Effectiveness of ontology-based e-Learning in healthcare management: a case study from Romania

Lidia BĂJENARU[1,2], Mihaela TOMESCU[1], Adrian Victor VEVERA[1]

[1] National Institute for Research & Development in Informatics - ICI Bucharest, 8-10, Maresal Averescu Avenue, sector 1, Bucharest, Romania

[2] University Politehnica of Bucharest, 313, Splaiul Independentei, sector 6, Bucharest, Romania

lidia.bajenaru@ici.ro, mihaela.tomescu@ici.ro, victor.vevera@ici.ro

Abstract: *Human resources management is an essential condition for increasing the performance of an organization in the public or private medical sector. The need to increase the quality of the medical act in contemporary Romanian society at the level of the standards on the international level implies the improvement of the quality of the healthcare management, which implies the increase of the level of professionalism of the managers. The paper proposes an e-Learning environment based on new semantic technologies, capable of leading the process of building personalized educational content, with the aim of training managers from a university hospital in Romania. The ontology-based e-Learning system is addressed to managers in a hospital but also to other people who want to access management positions in healthcare facilities in Romania. The system aims to offer a training course for professionals in the field of medical management, at a competitive level, according to the real requirements of the Romanian and European health system.*

Keywords: e-Learning, Healthcare, Management, Semantic Web, Ontology.

1. Introduction

Learning, an indispensable activity in today's knowledge-based society, is influenced by global changes, the increase in competition in all environments, the ICT (Information and Communication Technology) revolution, respectively by the importance of the network computer and the need to transfer information. The learning context and the requirements take new shapes, learning becoming more flexible, accessible and efficient through the use of the web (Tudor, Kyaw & Atun, 2018).

With the expansion and development of Web 2.0, e-Learning 2.0 enabled the transition from knowledge transfer to education as a creative activity, and e-Learning 3.0 offers intelligent solutions for web search, document management, and content organization, and the learning process will be more efficient through the use of collaboration techniques (Kozlova & Pikhart, 2021). Web 3.0, known as

https://doi.org/10.58503/icvl-v18y202317

the semantic web becomes an innovative technology that underlies the new e-Learning requirements (Yao & Sun, 2010). The enormous growth of learning resources available online through massive open online courses and learning management systems has necessitated personalized resource recommendations. Techniques such as ontology, artificial intelligence, among others, can provide personalized recommendations. Ontology is a way to model learners and learning resources, and offer great potential in environments such as online education, by providing, sharing, and reusing information between educational systems and providing support in their personalization (George & Lal, 2019).

Human resources management is an essential condition for increasing the performance of an organization in the public or private medical sector. Improving the management of human resources at the level of a medical unit requires the development of effective strategies. e-Learning allows transform health leadership and management education and addresses diverse training needs by facilitating information sharing, experiential learning, collaboration and just-in-time support through accessible, easily updated, scalable, and engaging training resources (Tudor, Kyaw & Atun, 2018). The management functions are analysed by many works in relation to digital transformation (Anghel, Pereteanu & Cîrnu, 2020). The core functions of management are interrelated and interdependent, and effective management requires a balanced approach to all (Banciu, Vevera & Popa, 2023).

The need to increase the quality of the medical act in contemporary Romanian society at the level of the standards on the international level implies the improvement of the quality of the management of the heath unit, which implies the increase of the level of professionalism of the managers. This paper proposes an e-Learning environment based on new semantic technologies, capable of leading the process of building personalized educational content, with the aim of training managers from a university hospital in Romania. The e-Learning system is addressed to managers in a hospital but also to other people who want to access management positions in healthcare units in Romania.

This paper is organized as follows. Section 2 presents an overview about e-Learning healthcare systems and a selection of some applications that use ontologies in human resources management. Section 3 presents the ontology-based e-Learning platform for managers of healthcare system in Romania.

2. Overview

2.1 e-Learning healthcare systems

There are quite a number of e-Learning programmes for healthcare representatives that have been implemented, but evidence on their long-term outcomes is largely lacking, and direct comparisons between different delivery formats are very rare. At the international level there are a number of e-Learning platforms for healthcare domain, respectively knowledge in the field of Human

Resource Management (HRM). Also, there are organizations that provide support for medical e-Learning such as Medical Education Organizations Supporting E-Learning (Ruiz, Mintzer & Leipzig, 2006).

In paper (Reavley et al., 2021) 608 public servants completed either an e-Learning course and a blended course or a face-to-face course regarding provision of first aid to a person with depression or post-traumatic stress disorder. Both blended and eLearning courses led to significant longer-term improvements in knowledge, attitudes and intentions to help a person with a mental health problem. A self-study was applied to simultaneously research the development process and to integrate an evaluation of the resulting e-Learning program learning by the nurses who participated in pre and post-test questionnaires and focus group discussions is presented in (Mak & White, 2021). In USA, the University of Georgia Supplemental Nutrition Assistance Program Education includes a program that provides comprehensive eLearning nutrition education through a series of interactive lessons, learning games, educational and cooking videos, and online assessments to evaluate changes in participants' food- and nutrition- related behaviours (Stotz et al., 2019). Matete, Kimario & Behera (2023) have evaluated the use of three types of e-Learning, respectively text-driven, interactive, and simulation, in teacher education during COVID-19 in Africa. According with Everitt et al. (2022), in the areas of perinatal mental health and psychosocial, there were identified many innovative and diverse educational methods and strategies including face-to-face, online or blended learning that can be used to increase knowledge, skills and confidence of persons working in the nursing, midwifery and health disciplines.

Nowadays, in Romania, many universities use e-Learning platforms generally based on the Moodle-LMS platform or on the most popular collaborative educational platforms designed by Microsoft and Google. In the field of medical management, online learning programs are relatively new, appearing in postgraduate training programs and continuing professional education courses organized by software development companies. The National School of Public Health, Management and Professional Development, Bucharest (NSPHMPDB, 2023) conducts training courses to increase the effectiveness and efficiency of health services from the country, training courses in medical management, blended learning training techniques, by integrating online teaching tools into the specific activities of traditional education.

2.2 Ontologies in human resources management

Research on the use of ontologies in human resources management (HRM) has covered on different aspects. An ontological model that includes skills and occupations for e-recruitment systems needed to choose the right person for the job offered is presented in (Dorn, Naz & Pichlmair, 2007). The HRM ontology, which defines concepts such as competence, jobs and certain attributes of these concepts,

as well as the relationships between these concepts, can establish what competencies are required for a given job and what knowledge and experience are needed to reach a certain place, is described. A tool for representing knowledge in the corporate memory that guides the enterprise in the acquisition of capital is described in (Yelena & Probst, 2007).

Numerous studies and research attest to concerns in the realization of various IT systems based on ontologies in the healthcare field, such as the systems that provide access to interested parties to sources of medical data and knowledge belonging to an ontology (Ivanovic & Budimac, 2014); alert management system that helps managers integrate processes and handle events (Chiu et al., 2004); system that provides information exchange and communication in medical services using ontologies (Zeshan & Mohamad, 2012).

3. Study case: ontology-based e-Learning platform for managers of healthcare system in Romania

The e-Learning system is based on the ontologies models: the student model, the domain of interest model (HRM), and the learning process model, which play an important role in providing personalized training material. Modelling domain knowledge with ontologies is a key aspect of integrating information from different sources, supporting collaboration within virtual communities, as well as improving information retrieval. The prototype system offers learning techniques that ensure a structured organization of HRM knowledge, use, and retrieval of the necessary information, as well as new methods of data extraction from the web (Băjenaru, 2018; Băjenaru & Smeureanu, 2018).

3.1 The system ontology

In the ontology development process, respectively in the conceptualization phase, the information collected in the acquisition phase was organized and structured in a conceptual model that describes the identified solution. Concepts (terms) were identified, which define useful and potentially usable knowledge in the established field, as well as their meanings, which form the basis of a vocabulary of terms. Terms are represented by concepts, meanings, verbs, and properties; information about attributes or their values; information for the description of the concept itself; information related to the domain of knowledge, related attributes and constants. The Protégé-OWL environment was chosen for the development of the ontology (Horridge et al., 2011).

The classes identified are represented in the ontology developed using the Protégé environment as in Figure 1.

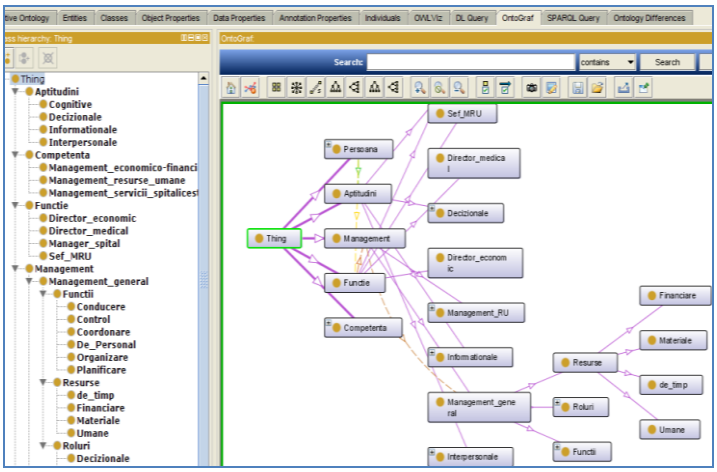

Figure 1. Graphical Representation of the Class Hierarchy of the System Ontology

In the left panel of the Protégé application, the concept hierarchy of the ontology is displayed in a tree, and in the right panel, the OntoGraf application provides a graphical representation of class and subclass hierarchies.

3.2 ONTO platform

To implement the e-Learning process in a real platform, an open-source web-based learning management system (LMS) was chosen. The e-Learning platform based on semantic web technology offers the necessary tools (e-Learning) to implement a new mechanism for obtaining relevant information from the Internet, offering the possibility of using the advantage offered by semantic web content and multimedia materials (materials in electronic format, links, images, animations, sound, movie, etc.). The e-Learning platform (ONTO) based on semantic web technology offers the necessary tools to implement a new mechanism for obtaining relevant information from the Internet, offering the possibility of using the advantage offered by semantic web content and multimedia materials sources (Băjenaru, 2018; Băjenaru & Smeureanu, 2018). Depending on the profile and function for which training is desired, the student will have access to the e-Learning platform, in order to obtain a personalized learning program based on a specific ontology, as well as to obtain bibliographies that meet their learning requirements.

In the following, the logical flow of actions offered by the prototype educational system for the acquisition of knowledge specific to a managerial function (position), by a student with higher medical education, who is training for the position of hospital manager, with the training level presented as advanced, visual/verbal learning style and other characteristics stored in his profile. According to the student profile and according to his training requirements, appropriate educational material is allocated, thus highlighting the personalization component of the prototype system. A training sequence, represented by specific

platform captures for a student who accesses the position of hospital manager and who has an advanced level of knowledge, is presented next.

The student has logged into the platform based on a username and password received from the administrator and is accessing it for the first time. On the main page of the platform, a wizard-type sequence opens, which ultimately has the role of determining the optimal educational content, personalized for the student. After that, the student has access to the training section, after having authenticated and tested the learning style and to identify the initial level of knowledge for the position of hospital manager (Figures 2 and 3).

Figure 2. Training Section - Main Page

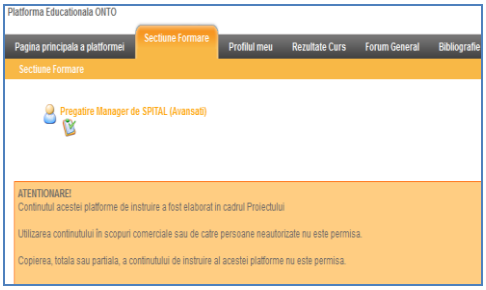

Figure 3. Training Section - Course Page

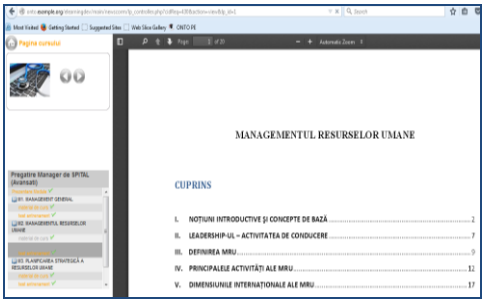

Figure 4. Course Module

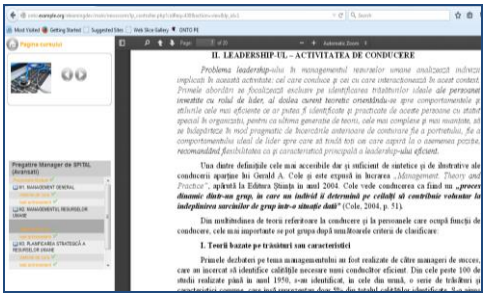

Figure 5. Lesson from a Course Module

In the captures there are associated with a user with the following profile: higher medical education, advanced training level, active/reflective learning style, initial test - grade 5, and other profile information. The educational materials offered by the e-Learning system can be materials stored on the server, organized in the form of course modules, which can be found in the Courses section. The completion of the module is completed with graded tests. Examples of course modules and lessons can be seen in Figures 4 and 5.

4. Conclusion

The ontology-based e-Learning system aims to solve some limitations of e-Learning systems, related to the flexibility of the computer-assisted learning

process as well as to the promoted teaching methods, by offering new facilities for students, such as adaptive and personalized training process, the provision of educational material corresponding to the profile of each student. More flexible medical staff, having very good knowledge in various fields, with more skills and oriented towards teamwork, represent an essential component of a desired health system, which requires a new approach to the professional training of medical staff, respectively managers from the health field. The ONTO e-Learning system presented in this paper proposes an efficient method of improving the training system, by ensuring a learning process specific to each person, which corresponds to their profile and objectives, thus offering personalized educational content. The system contributes to increasing the performance, competence and evaluation capacity of medical management professionals.

REFERENCES

Anghel, M., Pereteanu, G. C. & Cîrnu, C. E. (2020) Emerging Trends in Elearning and Mlearning from a Byod Perspective and Cyber Security Policies. *eLearning & Software for Education*. 1.

Băjenaru, L. & Smeureanu, I. (2018) Learning Style in Ontology-Based e-Learning System. In: Silaghi G., Buchmann R., Boja C. (eds) Informatics in Economy. IE 2016. *Lecture Notes in Business Information Processing.* vol 273. Springer, Cham. doi: 10.1007/978-3-319-73459-0_8.

Băjenaru, L. (2018) *Ontologii informatice în învățământul online (Computer Ontologies in Online Education*). ASE Publisher, https://www.ceeol.com/search/book-detail?id=954206.

Banciu, D., Vevera, A. V. & Popa, I. (2023) Digital Transformation Impact on Organization Management and Several Necessary Protective Actions. *Studies in Informatics and Control*. 32(1), 49-56.

Chiu, D. K. W., Kwok, B., Wong, R., Cheung, S. C. & Kafeza, E. (2004) Alert-driven e-Service Management. In *Proceedings of the 37th Hawaii International Conference on System Sciences*.

Dorn, J., Naz, T. & Pichlmair, M. (2007) Ontology Development for Human Resource Management. In Stary, C., Barachini, F., Hawamdeh S. (eds.), Proc. of the 4rd Int. Conference on Knowledge Managements. *Series on Information & Knowledge Management.* 6, 109–120.

Everitt, L., Stulz, V., Elmir, R. & Schmied, V. (2022) Educational programs and teaching strategies for health professionals responding to women with complex perinatal mental health and psychosocial concerns: A scoping review. *Nurse Education in Practice*. 60, 103319.

George, G. & Lal, A. M. (2019) Review of ontology-based recommender systems in e-Learning. *Computer Education.* 142, 103642. doi: 10.1016/j.compedu.2019.103642.

Horridge, M., Jupp, S., Moulton, G., Rector, A., Stevens, R. & Brandt, S. (2011) *A Practical Guide to Building OWL Ontologies Using Protégé 4 and CO-ODE Tools*, The University of Manchester.

Ivanovic, M. & Budimac, Z. (2014) An overview of ontologies and data resources in medical domains. *Expert Systems with Applications.* 41(11), 5158–5166.

Kozlova, D. & Pikhart, M. (2021) The Use of ICT in Higher Education from the Perspective of the University Students. *Procedia Computer Science.* 192, 2309-2317.

Mak, V. J. & White, P. J. (2021) The development of an e-learning program on the response and recognition of the deteriorating patient using self-study methodology. *Nurse Education in Practice.* 50, 102955.

Matete, R. E., Kimario, A. E. & Behera, N. P. (2023) Review on the use of eLearning in teacher education during the coronavirus disease (COVID-19) pandemic in Africa. *Heliyon*. 9(2), e13308.

National School of Public Health, Management and Professional Development, Bucharest (NSPHMPDB). http://www.snspms.ro/ [Accessed June 2023].

Reavley, N. J., Morgan, A. J., Fischer, J.-A., Kitchener, B. A., Bovopoulos, N. & Jorm, A. F. (2021) Longer-term effectiveness of eLearning and blended delivery of Mental Health First Aid training in the workplace: 2-Year follow-up of a randomised controlled trial. *Internet Interventions.* 25, 100434.

Ruiz, J. G., Mintzer, M. J. & Leipzig, R. M. (2006) The Impact of e-Learning in Medical Education. *Academic medicine.* 81(3), 207–212.

Stotz, S. A., Thompson, J. J., Bhargava, V., Scarrow, A., Capitano, K. & Lee, J. S. (2019) A Supplemental Produce and eLearning Nutrition Education Program for Georgians Who Use Safety-Net Clinics for Their Health Care. *Journal of Nutrition Education and Behavior.* 51(9), 1099-1106.

Tudor Car, L., Kyaw, B. M. & Atun, R. (2018) The role of eLearning in health management and leadership capacity building in health system: a systematic review. *Human Resources for Health*. 16, 44.

Yao, J. & Sun, Y. (2010) The Initial Idea of New Learning Society which Based on Cloud Computing. *Modern Educational Technology.* 20(1), 14-17.

Yelena, J. M. & Probst A.-R. (2007) Business concepts ontology for an enterprise performance and competences monitoring. *Computers in Industry*. 58 (2), 118-129.

Zeshan, F. & Mohamad, R. (2012) Medical Ontology in the Dynamic Healthcare Environment. Proc of the 3rd International Conference on Ambient Systems, Networks and Technologies (ANT). *Procedia Computer Science.* 10, 340-348.