Process-Oriented e-Learning System for Training Healthcare Professionals on Big Data Usage

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Keywords: Big Data, Healthcare, Process-Oriented, Workflow, Learning Analytics, e-Learning.

Abstract: Big data technology promises to transform the way in which medical care is delivered and help the healthcare industry to address problems related to variability in healthcare quality and escalating healthcare costs. However, integrating Big Data use in healthcare professionals' daily practice seems to be a challenging task as they are accustomed to making treatment decisions independently, using their own clinical judgement, rather than relying on protocols based on big data. Taking medical decisions based on Big Data - combined with physicians' valuable clinical knowledge and experience - can lead them to safer and more accurate diagnosis and focused treatments. In order to support this transformation in medical practice healthcare professionals (e.g. physicians, nurses, pharmacists) will need to be trained in the collection, integration and analysis of large data sets. To this end, this paper presents a process-oriented e-learning system which aims at making healthcare professionals understand how to use big data tools and giving them the necessary skills to improve operations. The system uses workflow technology and Learning Analytics which has been specifically planned for learners' custom needs.

1 INTRODUCTION

Big Data in healthcare have given great propulsion to research and to medical care as well. They have contributed to predicting diseases by studying genes while their use leads physicians to quickly targeted and effective diagnosis and treatments (Groves et al., 2013). They can stimulate innovation by identifying new treatments and approaches for the provision of medical care using data coming from clinical trials. They also promise to cut down the cost of the health system through the decrease of medical errors. Correct diagnosis will reduce unnecessary exams and limit wrong treatment.

However, healthcare organizations still have difficulties in fully taking advantage of big data's capabilities. This is because of the fact that they don't know where to «start from». Actually, everything begins from data. The use of big data in healthcare requires a set of many heterogeneous sums of data. The bigger the sum, the more the chances of finding a correct answer on the questions about medical practice. The use of the World Wide Web has made possible the collection of clinical data and the observation of epidemics on a global scale. The ever-increasing number of data will gradually lead to finding useful data, in better decisions and more effective attempts (Murdoch and Detsky, 2013).

Unfortunately, physicians don't have the totality of data related to patient healthcare (e.g. clinical data, electronic patient records' data, sensor data, emergency care data) which makes up Big Data (Raghupathi and Raghupathi, 2014) concentrated somewhere in order to access all of them. In addition, physicians are accustomed to making decisions based only on their judgment and not on data. The result is that one of five medical decisions is wrong or imperfect and the third reason for most fatalities is medical errors that occur due to unlucky medical decisions (Groves et al., 2013; Sun and Reddy, 2013; IBM, 2015). However, taking the fact that medical knowledge doubles every three years into consideration, it will be impossible for healthcare professionals to read all that information to be informed (Kohn, 2012).

Some organizations and academic medical centers have already started estimating capabilities that big data can offer in clinical practice and research and have adopted the use of big data analytics systems. Unfortunately, professors in medical schools have not been trained in order to

Karabetsou, V. and Malamateniou, F.
Process-Oriented e-Learning System for Training Healthcare Professionals on Big Data Usage.
DOI: 10.5220/0005828205230528
In *Proceedings of the 9th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2016) - Volume 5: HEALTHINF*, pages 523-528
ISBN: 978-989-758-170-0

manage and analyze data. Training in this sector is considered to require acquiring technological skills beyond a doctor's training capabilities. As a consequence, physicians cannot make use of big data analytics software and take advantage of their use (Moskowitz et al., 2015; Waxer, 2014).

Process oriented e-learning systems have recently received much attention, as they utilize workflow technology, to support highly structured teaching/learning processes. Furthermore, they allow not only to design and evaluate the effectiveness of processes, but also to easily redesign and improve them. Especially, when training healthcare professionals, redesigning of processes is required because of the constantly increase of medical knowledge (Lenz and Reichert, 2006).

In this paper a process-oriented e-learning system for training physicians on big data usage is presented. In particular, the prototype system uses workflow technology and aims at training physicians on how to search, gather, visualize and store medical data from their daily practice. Furthermore, Learning Analytics are incorporated into the system in order, not only for physicians to monitor their progress, but for the whole learning process to be evaluated.

2 BACKGROUND

The need to support teaching/learning processes, rather than simple tasks, in recent times has resulted in a new type of process-oriented, educational technology. By using workflow-based e-learning systems, it is possible to introduce flexible start and finish times for each task (unit of content) based on user's needs and progress. Technically, this is made possible by the coordination mechanism used by workflow technology. Furthermore, it is possible to increase flexibility of the curriculum. This means the introduction of flexible learning pathways so students can progress through the content in a variety of ways based on their needs and preferences (Marjanovic, 2007).

The use of digital technology in learning processes though, leads to the collection of more and more data. Data create awe with their breadth and heterogeneity but they can contribute to education development with the help of Learning Analytics. Learning Analytics can collect and process data with volume, variety and velocity, they can process "Big Data". The question is which educational data should be gathered and analyzed? Who should choose them? Which are the suitable criteria for this purpose? Ellaway et al., (2014) believe that professional medical education should use analytics' techniques which are proper for the temperaments and special needs of the health sector. Another question that someone should take in consideration is if learners must be aware of the whole procedure of gathering and analyzing educational data and if this awareness can affect the training outcome. Finally, it is important to examine how analysis' results should be used in order to identify best practices and to provide educational process success.

As far as physicians' special characteristics are concerned, someone could end up with the following conclusions:

- Despite technology's extensive growth and the fact that almost everyone owns modern devices, physicians are not quite familiar with all these. As a result, they still prefer studying printed documents (medical articles and books) to get informed. They also prefer storing data on paper (Raghupathi and Raghupathi, 2014).
- Their demanding schedules don't allow them to get informed and to digitize the printed data they own. Moreover, the lack of spare time makes it impossible for them to attend educational programmes that take place in traditional classes.
- During their daily clinical practice a lot of questions come up. These questions are about medicine of course, not only older but also new medical knowledge, and sometimes they are relative to other specialties. In all of these cases, physicians turn to their colleagues to ask for a piece of advice. What is more, there are asked to offer their services to e-patients, who have already searched for information online and have a lot of questions to ask.
- They use the internet to a limited extent, because they don't feel quite safe when they use it and they don't actually trust it. For this reason, although they use to sign in social networks, they don't use to search for medical information.
- A lot of physicians would choose distance learning to get educated, but they can't always find the proper e-learning program made for this purpose (Cortelyou-Ward et al., 2013; Ellaway et al., 2014).

As regards to the way of their training, they need to:

- Have support, guidance, confirmation and feedback during the whole process
- Have flexibility of space and time
- Attend a program that allows them to follow their own learning pace
- Make their own selections in order to draw their own learning path

- Get educated quickly, easily and economically.

As regards to the subject of their training, they need to:

- Get more familiar with new technology
- Use internet safely
- Have easy and quick access to the data they need in order to make decisions regarding medical diagnosis and treatment
- Get informed of Big Data usage benefits
- Use Big Data in their everyday practice, in order to improve medical care provided to patients
- Meet healthcare system's needs for reducing medical errors, unnecessary tests and cost
- Get informed about changes and improvements in medical field
- Share best practises with the medical community.

3 RELATED WORK

A lot of e-learning systems for training healthcare professional have been implemented. Some of them are based on Workflow technology. For example, Puustjärvi and Puustjärvi's (2010) proposal for physicians distance learning. They suggest a solution that provides physicians' daily duties coordination and the necessary learning material as well. Another example is the complete framework that Chodos et al., (2009) suggested for healthcare professionals training by video and virtual world simulations.

University of California, Davis (UC Davis, 2015) promises that applying clinical Analytics can "improve health care, manage risks and improve patient outcomes". UC Davis Extension's online Healthcare Analytics Certificate Program designed for working clinicians and IT professionals aims to help them acquire comprehensive understanding of the use and implementation of healthcare analytics.

A lot of Universities (University of Central Florida, Rio Salado Community College, Northern Arizona University, Purdue University, Ball State University, University of Michigan, University of Maryland, Graduate School of Medicine, University of Wollongong) use Learning Analytics in order to monitor and engage their students, provide them support when they need it and enhance the learning experience. In healthcare education though "learning analytics is in its infancy" (Dietz-Uhler and Hurn, 2013).

Elsevier, a world-leading provider of information solutions, which provides web-based courses for nursing and health professions students, will use Knewton's infrastructure "to power personalized digital solutions". Elsevier offers the educational content when Knewton provides analytics and technology (Knewton, 2014).

Recognizing the significance of gaming and learning analytics, the Stanford School of Medicine developed two educational games, Septris and SICKO, for medical students. The games were very well received and this proved that "the application of gaming and the collection of learning analytics data offer many potential opportunities in education" (Tsui et al., 2014).

4 THE LEARNING PROCESS MODEL

A high-level model of the learning process considered, which is based on constructivism learning theory, is shown in Figure 1. The learning process has been specifically designed for healthcare professionals to enable them realize the benefits from using healthcare analytics at their workplace. The model consists of the following activities:

- **Introduction.** Learners watch a video presentation with ultimate goal to help them digitize printed data, collect medical data online, organize, store and visualize them and to evaluate data usage in decision-making process according to diagnosis and treatment.
- **Assignment Subject Selection.** Learners are asked to choose among ten different subjects. They can also suggest their own subject. The free selection is necessary, because it will give them the possibility to collect data that they really need and can use in their medical practice. The fact that they find the subject interesting, will motivate them and get them engaged. Teacher is informed about their choice in order to be able to support them when needed.
- **File Creation.** Learners create the files in which they will store their data. They will store all the data they will collect about their subject in these files. The main file will be named after the subject and a number of sub-files will be also created. In the sub-files information about the subject's definition, symptoms, aetiology, diagnosis, prevention, treatment, medications and personal notes will be stored. This is a very simple way for anyone to o**rganize data t**hat doesn't demand any programming skills.

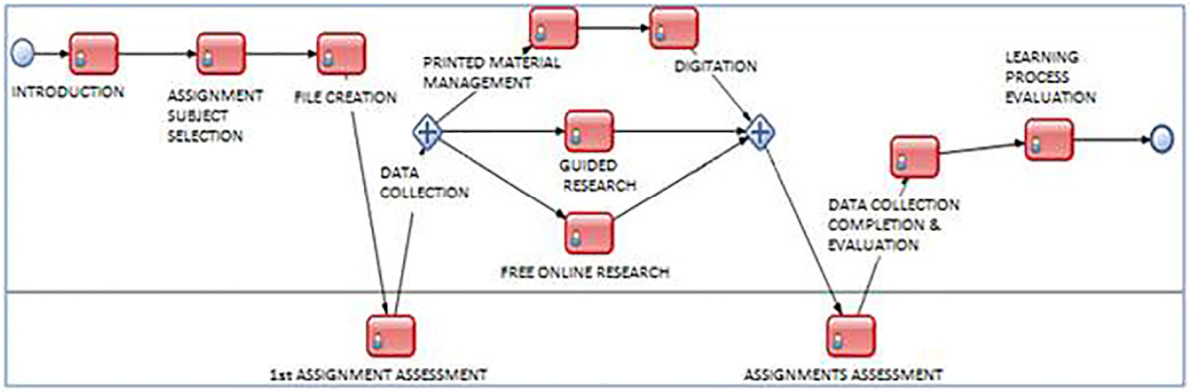

Figure 1. High-level BPM Studio model of the learning process.

- **1st Assignment Assessment.** Learners are informed about their performance. If they get grade under 50%, they will watch a simulation video in order to correct their assignment. Otherwise, they are addressed to the next activity.
- **Data Collection.** Learners gather all the data they could find and then store them in the files writing down useful metadata as the link, the date they found them and a short description of the content. Finding, collecting, organizing data and creating metadata about them, is a simple stage of analysis that can make data ready to be used and easily updated. Data collection constitutes a process activity consisting of three sub-activities:
  - **Printed Material Management and Digitation.** Learners check first if the material (e.g. articles, images, diagrams, video, medical books) already exists. If it doesn't exist, they will digitize their printed material. In any case, they should store data.
  - **Guided Research.** Learners collect data using suggested links of medical blogs and portals.
  - **Free Research Online.** Learners search for data using suggested combinations of words and directions to use internet in a safe way.
    Learners are informed about the way their assignments will be evaluated. The assessment depends on the volume of the data that they collect, the relevance of the data to the subject and the way that these data are organized.
- **Assignments' Assessment.** Teacher assesses each assignment separately. The average grade is automatically calculated and presented to him/her. If the average grade is less than 50%, teacher makes suggestions in order to help learners to complete their collection and submit it again. Otherwise, they are driven to the next activity.
- **Data Collection's Completion and Evaluation.** Learners are informed not only about the way they could use their data collection, but also about the way world medical community uses Big Data. They are informed about the medical databases that are created and furthermore about the Big Data analytics systems that are adopted by physicians, their advantages and their conditions, way and scope of use. They could collect and use Big Data alone or they could adopt a system that provides them all of the useful data they need in order to answer complicated questions.
- **Learning Process' Evaluation.** Learners are asked to evaluate the learning process by completing an evaluation rubric. The data that will come up from this procedure will enable the quality control of the process and will contribute to it's improvement through redesign.

5 IMPLEMENTATION ISSUES

The proposed system was implemented with Business Process Management Oracle BPM Studio 10g Release 3 (10.3.0). BPM Studio was used both for designing and implementing the learning process model and for implementing learning analytics.

As shown in Figure 2, learners are able to choose the subject of their assignment. Ten different subjects are proposed to them. They can choose one of them or they can submit their own subject. In addition, it offers educational designers the ability to review the workflow, when needed. For example, if

they notice that learners don't submit an assignment on time, they suspect that this assignment is too difficult and they can modify it properly.

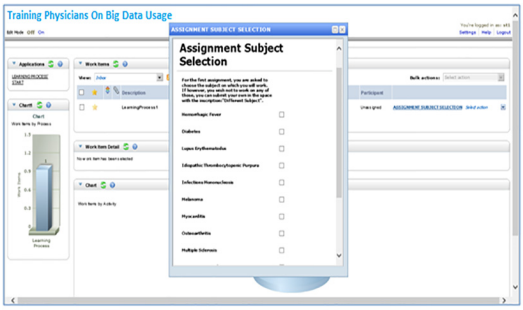

Figure 2: Assignment subject selection.

Learning Analytics is used to keep track of the learners' progress and intervene in cases when it is needed. As shown in Table 1, Learning Analytics are being used in two different ways, "Micro interventions" during the whole learning process and educational data gathering for future use. As "Micro interventions" are concerned, Chris Brooks' opinion was adopted which suggests giving support to learners at the right moment (Diaz and Brown, 2012). The proposed model includes a dashboard which presents the elapsed time between activities and another one where trainer can watch the average engagement time for participants to each activity.

There are also two charts for students where they monitor the learning process progress. At the same time, learners' privacy is being protected, because information is displayed anonymously. Teacher's intervention is immediate in order for learners not to abandon the process. Also, frequent assessment is applied for the teacher to will be able to detect problems and intervene immediately.

During the learning process lots of educational data are collected that are used to extract valuable conclusions. These data include learners' assignments, dashboards references, assignments comments and grades, learning process evaluation. The material that is gathered consists of texts, images, graphs, questionnaires and e-mail. Data volume and velocity depend on learners' number.

Table 1: Learning Analytics Implementation.

Goal	Actions
Prediction of learners' progress	○ 1st Assignment ○ Learning pace
Early detection of learners' difficulties	○ Date of assignments' delivery ○ Elapsed time between assignments (Dashboard) ○ Automated reminder of deadlines and detection of problems
Intervention when needed	○ Support learners providing extra material individually ○ Evaluate assignments using comments to guide and support ○ Support and encourage learners through e-mails
Motivating learners	○ Graphs presenting active work items in one activity and in the whole process ○ Inform learners about their assignments' evaluation criteria
Helping and improving learning process	○ Dashboard that visualize the average time that learners spend in each activity ○ Teacher's inform every time that a learner uploads an assignment with e-mail ○ Provided support evaluation ○ Completion of an assessment rubric

6 CONCLUDING REMARKS

While the use of big data shows exciting promise for improving health outcomes and controlling costs, healthcare professionals should increase their reliance on big data technology for triage, diagnosis and decision-making. To this end, training healthcare professionals on big data usage constitutes a rather challenging task. In this paper a process-oriented e-learning system was implemented with the objective to train physicians on big data usage. The system uses Learning analytics for monitoring learners' progress and for, improving the learning process.

With today's huge patient loads, treating patients sooner saves both lives and healthcare costs. To this end, the proposed system aims at helping healthcare professionals to deliver much more precise and personalized care by quickly making informed medical decisions.

System evaluation is a task to be undertaken in the near future aiming at determining the system usability. Thus, its potential weaknesses may be revealed suggesting alterations in the system design.

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