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eLearning Informatics: From Automation of Educational Activities to Intelligent Solutions Building

Malinka IVANOVA
Technical University of Sofia, College of Energy and Electronics, Sofia, Bulgaria
e-mail: m_ivanova@tu-sofia.bg

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Abstract. eLearning is fast progressing scientific field proposing novel and specific approaches in a range of domains. It is well established practice in universities, schools and organizations for delivering interactive, adaptive and flexible training, taking advantage of contemporary and emerging technologies. Informatics is a continuously evolving science presenting its theoretical and practical advances applicable in various research areas, including in eLearning. The paper presents an exploration focused on the symbiotic connection between Informatics and eLearning that leads to contemporary and innovative solutions, facilitating and automating a wide variety of activities at information processing. The term eLearning Informatics is conceptualized and explained as a scientific field outlining the current research achievements and further directions for development. The applied research methodology is based on outlining the main vision in the domain eLearning Informatics through utilization of bibliometric approach and construction of bibliometric networks as well as on detailed examination of topic-related scientific papers.

Keywords: Informatics, eLearning, Automation, Information, Information Systems, Information Technology, eLearning Informatics.

1. Introduction

Nowadays, one big part of educational process benefits of the usage of information technologies through different forms of eLearning and it does not matter the type of educational organization where it is provided: from universities and schools to small training organizations. Also, information technologies are used to support any form of knowledge delivery: in fully online universities and programs, distance and blended-learning programs and courses, face-to-face lectures and classes, Massive Open Online Courses (MOOCs). Information technologies are utilized to facilitate and automate the activities of all participants in an educational process: learners, educators,

administration and supportive staff, representatives and stakeholders and where it is applicable all other interested in that, including parents. Sometimes, "standard" solutions for education are preferred, for example, installation of Learning Management System (LMS) or a given software application to satisfy particular requirements of learners and educators. In other cases specific approaches are developed to ensure the successful programs and courses completion. Many scientific papers report adapted or emerged methods, algorithms and software programmes for improvement of general educational factors like flexibility (Aasbrenn and Bingen, 2009), mobility (Madeira *et al.*, 2009) and quality of education (Hay *et al.*, 2008) as well as for improvement specific educational characteristics such as: teaching concepts and theories that are hard to understand (Jeng *et al.*, 2010), promotion of deep learning (Czerkawski, 2014), critical analysis of teaching material (Kusmaryani *et al.*, 2019), transparent assessment (Rodríguez-Gómez and Ibarra-Sáiz, 2015).

eLearning as a research area continues to elaborate and evolve its theories and practices deciding the existing educational problems from didactical, methodological and technical point of view (Baz, 2018). The derived solutions become more adapted to the learners' preferences and teaching styles, more intelligent, increasing the learning and teaching performance and more complex, automating more and more educational tasks. This permanent development of eLearning is directed by the ubiquitous adoption of technologies, well formed technologically-driven society and as a result growing demands of learners.

Informatics is also a fast-stepping science that is in continuous progress, proposing technological products and tools that are applicable in different domains like: environmental sustainability (Watson *et al.*, 2010), intelligent spaces and human interactions in such environments (Liu *et al.*, 2010), civil engineering and construction (Turk, 2006). It takes its directional topics for development from the real world that wishes to become more useful and supportive for people. Some of its provisional resources in the form of concepts, theories and proposed solutions are applied in the context of eLearning too, giving huge possibilities for integrating technology in educational settings.

It can be seen that eLearning and Informatics are in a symbiotic connection where mutual interactions and ideas acceptance exists. In many situations, eLearning benefits from Informatics, adopting innovative non-educational software solutions for educational purposes or utilizes an emerged technology to enhance teaching and learning. In this situation Informatics is the driving force that pushes eLearning to use something new, giving answers to existing problems. In other cases, eLearning appears stimulating engine for Informatics, looking for a technological base that could implement and satisfy the current teaching/learning needs. eLearning could go further pushing Informatics to invent a specific solution according to emerged requirements of a learning process.

It can be said that a new direction of research *eLearning Informatics*, focused on mutually connected topics in the scientific fields of eLearning and Informatics, has to be explored and the best practices to be studied and analyzed. It will be extremely

beneficial to researchers, academicians, learners, as well as to experts and professionals that are responsible for implementation and deployment of technological and learning solutions in organizations.

The aim of the paper is to explore and discuss the conceptual bases of *eLearning Informatics* as a research field, after summarization and analysis of existing scientific production. A research framework of *eLearning Informatics* is proposed.

2. Research Methodology

An array of scientific literature is explored to study and summarize the contemporary state and the trends in research areas *eLearning* and *Informatics* as well as their intersection and mutual used themes. A research methodology with two procedures is applied that leads to improvement of the process related to the literature examination.

The first procedure is based on bibliometric approach which aim is to outline the main vision in the domain of *eLearning* and *Informatics*, according to the bibliographic data of scientific papers, indexed in scientific databases like SCOPUS and Web of Science. This bibliometric method is among the well accepted techniques by librarians and researchers for scientific production analysis. For example, Grandbois and Beheshti (2014) study the characteristics of open access articles; Hallinger and Kovačević (2019) analyze the articles related to educational administration; Tibaná-Herrera *et al.* (2018) outline the eLearning research field. The advantages and disadvantages of the bibliometric approach are discussed by Holden *et al.* (2005) as among the positive characteristics are mentioned: possibility for big datasets exploration, supporting decision making, facilitation the trends reveling. So, in this work, the bibliometric approach is applied and bibliographic networks construction for the terms *eLearning*, *Informatics* and their intersection with aim the terms concerning the research area *eLearning Informatics* to be derived. The purpose of the second procedure is summarization and analysis of scientific knowledge in domains related to *eLearning* and *Informatics* based on exploration the content of research papers and articles.

The steps of the first procedure are the following:

1. The aim of the first step is to extract the main and novel research topics that are in the scope of exploration by researchers in both scientific fields *eLearning* and *Informatics* in the last years. For this purpose, the indexed scientific papers in the abstract and citation databases Scopus and Web of Science are identified according to several keywords *eLearning* (*e-learning*, *electronic learning*) and *Informatics*. Then the searched results are refined according to: relevance, time period – publications made during 2017, 2018 and 2019 year, searched terms to be included in the title, abstract and keywords, the document type – conference paper, article, and review, and documents written in English language. The bibliographic datasets are extracted in July, 2019.
2. The second step is focused on the visual analysis of the gathered by databases bibliographic data, showing keywords co-occurrence in the papers through applying

the technique of visualization of similarities (Perianes-Rodriguez *et al.*, 2016) and utilization of VOSviewer. For this purpose, the bibliographic data are extracted in CSV format from Scopus and as structured text in TXT format from Web of Science. VOSviewer is software for visualization of bibliographic data to present the formed bibliographic networks, constructed on information for citations, co-citations, bibliographic coupling and co-authorships relations.

3. Through the third step the analysis and comparison of the extracted visual data through defined descriptors is performed. Descriptors are terms that describe the researched topics and are extracted after examination the bibliographic data of the selected papers included in their title, abstract and keywords. The result is a set of maps presenting the main descriptors for research fields of the *eLearning* and *Informatics*.
4. The fourth step includes development of a conceptual model of derived terms concerning the research area *eLearning Informatics*, based on summarization and analysis of extracted from databases descriptors.

The second procedure concerns two steps:

1. The first step consists of formation of multiple search quarries in the abstract and citation indexing databases Scopus and Web of Science, the scientific-oriented search engines Google Scholar and Semantic Scholar to select papers for further exploration concerning the research fields connected to the derived terms and related to the *eLearning Informatics*. The queries are refined according to their relevance without limitation in the publication year.
2. This exploration leads to extracting key definitions and analysis performance of theoretical and practical results that outline the current attainments and developmental trends.

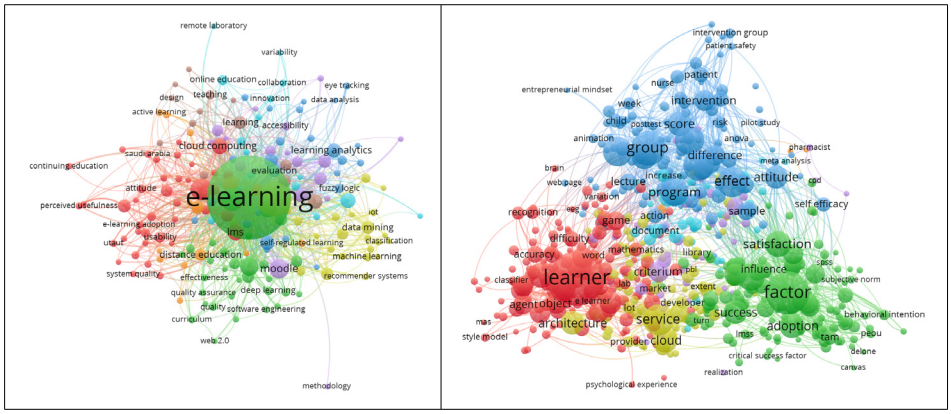
3. eLearning Informatics Descriptors

The typical descriptors for the term *eLearning* are extracted concerning the described procedures in the research methodology. Queries with keywords *eLearning* and its equivalent terms *e-learning* and *electronic learning* are formed for searching in the article title, abstract and keywords of the published papers and the received results are refined according to relevance, year of publication, document type, and language. The constructed bibliographic networks through VOSviewer present the extracted bibliographic data from 500 representative scientific documents in Web of Science and 2000 representative scientific documents from Scopus.

The bibliographic networks are built through utilization of two methods:

(1) Maps creation based on bibliographic data as the type of analysis is co-occurrence, the unit of analysis is author keywords, the counting method is full counting, the minimum number of occurrences of a keyword is 5.
(2) Maps creation based on text data as the fields from which terms are extracted are title and abstract fields, the counting method is full counting.

The bibliographic networks for the term *eLearning* (*e-learning*, *electronic learning*) and for the term *Informatics* constructed on data from Web of Science and Scopus consists of eight clusters. Each cluster contains closely related terms. Sometimes the clusters are not so clearly outlined, because of the interdisciplinary usage of given terms. The descriptors received after analysis the bibliographic data related to intersection of the two terms *Informatics* and *eLearning* show that the scientific papers that discuss in parallel the both terms are focused on how eLearning is applied in Informatics education, but not on exploration of a new research area *eLearning Informatics*. The constructed bibliographic networks for the terms *eLearning*, *Informatics* and both keywords *eLearning* and *Informatics* are presented in two variants (a) according to the first method and b) performing the second method) respectively on Fig. 1, Fig. 2 and Fig. 3, according to the Scopus datasets. The bibliographic networks with datasets extracted



a) according to first method b) according to second method

Fig. 1. The constructed bibliographic network for the term eLearning through VOSviewer.

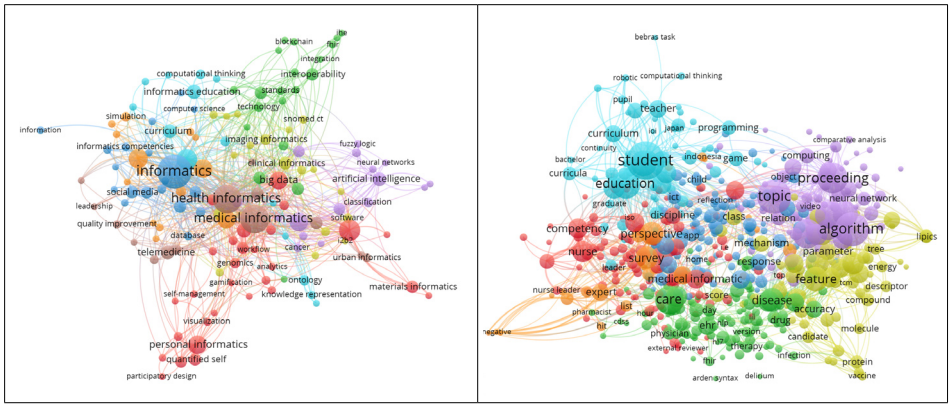


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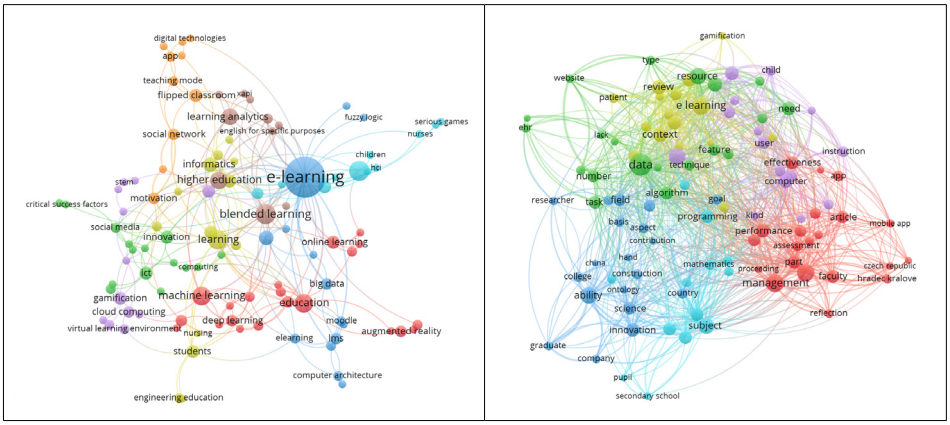
Fig. 2. The constructed bibliographic network for the term *Informatics* through VOSviewer.



a) according to the first method b) according to the second method

Fig. 3. The constructed bibliographic network for the terms *eLearning* and *Informatics* through VOSviewer.

from Web of Science are also constructed, but they are not presented here, because of their similarity to the Scopus results.

The derived descriptors for each cluster of the terms *eLearning*, *Informatics* and both keywords *eLearning* and *Informatics* from the databases Scopus and Web of Science are classified in thematic groups and presented through concept maps on Fig. 4, Fig. 5 and Fig. 6.

The terms organized in clusters by VOSviewer and then classified in thematic-related groups by the author lead to understanding the recently explored topics by researchers in published scientific articles. On this base the conceptual model of the research area *eLearning Informatics* is created and presented on Fig. 7. The terms describing the *eLearning Informatics* domain are divided in two groups:

(1) Development of educational theories and models, giving directions for generation of new knowledge from *pedagogical* and *didactical* point of view.
(2) From *computer science* perspective – development of methods, techniques, software for data analysis and modeling, for databases and digital repositories organization and maintain, improvement of theory and practice at development of algorithms, artificial intelligence solutions, programming languages, eLearning software and technologies.

4. eLearning Informatics Definition

In the common case, the term *information technology* is used to point out the technologies for information collecting, processing, transferring, storing, analyzing or presenting and their study are in the scope of Informatics and *Informatics* is described as a scientific

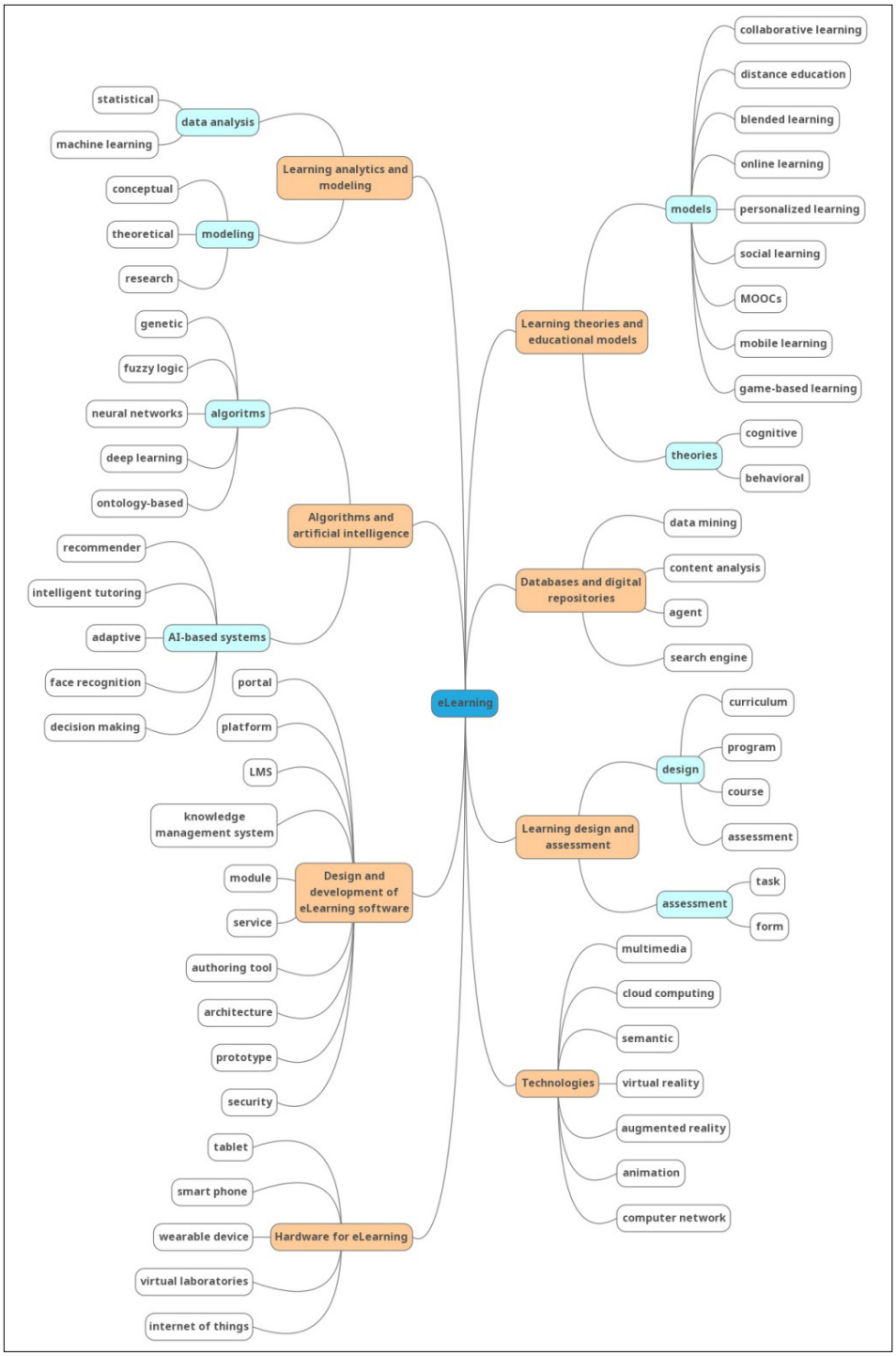


Fig. 4. The derived descriptors for the term *eLearning*, classifying in eight groups.

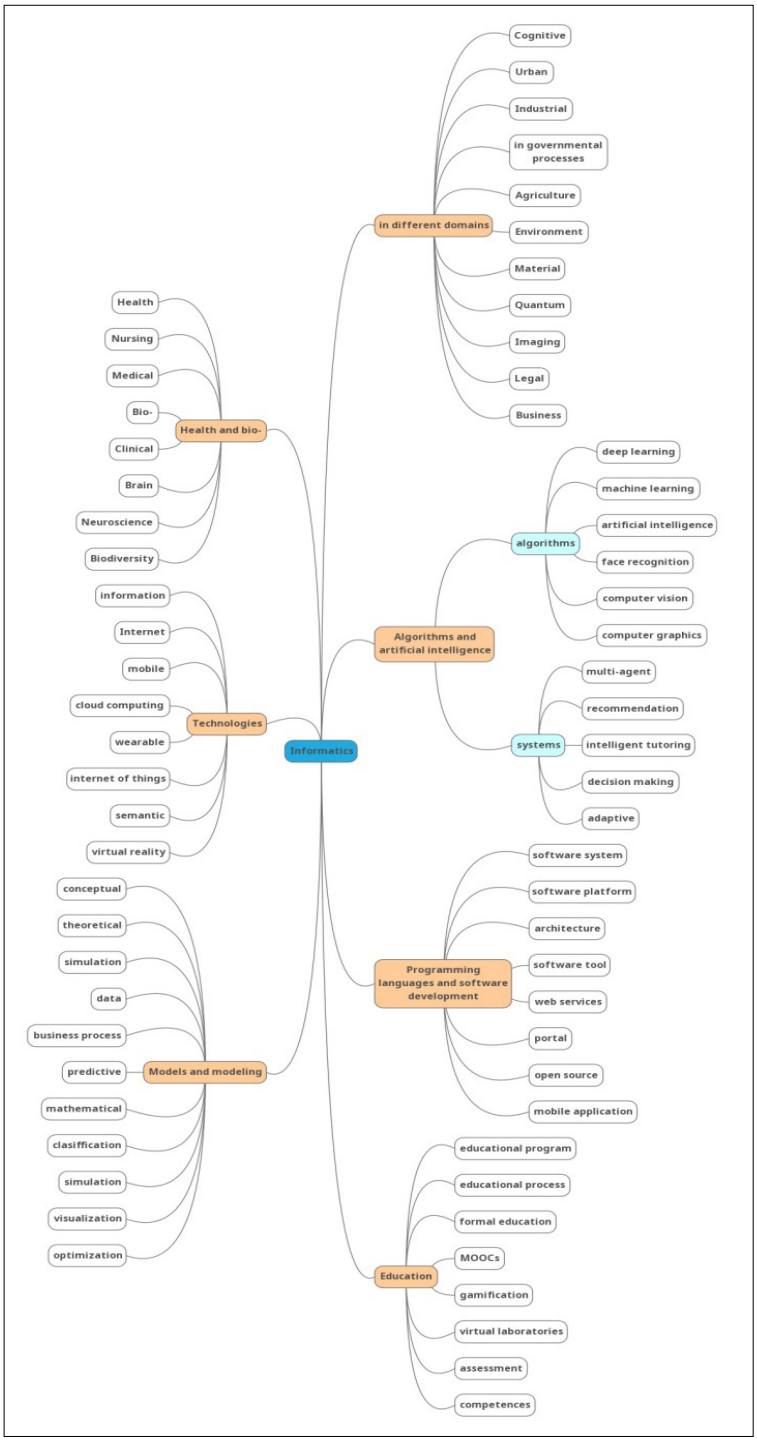


Fig. 5. The derived descriptors for the term *Informatics*, classifying in seven groups.

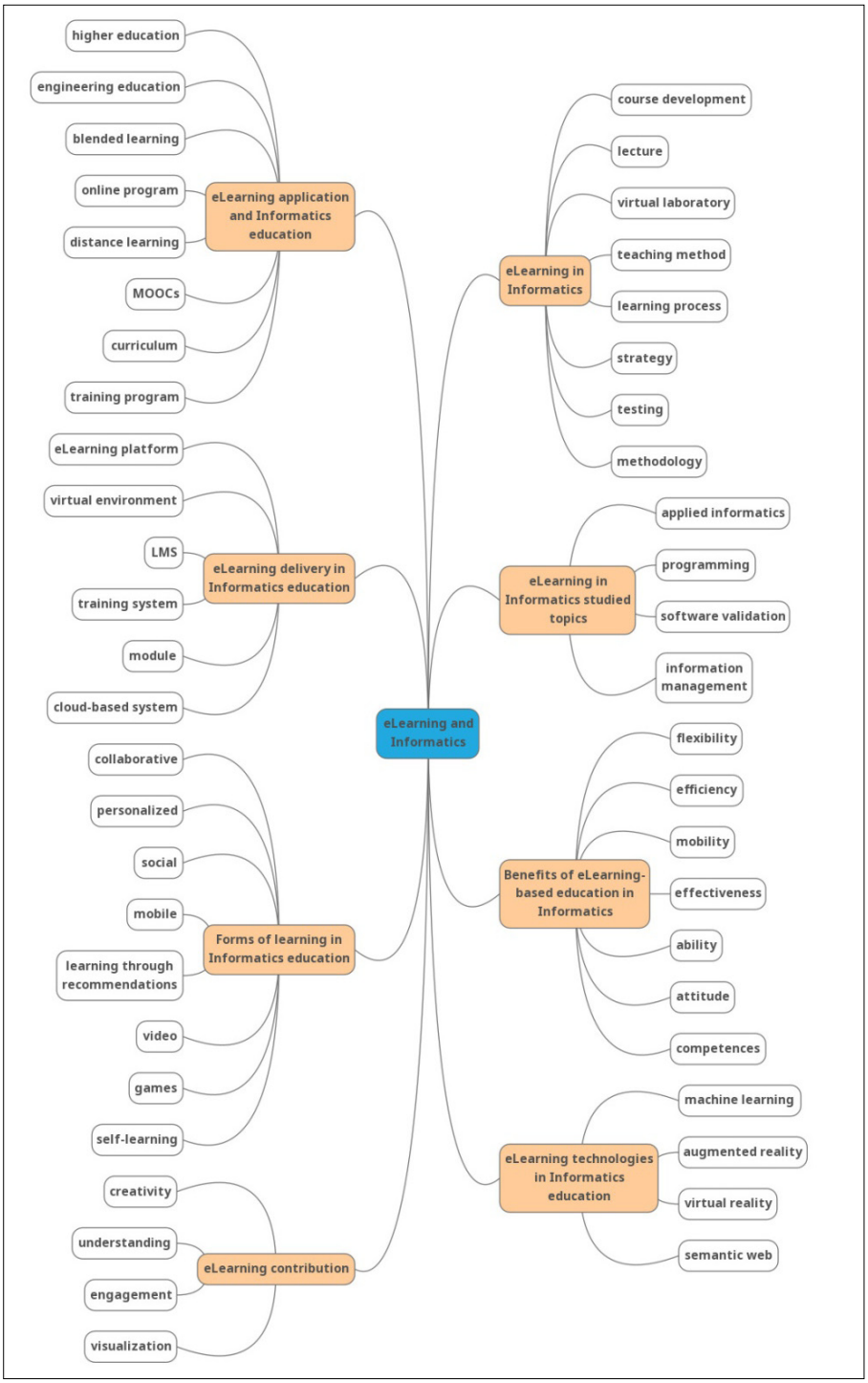


Fig. 6. The derived descriptors for the term *eLearning* and *Informatics*, classifying in eight groups.

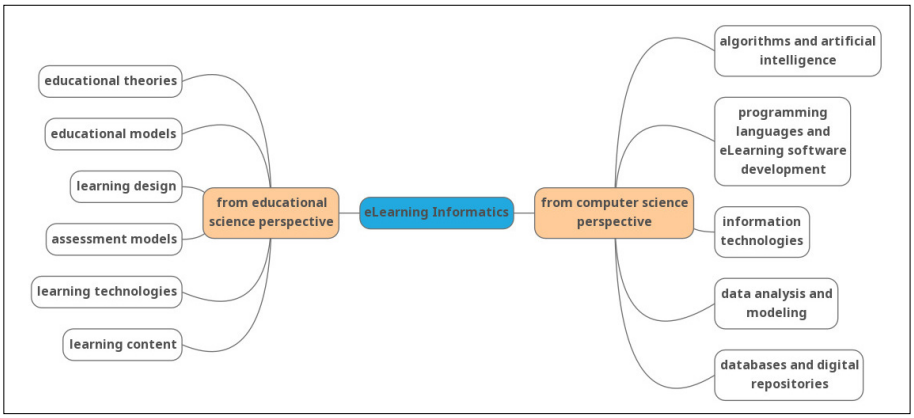


Fig. 7. Conceptual model of derived terms concerning the research area *eLearning Informatics.*

branch that involves scientific theories of information science, information technology and development of information systems.

Different definitions explaining in more precise way the term *Informatics* are found. Informatics is defined as a science that studies "the representation, processing and communication of information in natural and engineered systems" (The University of Edinburgh, 2019). Informatics is seen as a part of information engineering that includes information processing and development of information systems (Wikipedia, 2019a). Informatics is connected to "a process for designing and production of theorems, algorithms, methods, programes, and systems that could be applied to different objects" (Sysło and Kwiatkowska, 2019).

eLearning term in its general use comes to explain utilization of a wide variety of technologies including information technologies to facilitate educators and to create rich learning experience for learners, in many cases delivered in the form of computer-based training or web-based learning. eLearning very often is understood as the utilization of "electronic technologies for teaching and learning" (Andrews and Haythornthwaite, 2007). The term eLearning is seen as a hybrid consisting of two parts: (1) technology for information and knowledge transfer and presentation and (2) process of learning with its pedagogical, methodological and psychological issues. Also, eLearning is described as a method for knowledge delivery to different geographically locations to learners with limitations, restrictions and difficulties to give them a set with competences (FAO, 2011). Sangra *et al.* (2012) outline that it is very difficult to include all features of eLearning in one definition, but they express their opinion that "eLearning could be considered a natural evolution of distance learning which has always taken advantage of the latest tools to emerge in the context of technologies for structuring education".

It can be seen that the above described two terms *Informatics* and *eLearning* are very complex with multiple features and just one simple definition is not enough to present their scope of developing directions and interdisciplinary. Anyway, if a summarization performs, then it can be said that *Informatics* is a scientific field contributing to design and development of tools for automation of information processing that could be applied

to a range of applicable areas. In this work the term Informatics is examined in the meaning of the term Computer science (Wikipedia, 2020) that studies data and information processing, algorithms development and software systems design. *eLearning* is another scientific field concerning design and development of educational and technological tools for automation of teaching and learning activities.

Regarding the *eLearning Informatics* it could be defined as a scientific field that describes the application of Informatics within the context of eLearning framework, consisting of infrastructure, theoretical concepts, practices and participants that operate with information and information flows. eLearning takes advantages of Informatics' tools to elaborate its theories and to automate its practical tasks. Informatics benefits of eLearning with further development of information theories and information technologies to satisfy eLearning requirements. The *eLearning Informatics* represents symbiosis and in parallel with this the intersection between Informatics and eLearning organically combining information and learning theories and technologies.

Taking into account the formed definition and the derived terms presented on Fig.7, the main research topics of *eLearning Informatics* are seen in the following directions:

(1) Educational theories and models – exploring a wide variety of teaching and learning scenarios in the context of eLearning and how these scenarios could be supported from Informatics side.
(2) Learning design, instructional design, and its conceptual bases and how Informatics could assist them.
(3) Assessment models typical for eLearning and the role of Informatics.
(4) Learning technologies – technologies that are accepted by eLearning to facilitate the teaching and learning processes and the importance of Informatics for their further development.
(5) Teaching and learning content creation and its presentation in different formats and the Informatics tools.
(6) Visualization – information analysis and its graphical presentation for eLearning purposes.
(7) Modeling and conceptualization of eLearning topics – information gathering and a system description through models.
(8) Algorithization – algorithms development for information processing and automating various educational tasks.
(9) Software design and development for eLearning – software solutions building for tasks automation.
(10) Information technologies development – for production of novel tools and solutions applicable in eLearning.

The research framework, summarizing the research, domain and product aspects of *eLearning Informatics*, is presented on Fig. 8.

The following sections summarize the examined literature related to the topics that form the domain aspect of eLearning Informatics. This gives understanding of the current state and future challenges and reveals the mutual interactions between eLearning and Informatics.

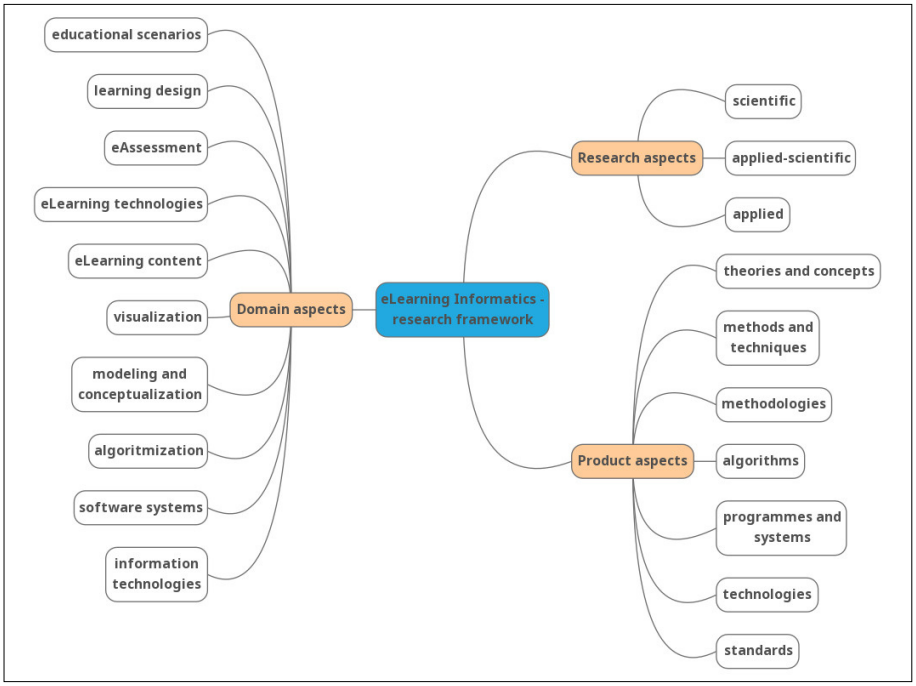


Fig. 8. Research framework of eLearning Informatics.

4.1. *Educational Theories in eLearning*

A *theory* consists of statements and principles important for a given knowledge domain. A definition of *educational theory* says that it is "the theory for the purpose, application and interpretation of education and learning" (University College Dublin, 2019). Also, the discussion continues with the statement that educational theory could include a number of theories for better understanding how learners learn and how teachers should teach. The processes of learning and teaching are complex human activities and clear description on how learners learn and how the teacher should teach does not exist instead of that there are different theories that explore the processes of learning and teaching. *Learning theories* are focused on explanations how learners perceive, process and manage knowledge during learning process according to learners' specific characteristics and the properties of the learning environment (Wikipedia, 2019b).

eLearning takes advantages of existing well-grasped educational theories as well as introduces new approaches. Among the well-established educational theories used in eLearning are: (1) *behaviorism* – explains how the learner changes his behavior during learning process according to the input stimuli and he depends of the knowledge transfer from the teacher; (2) *cognitivism* – sees the learner's changing behavior based on development of his cognitive process of mind; (3) *constructivism* – describes how the learner

constructs his own knowledge interacting with learning materials and by experience; (4) *active learning* – the learner is actively involved in the learning process through interactions and doing (Pange and Pange, 2011; Picciano, 2017; Hadjerrouit, 2007); (5) *social learning* – the learner changes his behavior during the learning process based on experience or observation the behavior of others (Quigley, 2018); (6) *blended learning* – learning occurs in environment that combines eLearning and face-to-face techniques (Gambari et al, 2017). Several new learning theories are introduced like: (1) *personalized learning* – the instruction is individualized for the concrete learner who directs his own learning (Redding, 2013); (2) *adaptive learning* – the learning path is constructed according to the learner's characteristics and achievements (Shelle *et al.*, 2018); (3) *connectivism* – the learner receives knowledge in a learning community connecting to other learners (Goldie, 2016); (4) *collaborative learning* – a learning process is performed by more than one learner in virtual learning environment (Badawy, 2012); (5) *peer-assisted learning* – the learners learn from each other sharing their understanding about giving learning content (Edwards and Bone, 2012); (6) *experimental learning* – the learner learns through performance of well-organized learning activities (Langley, 2007); (7) *flipped classroom* – it is an element of blended learning where classroom and homework activities are reversed (Evseeva and Solozhenko, 2015).

Teaching theories are summaries by Peter (2011) and classified in three groups: (1) *Formal theories of teaching* that is based on given logic (metaphysical, epistemological assumptions and propositions) and includes questioning methods, teachers presentation and demonstration of information and knowledge, teaching influences on shape and mould of learner behavior, the teacher gives possibilities the learner to discover new knowledge; (2) *Descriptive theory of teaching* – the teacher utilizes given propositions and observations and the theory includes statements like: the teacher directs the learner through instructions and the teacher takes into account the uniqueness of every learner; (3) *Normative theory of teaching* consists of theories explaining the teachers' behavior: the teacher uses techniques of dialog to develop metacognitive skills to learners, the teacher performs typical activities in social and behavioral aspect, the teacher performs activities such as identifying learning goals and teaching strategy to establish given relationship with learners, teaching is described as process focused on inducing change in learners' behaviour.

Anyway, the above-mentioned *theories of teaching* are described from the point of view of face-to-face classroom and they are not analyzed from the eLearning perspective.

Nowadays, popularity gain *intelligent tutoring systems* as software programmes with tutoring functions. They are based on one or several teaching methods like: presenting the teaching material, asking questions and assigning learning tasks, providing feedback or hints, performing dialog with learners (Ma *et al.*, 2014).

The directions for research are seen in conceptualization, theorizing and notational description of how learners learn and teachers teach in eLearning environment and the conversion of created educational concepts and theories in machine-readable way for development of smart and intelligent solutions.

4.2. *Learning Design and Instructional Design*

Learning design theory explains how the teacher could be supported to engage and motivate learners in their learning (Koper and Bennett, 2008). *Learning design* is defined as "description of the teaching-learning process that takes place in the unit of learning" (Koper, 2005). This is an educational plan that explains the participants in the unit of learning, their teaching/learning activities concerning teaching/learning goals, the educational environment with learning objects and learning services that will be used as well as the description of educational scenarios.

Learning design language is developed for converting learning designs in programming code and its semantics is defined through IMS Learning Design (LD) specification.

Adaptive learning strategies could be designed in one unit of learning for achieving personalized learning (Burgos *et al.*, 2006) as the adaptivity is realized through changes in the programme interface, learning flow or content objects according to the learner performance.

The tasks related to preparation of *learning designs* are automated through authoring tools like: ReCourse, Reload LD Editor, Prolix, Collage, MOT+ and others that are based on IMS LD specification. A run time engine for handling *learning design* packages, created according to the IMS LD specification is CopperCore that is easy for integration in LMSs (Vogten *et al.*, 2006). Learning activity management system (LAMS) is a popular platform for designing and managing learning design scenarios, but it is not based on IMS LD specification (Cameron, 2006). Standard LMS like Moodle also proposes tools for learning planning and organizing (Bower and Wittmann, 2011).

Instructional design theory supports teachers giving the methods for active engagement of learners, techniques for providing informative feedback and mechanisms for motivation to learn (Reigeluth, 1999). How an instruction could like in a technology-oriented education is discussed by Reigeluth (2012) and the role of technology is seen in the following four directions: learning records for attainments of learners to be kept, the learning plan to include techniques for identification of long-term goal or creation of personal learning plan for every learner, the instruction to include task space and instructional space tools for learning and the assessment to be included in the instruction.

The automation of tasks related to instructional design creation through software tools and systems based on concepts of intelligent tutoring systems are presented by Nkambou *et al.* (2010).

A wide variety of instructional design models exist to show different methods for knowledge receiving, analyzing, demonstrating and applying in practice by learners. Review and analysis of instructional design models is presented in (Donmez and Cagiltay, 2016) and they are categorized in the following groups: classroom-oriented models, product-oriented models, and system-oriented models.

The topics for research in the areas of learning and instructional design are related to the achievement of effectiveness, adaptivity, personalization in teaching and learning as well as self-evolving learning designs according to the learners and teachers set of criteria.

4.3. *eAssessment*

In its common understanding, the eAssessment is a term that describes the usage of technologies for assessing learners' knowledge, skills and competences in eLearning environment. The precise definition says that eAssessment utilizes digital devices (computers, mobile devices, tablets) "to assist the construction, delivery, storage or reporting of student assessment tasks, responses, grades and feedback" (Crisp, 2011).

A literature review reveals that the most used tools for eAssessment are these that are part of LMSs like: Moodle, Blackboard, Atutor, SAKAI, etc. that give possibility for personalized and group-based assessment activities (Bukie, 2014). Also, specially created cloud-based platforms for eAssessment are utilized in support of teachers and learners with possibility for organization of different types of assessment: summative, formative, diagnostic, integrative. Examples of such platforms are: Cirrus – with functions for converting writing text and mathematical formulas in digital format, Rogo – with several testing functions and possibility for integration of different media formats, Surpass – with features for online examination and language testing.

An innovative solution for trust-based and adaptive eAssessment is the TeSLA system that proposes tools for face recognition, voice recognition, keystroke dynamics, forensic analysis, and plagiarism and could be integrated to LMSs like Moodle and Blackboard (Ivanova *et al.*, 2018). A wide variety of assessment activities could be evaluated through the TeSLA system: quizzes, forum participation, blog notes, learning diary, oral presentation, game or simulation task, role-play task, practice in a laboratory with voice explanation, mathematical problems, others (Okada *et al.*, 2019).

eAssessment is a huge area for research in directions related to development of theories, models and practical solutions for flexible, adaptive, secure and intelligent eAssessment systems.

4.4. *eLearning Technologies*

The wider understanding about the terms *educational technology*, *learning technology*, *instructional technology* is related to the utilization of diverse technological tools like media, eportfolios, machines, networking hardware, virtual reality systems, augmented reality software, video conferencing software, assessment systems, intelligent tutoring systems, etc. that improve the effectiveness and quality of teaching and learning (Brückner, 2015; Drozdová, 2007).

One more detailed definition of *educational technology* describes this term as "the study and ethical practice of facilitating learning and improving performance by creating, using and managing appropriate technological process and resources" (Richey, 2008). Brückner (2015) explains that the term *educational technology* includes not only technological tools for improving educational science, but also tools for evolving the theoretical, algorithmic and heuristic processes and procedures.

A definition of *Instructional technology* is given by Drozdová (2007) and it concerns theory and practice for designing, developing, applying processes and resources for attaining better learning.

Emerging *eLearning technologies* adopted by teachers to deliver rich learning experience and to optimize knowledge transferred to learners are summarized by Craig *et al.* (2012) in the following categories: assessment and survey applications, tools for synchronous and asynchronous communication, digital repositories, tools for managing students' grades and progress reporting, documents and image sharing, podcast streaming, social bookmarking and networking, RSS subscriptions, virtual worlds, weblogs and microblogs, wikis.

An idea about *smart and sustainable learning technologies* is introduced by Coombs and Bhattacharya (2018) with possibility related technologies to evolve and converge. They discuss a new framework for *smart and sustainable learning technologies* that is related to the building of a smart learning environment with a set of tools for "co-construction of knowledge, communication and interpersonal skills and reflective thinking skills, along with peer and self-assessment for learning".

Technologies like virtual and augmented reality, virtual laboratories, intelligent face and voice recognition, semantic web, others should be further explored and evolved for eLearning purposes and development of smart learning environments.

4.5. *eLearning Content*

eLearning content in the form of learning materials, instructions for learners, assessment content, tutorials, assignments must be designed carefully presenting in clear way their purpose and meaning and considering the learners' profiles, learning styles and learning goals.

Development of eLearning content involves the extensively work of domain experts, learning and instructional designers, media developers (production personnel) and technical experts with the supportive ecosystem of authoring tools. In a small project a person plays all of these roles. Ibarra-Florencio *et al.* (2014) present a web-based system that facilitates the creation of eLearning content and organizes interactions among all persons who take part in its development. The system utilizes a set of templates with learning objects derived from the best practices in learning design and technical design. The system increases the effectiveness at content development and decreases the time for its production.

Elghibari *et al.* (2019) presents an agent-based system for revising and updating available online learning content and dynamically improve its quality.

The future research must be directed to examination of current practices in eLearning content development and its mutual connections with learning and instructional design, technologies for content production, presentation and integration in eLearning platforms, technologies for content searching and classifying, machine analysis of eLearning content with aim the content to be updated, to be with high quality and interactive presentation. Other field for research in eLearning content concerns content standardization that contributes to its reusability, compatibility and interoperability.

4.6. *Visualization*

Information visualization is a research area that is focused on the development of visualization methods to facilitate data understanding, analysis and evaluation (Khan and Khan, 2011). *Information visualization* is placed between data and information and "provides methods and tools with which to organize and represent the data to finally produce information" (Mazza, 2009). Also, *information visualization* is defined as a cognitive process that allows better data understanding as well as acting according to this data understanding (Chen, 2017).

Visualization in eLearning supports information perception, highlighting the important information chunks. It contributes to information comprehension and learner analytics improving the effectiveness of learning. Also, it is related to a learning style where a learner studies information through graphical objects and interactions. Learner performance and learner progress could be improved through information visualization. Visualization facilitates learning designers and teachers serving summarized information in the form of graphs, charts, plots, diagrams, dynamic analytical pictures (Nachimas and Hershkovitz, 2006; Williams and Conlan, 2007; Kuosa *et al.*, 2016).

And here comes *visual informatics* (Visual Informatics, 2011) to assist eLearning, giving tools for development of theories, algorithms, technologies and software products to improve information visualization, analysis and reporting.

4.7. *Modeling and Conceptualization*

Summarization of definitions concerning the term *model* is proposed in (Muller *et al.*, 2012) where the model is described as "information of something", "abstraction of a real system", "a set of statements about some system" and several features point out that the model should exactly reflects the original, the model should be understandable, useful, with possibility for predictiveness.

The term *conceptual model* is explained in (Robinson *et al.*, 2015) as "a concise and precise consolidation of all goal-relevant structural and behavioral features of the system under investigation presented in a predefined format" and *conceptual modeling* is presented as a process that includes answers to several questions like: What to model? What kind of features to include the model? How the model to be abstracted from the real world?

The term *system modeling* is presented by Marchese (2013) as a "process for developing abstract models of a system" and every model shows different perspectives of the modeled system: the external view, behavioral view, a view with interactions and structural view.

Modeling and conceptualization of objects, systems, events and processes in eLearning is an important task leading to better human understanding and analyzing of a given topic or situation as well as the further usages of created models from machines.

Modeling in eLearning is well accepted practice for information processing and ideas presented in the form of a wide variety of models and meta-models and several scientific works are mentioned below. The importance of *instructional design models* for distance learning courses development is discussed by Baig (2011). Instructional design models for different types of MOOCs courses are presented in (Output 5 SCORE2020, 2016); A *model for evaluation of quality* of eLearning systems is proposed in (Hadullo *et al.*, 2017); A comparison of existing *learner' model* for adaptive eLearning environments is performed in (Vagale and Niedrite, 2012); A *meta-model* for development of eLearning materials is presented in (Balina *et al.*, 2014); An adaptive meta-model for eLearning in support of teachers, instructional designers and experts is shown in (Berlanga and García, 2004).

Among the most popular *Informatics tools for modeling* utilized in the area of eLearning are found: (1) *neural networks* – for learner modeling, for improvement of eLearning environment, for prediction of eLearning efficiency (Halachev, 2012); (2) *genetic algorithms* – for curriculum sequencing in personalized eLearning system, for learning path sequencing (Shmelev *et al.*, 2015); (3) *ant colony optimization algorithm* – for eLearning adaptation, for determination of optimized learning path (Sivakumar and Praveena, 2015); (4) *reinforcement learning algorithm* – for adaptation in eLearning (Velusamy *et al.*, 2013); (5) *Markov chains* – for prediction and recommendation of learning sequences (Huang *et al.*, 2009); (5) *Fuzzy logic* – for learner modeling and decision making in online learning systems (Al-Aubidy, 2005); (6) *Petri nets* – for adaptation in eLearning (Omrani, 2011); *ontology models* in eLearning (Tunde *et al.*, 2015).

4.8. *Algorithmization*

The term *algorithm* is explained as a sequence of actions performed for solving a problem (Tawfiq and Ali, 2019). Also, it is seen as a formula or small procedure that describes performance of activities. Other definition of algorithm is related to a step-by-step method as well as series of instructions for operations performance (Technopedia, 2019). Algorithmization is a term related to applying one or a set of algorithms to automate different tasks solving a wide variety of problems and incorporating them in development of software agents, modules or systems.

In the area of eLearning according to the emerged problems in a concrete context existing or recently created algorithms are applied. Many scientific papers report for adoption of existing algorithms typical for domains different than eLearning – for example, a comparison of algorithms for information searching with aim their implementation in LMS is given in (Xhaferi *et al.*, 2015), or novel algorithms are developed for specific purposes in eLearning systems – for individualization of learning paths (Rauch *et al.*), for collaborative filtering and recommendation (Loll and Pinkwart, 2009).

Informatics proposes algorithm theory for synthesis, analysis, performance and optimization of different types of algorithms as well as their practical implementation for data mining, sorting, comparing, analyzing, visualizing.

4.9. *Software Design and Development*

The *theory of software engineering process* proposes models and tools in support of the conversion the project idea to realization of functioning software. Software engineering process presents the stages in software development, their order and criteria for progressing from one stage to another (Vohra and Singh, 2013). Different models exist facilitating the software development in organizational settings. Well known and contemporary emerged programming languages are used for transformation algorithms in programmes (Reddy *et al.*, 2018) and (visual) platforms for programming contribute to the achievement of faster and qualitative software development (Hilwa, 2009).

A big array of scientific production is focused on development of agents, tools, modules, (smart and intelligent) systems for eLearning to automate teachers and learners' activities and in this way to achieve efficacy and high educational quality. For example, an adaptive eLearning system with personalized features is explained in (Tseng *et al.*, 2008) and intelligent tutoring system for teaching development of Android applications is presented in (Rekhawi and Naser, 2018).

It can be seen that the Informatics theories and practices concerning software design and development are very well exploited in the context of eLearning to satisfy the needs for the realization of a wide variety of learning scenarios – for adaptive, personalized, peer-to-peer, self-learning.

4.10. *Information Technologies*

The multidimensional aspect of the terms *technology* and *technology transfer* is discussed in (Wahab *et al.*, 2012). *Technology* could be defined as necessary information to reach given production outcomes, including the information about the production process. Technology allows reuse and reproduction.

Technology transfer is seen as a complex process for technology usage for a given purpose.

Information technology is defined as the use of devices (computers, storage, networking), infrastructure and processes for processing and exchange of electronic data (Bigelow, 2019).

In the centre of technology development in eLearning is an educational problem that should be resolved in a new way to achieve the required outputs. Examples of novel technologies and intelligent techniques applicable to eLearning are focused on learning personalization (Markowska-Kaczmar *et al.*, 2010), intelligent textbooks creation (Boulanger and Kumar, 2019), using social robots as tutors and peer learners (Belpaeme *et al.*, 2018) and technology for information exchange between intelligent systems and laboratory equipment (Samigulina and Samigulina, 2016) that emerging to resolve available educational problems.

Contemporary information technologies address problems in prediction of learner's behaviour and performance, content and learning tasks sequencing, issues that concern the affective states of learners, challenges in dialog, tutoring and learner-assisted sys-

tems in context of self-learning, life-long learning, formal and informal learning, and problems related to learners with learning difficulties.

Conclusions

The performed research discusses a new area for further exploration *eLearning Informatics* which domain is outlined through utilization of bibliometric method and detailed examination of the published scientific production. The derived terms through usage of VOSviewer are additionally grouped that is used for creation of a conceptual model concerning the research area *eLearning Informatics*. The conceptual model shows the perspectives for *eLearning Informatics* examination: (1) educational, that comes to present the main educational-related topics to eLearning that requires assistance from Informatics side, like: educational theories, educational models, learning design, assessment models, learning technologies, learning content; (2) computer science, that presents the need from tools for data analysis and modelling, for management of databases and digital repositories, for development of machine learning and artificial intelligence algorithms, programming languages, information technologies and software for eLearning purposes.

A definition of *eLearning Informatics* is proposed and it is seen as a scientific field that studies data and information processing, algorithms development and software systems building to facilitate the activities of participants in eLearning.

The research framework of *eLearning Informatics* is created from domain, research and product perspectives. The domain outlines the scope of *eLearning Informatics*, describing the main topics for further exploration. The research aspects point out that the contributions of *eLearning Informatics* could be scientific, applied-scientific and applied. The product aspects point out the generated artefacts: theories and concepts, methods and techniques, methodologies, algorithms, programmes and systems, technologies, standards.

Also, detailed discussion of topics included in the *eLearning Informatics* domain is provided after extensive literature review and the main findings could be summarized as follows:

- Educational theories and scenarios should be extended to satisfy the new technological requirements of eLearning, they must be converted into machine-readable code for usage in development of smart and intelligent systems.
- Instructional and learning designs should be adaptable and self-evolved, concerning the teaching and learning goals, through suitable models and algorithms.
- eAssessment needs contemporary methods for data processing, storage and transferring which to be implemented in intelligent and secure systems for management of a wide variety of assessment tasks.
- eLearning, taking the advantages of existing and emerging technologies like augmented and virtual reality, virtual laboratories, systems for face and voice recognition, semantic web, is appeared to be a driving force for development of specific technologies.

- The developed eLearning content must be interactive and in multi-mode formats, it must be created on the ground of appropriate instructional and learning design theories, based on standards and for realization of those appropriate technologies must be utilized or developed.
- Teaching and learning materials, learning content, user interface of software systems, learning analytics need modern tools for multi-perspective visualizations.
- Several very popular techniques and algorithms for modelling and conceptualization are well accepted in the eLearning field, like: supervised and unsupervised machine learning algorithms, genetic algorithms, reinforcement algorithms, Markov chains, Petri nets, Fuzzy theories, ontology modelling.
- Improvement of existing and development of new algorithms for eLearning will contribute to realization of more flexible, personalized and adaptable systems.
- Information technologies need further development in support of recognition of students and teachers' affective states, in support of learners with different difficulties, in support of lifelong learners.

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M. Ivanova is associate professor in Communications and Computer Science at College of Energy and Electronics in Technical University of Sofia. She received MSc degree in Automation and Electronics and PhD degree in Automation of engineering work and systems for automated design from Technical University of Sofia. Her research interests include eLearning, technology enhanced learning, eAssessment, artificial intelligence, machine learning, security and privacy.