessing how well the knowledge has been acquired: tests of various formats, controlling tasks, questions, and dialogues.
7. Organise education process using flipped learning model.
8. Assess and analyse the results. Make conclusion on reorganisation of education process components, as well as learning content.

Advantages and Disadvantages of Flipped Learning

The main advantage of flipped learning is the possibility of combining the advantages of online and classroom lesson under the direction and supervision of a lecturer, and the most significant positive results thereof are as follows (Romanych, 2015):

– the possibility of customising the education by the students, as well as expanding the area of their interests;
– an increase in cognitive activity, development of cooperation skills, improvement of IT-competences;
– accessibility and flexibility of the online learning environment
– improving the quality of acquired practical skills by decreasing the number of classroom hours;
– realising the responsibility and importance of self-study.
– Despite the above-mentioned advantages of flipped learning, there is a number of significant barriers to its effective use:
– increased entry threshold for flipped learning students and requirement for sufficient level of IT competences of all participants of training. This requirement can be easily met by IT students, since their basic IT competences allow them to enter the education process utilising ICT tools quite quickly. This idea was proved by the analysis of the data of students survey, the results are presented Yalova and Zavgorodnii (2016);
– the need to produce video lectures or podcasts by teachers, which is a quite time-consuming, labour-intensive additional work to be made in preparation for lessons;

– the need to replace the traditional lectures with lessons using material-comprehension technologies;
– the lack of a legal basis, as well as the role and place of flipped learning in the traditional education, the duties and rights of teachers and students;
– the students must make themselves acquainted with theoretical material prior to the lesson, failing to fulfil this requirement will result in the idea of flipped learning as to classroom work on discussion and consolidation of the material being will be nullified.

Architecture of a Course Arranged in Accordance with Flipped Learning

Concept

The architecture of each lesson implemented according to flipped learning model consists of two interrelated and mandatory parts: online part and face-to-face part (Figure 2). The online part supports the students in consolidation of theoretical material during self-study before the classroom lesson. The face-to-face part is carried out under the direction of a teacher, its purpose being mastering practical skills and formation of professional competences.

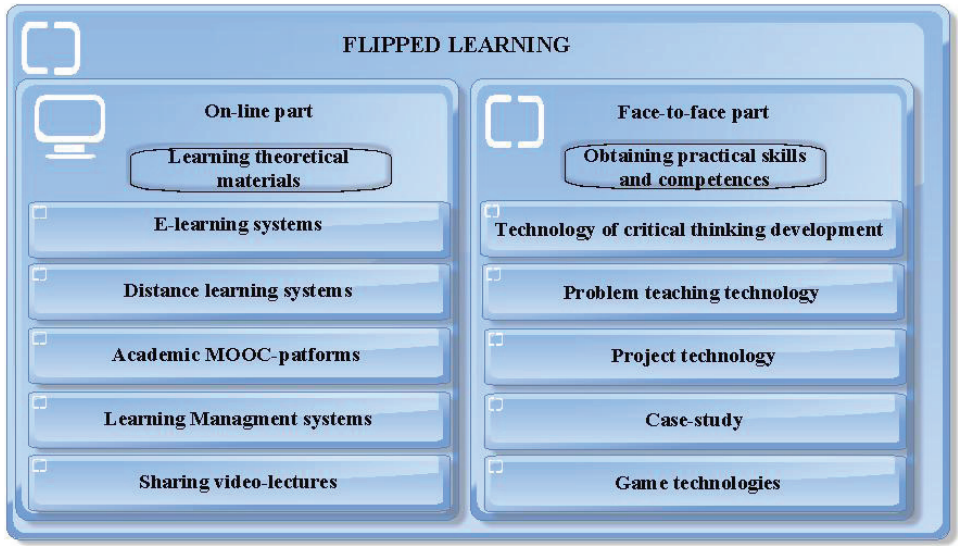

Figure 2. Flipped learning architecture
S o u r c e: own work.

Online part of flipped learning. The online part can be implemented by means of self-developed e-learning or online learning systems, academic MOOCs (massive open online courses) platforms (Yalova & Yashyna, 2017), or by means of existing commercial and non-commercial learning management systems (LMSs), which are comparedin the article by Yalova and Zavgorodnii (2016). The main task of the students regarding the online part is self-preparation prior to classroom lesson by reviewing the video materials, video lectures, and podcasts developed by the teacher. To ensure the most effective implementation of flipped learning technology, its online part shall contain the following mechanisms:

– managing the educational e-content created by lecturers in the forms of video lectures, podcasts, brief learning media materials;
– structured presentation of educational materials according to education programmes, curricula, or working plans for a subject, representation of logical and structural scheme of a subject, interconnections between topics;
– tools for presenting and viewing the educational material, implementation of online video player or download system. Presentation of educational materials using multimedia;
– mechanisms for remote examination by a teacher or self-examination.

The online part of flipped learning model allows the students to customise the learning process by arranging an individual learning pace, choosing convenient time and place to study, using the possibility of replaying the materials while focusing on points unclear to them. The main obstacle for efficient use of the online part in flipped learning is that the students do not devote enough attention to self-study and self-examination. However, the insufficient motivation to cognitive tasks performed, that teachers always encounter, will be very hard to change, whichever learning model is chosen. That is why we should not underestimate the importance of utilising the modern ICTs for motivating students to self-study and growing interest in learning process. At the same time there is a number of requirements and recommendations for the video materials:

– the videos ought to be brief, comprehensive, and engaging;
– maximum duration for a single video lecture is 30 minutes, recommended duration – l0 minutes;
– it is reasonable to divide a single topic into several videos or podcasts;
– utilising various visualisation forms: infographics, animations, video captures, for instance, actions videorecorded during coding activity;
– accounting for psychological features of the students during creation of the video, selection of fonts, structure, number of comments. Especially, one has to pay attention to tips and hints given to the students. Such hints should, on the one hand, give a student some relevant help in learning situation, on the other hand, they shall not hinder the student in his or her individual activity;

– supplementing videos with other digital materials: presentations, subtitles, tests, etc.;
– links to external additional resources: web-links to program code examples on the Internet or other educational videos.

The educational e-content should be supplemented with virtual discussion platforms or feedback mechanisms enabling communication between all participants. Arrangement of online cooperation between the students can serve as additional mechanism for motivating students to successful learning.

Pedagogical techniques for face-to-face part of flipped learning. The arrangement of face-to-face component of flipped learning is equally important. The teacher faces a number of challenges requiring considerable effort and time, since the flipped learning model assumes changes in learning process priorities. The role of the classroom work is changing, the priority shifts to acquiring practical skills and abilities according to current requirements. The face-to-face part deals with arrangement of active cognitive tasks by applying various forms of material presentation, examining the acquired knowledge, switching between learning patterns in order to enhance the cognitive abilities of the students, so that the knowledge is acquired faster and remembered for longer periods of time. In order to achieve this goal, modern pedagogical technologies can be reasonably applied – models of collective pedagogical activity on designing, organising and conducting the educational process (Koshechko, 2015) that includes three phases: the evocation of meaning, the realisation of meaning, and reflection. The authors would like to recommend the following education techniques for the phases of realisation and reflection in the process of teaching IT-students:

1. Technique of critical thinking development, which aims to teach how to discuss, evaluate, identify, and solve IT problems. It involves the following methods:
   a) cluster method assumes generalisation of information in a given problem domain and presentation of its main units in a graphical form in the form of a scheme with displayed links;
   b) table method assumes generalisation of information in a given problem domain and presenting it in table form, for instance, table of terms in the format “Keyword – Definition” or completion table in the format “I know – I do not know – I want to know – I’ve learned”;
   c) insert method is used during the realisation phase when a student learns theoretical material; it assumes marking the text with such set phrases as *I know*, *I understand*, *Contrary to what I know*, *I did not understand*. Despite the fact that this method assumes a combination of reading and writing in the classical understanding of those terms, it can also be applied to video-materials with students marking their impressions of what they see;

   d) Cinquain creation method assumes presenting the material being learned as five lines of text. The first line – one word describing the topic of the problem domain or the object. The second line – two adjectives describing the properties of the object. The third line – three verbs describing the object's characteristic actions. The fourth line – a phrase reflecting author's attitude towards the object. The fifth line – one word being a conclusion.
2. Project technique assumes taking a particular problem from the problem domain and solving it while applying the acquired knowledge and mastering new skills. Project technique implementation phases: organisational phase, search phase, conclusion phase, and reflection. This technology is especially useful for disciplines that assume development of course projects.
3. Problem learning technique assumes arrangement of self-reliant search activity for solving the given tasks; this leads to acquiring new knowledge and competences, as well as developing cognitive skills, creative thinking, etc. Generally, the problem-learning technique includes describing the problem, creating a hypothesis for its solution, outlining and discussing the ways of its verification, proving the hypothesis, and analysing the results.
4. Game-based techniques combine activities aimed at obtaining real-problem experience, as well as improving behavioural self-management. There is a number of pedagogical games, of which intellectual, cognitive, training, and subject-oriented games can be mentioned as suitable for teaching IT-students, the functions shall be distributed according to the roles of IT-project participant.
5. Case study is an interactive learning technique based on real-world and abstract situations, that is aimed not only at developing theoretical knowledge, but rather at generating practical skills and abilities. One can name the following approaches to the case-study technique:
   a) incident method, the main purpose of which is developing or improving the skills of making professional decisions accounting for lack of information, as well as rational collection and utilisation of the data required for making effective decisions. The students have to search for the information on their own, since instead of a detailed description of the problem situation and the problem domain they receive only a brief note about the incident.
   b) In-basket method is a technique aimed at developing professional competences by creating situations that are as close to the real-world problems as possible, where the student acts as a decision-maker, for instance, analysing software requirements or business process reengineering problem.

The classroom lesson in flipped learning model can consist of the following phases:

1. Motivation for learning. Definition of problem keyword, rising interest through practical activities.
2. Strengthening the knowledge acquired during online self-study: answers and questions, explaining the points that were not understood, giving examples, group work, simulation of problem situations, discussions, cross-discussion, etc.
3. Learning the new material through the solution of practical problems, developing professional competences through solving the similar tasks but with other input conditions, personal tasks, group tasks with software development functions divided between participants, fixing program bugs, code refactoring, evaluating software and interface quality, etc.
4. Assessment of material apprehension: a brief quiz or test incorporating various forms of questions: a question with a single correct option, a question with multiple correct options, or a question that shall be answered without any option.
5. Debriefing, that is, making conclusions, collecting remarks, answering questions, motivating to further self-study.

Conclusions

The article analyses the origins, preconditions, methods, and practice of introducing flipped learning concept into higher-education system in Ukraine and elsewhere. The traditional and flipped learning, as a type of blending learning, are compared. The algorithm is given for implementing the flipped learning model in IT-related subjects. It is universal, mass-applicable, result-oriented, and determined, it can be applied in Ukrainian universities. The article provides the scheme for traditional education transformation, as well as describes how the education process precedes change in flipped learning model. The architecture of the flipped learning model consists of online and face-to-face parts, for each of them the authors propose the methods, mechanisms, technologies, and software tools for their implementation.

The flipped learning is considered a relatively new approach, and therefore it is quite difficult to find research articles that would compare flipped learning to traditional approaches. The eight-year experiment, aimed at comparing the professional level of graduates who participated in flipped leaning to those of tradition system, is currently being conducted at Harvey Mudd College (Claremont, California). The preliminary assessment of the results shows that the effectiveness of

knowledge acquisition does not decrease in case of flipped learning, at the same time providing the students with the flexibility of the educational process and presentation of learning materials, thus allowing them not to worry about missing classroom lessons.

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Metoda odwróconej klasy w nauczaniu informatyki ukraińskich studentów

Streszczenie

Artykuł poświęcony jest wykorzystaniu metody odwróconej klasy (flipped classroom) w poprawie jakości kształcenia studentów kierunków informatycznych. W pracy przedstawiono zalety i wady uczenia się metodą odwróconą, opisano także przeszkody w jego wprowadzeniu. Pokazano modyfikację funkcji edukacyjnych, ról, działań i wzajemnych powiązań uczestników podczas realizacji uczenia się metodą odwróconą. Algorytm implementacji uczenia odwróconego jest proponowany dla dyscypliny uniwersyteckiej. Podano jednolity program dla kursu odwróconego, który obejmuje część stacjonarną (twarzą w twarz) i część on-line. Opisano formularze i wymagania dotyczące treści elektronicznych. Omówiono również technologie wdrażania metody uczenia się przez Internet. Zaproponowane innowacyjne technologie edukacyjne mogą być przydatne w realizacji tematów z zakresu IT, a także do tworzenia umiejętności zawodowych uczniów. Proponowane rozwiązania zostały ujednolicone, dlatego można je wykorzystać na ukraińskich uniwersytetach.

Słowa kluczowe: nauka odwrócona, nauka łączona, nauka na odległość, nauczanie studentów informatyki

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Перевернутое обучения для подготовки IT-студентов

Аннотоция

Статья посвящена рассмотрению вопроса применения перевернутого обучения как средства повышения качества подготовки соискателей высшего образования в области знаний «Информационные технологии». В статье описаны преимущества и недостатки применения перевернутого обучения, определены трудности на пути его внедрения в традиционный образовательный процесс. Представлена схема модификации образовательных функций, ролей, действий и взаимосвязей субъектов обучения в ходе реализации перевернутого обучения. Предложен алгоритм реализации модели перевернутого обучения для учебной дисциплины университета. Представлена унифицированная архитектура перевернутого курса, которая состоит из он-лайн и аудиторной составляющих. Описаны формы и требования к разработке электронного учебного контента он-лайн части перевернутого

обучения. Представлены подходы и технологии реализации он-лайн части перевернутого курса. Рекомендованы инновационные педагогические технологии, использование которых является целесообразным на этап восприятия и рефлексии знаний при формировании профессиональных компетентностей студентов. Предложенные решения являются универсальными и сформированы путем обобщения знаний о предметной области и могут быть применены в высших учебных заведениях Украины при разработке перевернутых курсов для различных специальностей.

К л ю ч е в ы е с л о в а: перевернутое обучение, смешанное обучение, дистанционное обучение, подготовка IT-студентов

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Aprendizaje invertido para la enseñanza de estudiantes ucranianos de TI

R e s u m e n

El documento está dedicado a la utilización del aprendizaje invertido para mejorar la calidad educativa de los estudiantes de TI. El documento ofrece las ventajas y desventajas del aprendizaje invertido, también se describen los obstáculos para su adopción. Se muestra la modificación de las funciones educativas, roles, acciones e interconexiones de los participantes durante la implementación del aprendizaje invertido. Se propone un algoritmo de implementación de aprendizaje invertido para una disciplina universitaria. Se proporciona una arquitectura uniforme para el curso invertido que consta de partes cara a cara y en línea. Se describen los formularios y requisitos para el contenido electrónico. También se discuten enfoques y tecnologías para implementar la parte en línea del aprendizaje invertido. Se proponen tecnologías educativas innovadoras que pueden ser útiles en las fases de realización del significado y reflexión del conocimiento, así como para crear las habilidades de los estudiantes profesionales. Las soluciones propuestas son uniformes y están formadas por la generalización del conocimiento sobre el dominio de datos, pueden utilizarse en universidades ucranianas.

P a l a b r a s c l a v e: aprendizaje invertido, aprendizaje combinado, aprendizaje a distancia, enseñanza de estudiantes de TI