iCBLS: An interactive case-based learning system for medical education

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ARTICLE INFO

Keywords:
Medical education
Case-based learning
Teaching methodology

ABSTRACT

Medical students should be able to actively apply clinical reasoning skills to further their interpretative, diagnostic, and treatment skills in a non-obtrusive and scalable way. Case-Based Learning (CBL) approach has been receiving attention in medical education as it is a student-centered teaching methodology that exposes students to real-world scenarios that need to be solved using their reasoning skills and existing theoretical knowledge. In this paper, we propose an interactive CBL System, called iCBLS, which supports the development of collaborative clinical reasoning skills for medical students in an online environment. The iCBLS consists of three modules: (i) system administration (SA), (ii) clinical case creation (CCC) with an innovative semi-automatic approach, and (iii) case formulation (CF) through intervention of medical students' and teachers' knowledge. Two evaluations under the umbrella of the context/input/process/product (CIPP) model have been performed with a Glycemia study. The first focused on the system satisfaction, evaluated by 54 students. The latter aimed to evaluate the system effectiveness, simulated by 155 students. The results show a high success rate of 70% for students' interaction, 76.4% for group learning, 72.8% for solo learning, and 74.6% for improved clinical skills.

1. Introduction

Medical education is an active area of research and has undergone significant revolution in the past few decades. In health education, the purpose of medical education programs is to: (1) develop educational leaders, (2) change the learners' knowledge, skills, or attitudes, and (3) improve educational structures [1]. Various teaching methodologies have been introduced in professional health education [2], where Case-Based Learning (CBL) is known to be an effective learning approach for small groups of medical students at undergraduate level education as well as for professional development [3–6].

In professional education for health and social care domains, the clinical case is a key component in learning activities, which includes basic, social, and clinical studies of the patient. Normally, in CBL practice non-real patient medical cases are developed in addition to unplanned clinical encounters, which totally relies on patient's goodwill [3]. Furthermore, students also feel that classroom CBL activities require a significant amount of time [7]. Sometimes, students feel uncomfortable while participating in group learning activities and they prefer to work alone [8]. Medical students tend to choose computer-based cases [3,9] and opt for web-based cases as compared to lectures for their learning [10,11]. Additionally, more attention is given to online/web-based learning environments [3] and real-life clinical case(s) are increasingly emphasised in medical students' practice [3,12,13]. Finally, less attention is given to the development mechanisms of real-world clinical cases and most of the stakeholders, including learners, teachers, administrators, and other health professionals, are interested in change [1].

Keeping in view all aforementioned facts, we focused on designing and developing an interactive computational e-learning platform by using CBL concepts so that medical students are provided the following learning activities: (1) practicing real-world case(s) before and outside the class to determine the treatment of patients in an easy to use manner, (2) identifying the components of a medical chart (such as demographics, chief complaint, medical history, etc.) from a given clinical case, and (3) constructing appropriate interpretations about a patient's problem to create a significant medical story using identified components within the context of his or her life. In order to achieve
these goals and expectations, this study was undertaken with the following objectives: (1) create a real-world online and computer-based clinical case (see Sections 3.2 and 4.2); and (2) identify basic science information relevant to patient data for their practice (see Sections 3.3 and 4.3).

In this study, we have designed and developed an interactive Case-Based Learning System (iCBLS) based on the current CBL practices in the School of Medicine, University of Tasmania, Australia. This study is the extension of work mentioned in [14] that lacks the support of acquiring real-world patient cases, and is also detailed study of some parts of work [15]. The proposed iCBLS provides features such as: an online learning environment, interactivity, flexibility, display of the entire collection of data at one place, a paging facility, and support for in-line reviewing to edit and delete the displayed data. The iCBLS consists of three modules: (i) system administration (SA), (ii) clinical case creation (CCC), and (iii) case formulation (CF). The SA module manages multiple types of users and it maintains the hierarchy of courses, their units, and clinical cases for each unit. Similarly, the CCC module is based on an innovative semi-automatic approach that consists of three steps. First, graphs are generated from a patient's vital signs with a single click. In the second step, a clinical case is generated automatically by integrating basic history, and vital signs information. Finally, in the third step, the medical teacher refines the generated case in order to create the real-world clinical case. The CF module is based on identification of the medical-chart's components in order to formulate the summaries of CBL cases through the intervention of medical students' as well as teachers' knowledge and getting feedback from the concerned teacher. In addition, the CF module enables the students to practice the real-world case(s) before and outside the class.

The key contributions of this research are as follows:

1. This work focuses on developing an intelligent computational e-learning platform for CBL in medicine that enriches and enhances the learning experience for medical students.
2. The paper shows the design and development of an interactive CCC module that supports an innovative method to real-world clinical case creation using a semi-automatic approach.
3. The paper shows the design and development of an interactive CF module that provides a flexible case formulation environment.

The paper is organized as follows: Section 2 covers the related work; the methodology of the proposed iCBLS is discussed in Section 3. Section 4 discusses the iCBLS along with a case study scenario. Section 5 provides the details of evaluations performed along with results, while Section 6 discusses the significance, challenges and limitations of the proposed system. Section 7 concludes the paper with a summary of the research findings.

2. Related work

In the Introduction section, we discussed about the background information relating to medical education and Case-Based Learning (CBL). This section demonstrates more detailed pedagogical concepts, methodologies applied in CBL, and the related web-based learning systems in medical education. It is further classified as: (1) background subsection, which describes the basics of CBL with respect to background, features, and its comparisons with Problem-Based Learning (PBL); and (2) review subsection, which overviews the existing web-based learning systems, compares with well-established CBL systems, and finally presents the overall limitations of existing learning systems.

2.1. Background for case-based learning

CBL was introduced by pedagogy experts to improve knowledge exploration, emphasize critical thinking, achieve better collaboration, and increase opportunities for receiving feedback [4]. Research literature provides multiple features of CBL, such as: (i) it assists students to examine fact-based data, employ analytical tools, articulate their concerns, and draw conclusions for relating to new situations [16,17], (ii) offers an opportunity to realize theory in practice [17], and (iii) develops students’ clinical skills in independent and group learning, as well as in communication and critical thinking to acquire meaningful knowledge for improving students’ attitude towards medical education [6,17–23].

CBL is a teaching methodology that utilizes PBL principles. Scavarda et al. [24] and Thistlethwaite et al. [3] described CBL as more structured than PBL as it uses authentic cases for clinical practice. Similarly, Grauer et al. [25] noted that CBL methods require less time and are more efficient in providing large amounts of material compared to PBL. Moreover, Umbrin [26] differentiated PBL from CBL and defined the steps for learning in both PBL as well as CBL. In PBL, the steps are: Problem → Explore problem → Self-learning → Group discussion, while in CBL, the steps are: Prior reading → Problem → Seeking out extra information → Interview with a knowledge expert. Furthermore, the researcher of [26] mentioned that in PBL, students improved their problem solving skills; while in CBL, students learned clinical skills. In addition, in PBL, the role of a facilitator is passive as opposed to CBL, where a facilitator’s role is active. Finally, the researcher of [26] concluded that CBL is a preferred methodology over PBL.

2.2. Review of existing web-based learning systems

In order to support the learning outcomes of students, a plethora of web-based learning systems have been developed [14,27–35]. A review of the literature shows that learning systems, Design A Case (DAC) [27] and Extension for Community Healthcare Outcomes (ECHO) [28] are well established CBL projects. The ECHO platform was developed for case-based learning in which primary and specialty care providers working together to provide care for patients using video conferencing and sharing electronic records. Similarly, the DAC provided an online educational tool, which is designed to supplement the traditional teaching and allows to develop health related virtual cases for medical students. Both ECHO and DAC projects support the postgraduate medical students; however, they do not allow the medical teacher to visualize vital signs, which is an important feature while developing clinical cases.

Ali et al. [14] developed an online CBL tool, called Interactive Case-Based Flip Learning Tool (ICBFLT), which formulates the CBL case summaries (e.g., further history, examination, and investigations) of virtual patient through intervention of student as well as medical experts’ knowledge. This tool also provides learning services to medical students before attending the actual class. Boubouka [34] designed a case-based learning environment, called CASes for Teaching and Learning (CASTLE) for supporting teaching as well as learning through cases. In CASTLE, a teacher can author the cases for their students and also monitors the elaboration of scenarios interpreted by their students. As conclusion, ICBFLT and CASTLE lack the support of acquiring real-world patient cases. For medical training purposes, Dilullo et al. [31] created online predefined case-based tutorials to provide clinical exposure to the medical students without the support of acquiring real-world patient cases and do not provide feedback to students.

Cheng et al. [30] adopted a web-based prototype system called Health Information Network Teaching-case System (HINTS) in practical training of medical students for clinical medicine. They also explained the development mechanism of teaching cases but with no support of providing feedback to students. Shyu et al. [29] established a platform, called Virtual Medical School (VMS) for problem-based learning. They utilized their online authoring tools to capture the patient cases from Hospital Information System database. Suebaikun and Haddawy [32] developed a problem-based learning system, called Collaborative Medical Tutor (COMET) for medical students to provide intelligent tutoring during problem solving tasks. The COMET generates tutorial hints to
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