Advances in Medical Education

Series Editors: Susanne Lajoie · Yvonne Steinert

Susan Bridges
Lap Ki Chan
Cindy E. Hmelo-Silver *Editors*

Educational Technologies in Medical and Health Sciences Education

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Volume 5

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Preface

This volume follows on from an earlier collection (Bridges, Whitehill, & McGrath, 2012) "Problem-Based Learning in Clinical Education" and seeks to build on what this editorial team, all of whom contributed to that volume, had come through our research to identify as an emerging trend in problem-based learning, i.e. the growing role of educational technologies. Our aim in this 2015 volume is to expand upon these initial thoughts and earlier research to share recent scholarship investigating our understandings of educational technologies in two specific contexts in health sciences education: (a) knowledge building in problem-based learning and (b) applied learning in clinical contexts. Our definition of educational technologies for the purpose of this edited volume broadly encompasses affordances for learning in physical and virtual learning spaces. As such, this includes both the installation of new hardware and infrastructure as well as the development of new software to support learning within and across the two thematic contexts. To date, one can broadly describe the uses of educational technologies in health sciences in preparing undergraduate and postgraduate students for clinical practice as blended synchronous and/or asynchronous approaches.

Chapters in this evidence-based collection draw on studies that examine educational technologies in medical and health sciences programmes which lead to applied, clinical practice. The range of affordances includes digital learning objects, such as video cases and virtual patients; learning management systems; virtual reality software and 3D simulations; as well the innovative use of hardware such as interactive whiteboards with internet searching capability; and integration of mobile devices. This list is not exhaustive but illustrates the broad range of applications in this under-researched field.

The focus in the collection is research-based seeking to expand and synthesise current understandings of both theoretical backgrounds and empirical evidence regarding the use of educational technologies in medical and health sciences education. While more general literature on their use in teaching and learning exists, this volume's contribution aims to be in publishing studies that reflect the growing body of empirical research on educational technologies for situated, contextual learning in clinical education. It draws on both evaluation and applied research data to analyse patterns of usage as well as individual and group cognition and psychomotor skill development. An eclectic approach has been taken by including various methodological and analytic lenses so as to support wider understandings of the impact (intended or not) of educational technologies on the learning process in these two contexts.

Practical implications of each study illustrate how the inclusion of such technologies can be purposefully designed to enhance deep learning and promote student engagement. In summary, the focus of this volume is twofold—research-driven and embracing new methodologies to explore how the inclusion of educational technologies can enhance students' learning in health professions education courses and programme. We trust readers will enjoy this wide-ranging sample of the cutting-edge work being undertaken with educational technologies in medical and health sciences education.

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Hong Kong Lap Ki Chan
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Contents

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Chapter 1
Situated Learning and Educational Technologies: Theory and Practice

Susan Bridges, Lap Ki Chan, and Cindy E. Hmelo-Silver

1.1 Introduction

Whilst focusing on how new and emerging technologies are being implemented and researched in medical and health sciences education contexts, conceptually this collection is drawn together by a common interest in situated learning which creates an apprenticeship in thinking (Lave & Wenger, 1991). Key to situated learning is the *authenticity of the learning context*—be it simulated as in PBL discussions in university classrooms or applied as in patient diagnosis and treatment in clinical settings. Collins and Kapur (2014) view situated learning as one of the key themes in research on cognitive apprenticeship and describe it as occurring in environments, be they real or simulated, where "learners are given real-world tasks and the scaffolding they need to carry out such tasks" (p. 117). As such, the focus is on helping students to both accomplish tasks and learn from them. The key here is the authenticity of the learning environments. For students in problem and case-based inquiry, the real-world relevance of the scenario or case leads to heightened engagement and deep approaches to learning (Biggs & Tang, 2011; Prosser & Trigwell, 1999). When adopting deep approaches, students work at a more conceptual level to achieve academically challenging learning outcomes. They engage in critically reviewing and

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synthesizing new information with prior and current knowledge in order to creatively apply new understandings to novel situations. In a situated view of learning, these novel situations are authentic and related to current life worlds or future professional practice. The view taken in this collection is that, by infusing educational technologies into situated learning contexts, there is potential to enhance authenticity as well as support the scaffolding of the development of both knowledge and practical skills.

Also critical to the concept of situated learning is the *social dimension* of this authentic, context-based learning. As the studies in this volume describe, problem-based and clinical learning is situated in small groups under guidance from tutors and clinicians thus providing authentic, culturally relevant and socially complex learning environments. In the process of collaborative knowledge building and creation (Scardemalia & Bereiter, 2014) these mentored learning communities evolve into productive teams which develop not only the necessary knowledge but also the attributes of their developing professional identities. Deep approaches to learning are a desired effect of situated learning. This is actualized not only through the integration of authentic tasks embedded in a philosophy of inquiry but also through the development of social attributes necessary for the profession.

The chapters in this book, therefore, have a common interest not only in the technologies that can be developed for education per se, but in researching technology-enhanced education in the medical and health professions. The shared goal is to ascertain how the potentials of these technologies are productively harnessed to support and scaffold student learning in these complex contexts. In Part 1, the range of PBL contexts examined includes problem and case scenarios ranging from the broad and largely hypothetical to those drawing on real patient cases. In Part 2, the clinical contexts include learning in clinical rotations and clerkships. Both are focused on "active engagement" in "accessible forms of authentic disciplinary practices", notions supported by learning sciences research into student learning outcomes (Nathan & Sawyer, 2014, p. 34). Further, when considering inducting learners into the "epistemology of the discipline—the ways knowledge in a field is structured and produced" (ibid), the evidence provided across the variety of studies in this collection is that educational technologies hold a critical role in supporting this process of induction or "cognitive apprenticeship" (Brown, Collins, & Duguid, 1989).

Research from a situated learning perspective has been conducted on practical placements in nurse education (Cope, Cuthbertson, & Stoddart, 2000) and found that mentoring approaches were associated with situated learning and cognitive apprenticeship in clinical nursing. Situated learning with new technologies in clinical dental education has drawn upon multimodal literacies whereby students develop authentic digital tasks and peer-review them in closed online communities. This project also found mentors to take a key role in shaping and engaging in multiple overlapping communities of practice (Bridges, Chang, Chu, & Gardner, 2014; Gardner, Bridges, & Walmsley, 2012). For professional development of academics teaching across the medical and health sciences, online mentorship in the form of a peer-reviewed resource bank of learning and teaching materials, the MedEdPORTAL also echoes the notions of community of practice and authentic learning (Association of American Medical Colleges, 2015).

We see the following chapters in this volume as contributing to this body of research and shared practice by providing insights into cutting edge practices in health sciences education. In structuring the volume, we have taken a situated approach by delineating two contexts—problem-based learning and clinical learning. Although this is a convenient way to structure the volume, we did not see these contexts as separate. Research has shown that disciplinary knowledge building across these contexts is mutually informative and iterative, even more so in integrated curriculum designs (Lu, Bridges, & Hmelo-Silver, 2014). We trust that our readers will enjoy this rich sampling of current research into educational technologies in health sciences education.

1.2 Part 1. Exploring Educational Technologies in Problem-based Contexts

The chapters in this section considered how educational technologies are used in PBL contexts. In the chapter "How E-learning Can Support PBL Groups: A Literature Review" the authors engaged in a systematic review to explore the research on how technology has been used to support PBL in both face-to-face and online group with a focus on tools that create context and support communication (or both). This theme of context setting and communication tools continues over the next three chapters. The next chapter, "Technology and group processes in PBL tutorials: An ethnographic study" takes a deep dive into how technology affects group dynamics in PBL by studying the effects of an interactive whiteboard and how that leads to new learning practices. In "Video as Context and Conduit for Problem-based Learning" the authors examine how video can be used to set an emotionally laden context and using video conferencing as a communication tool in a cross cultural setting to create a community of inquiry. The chapter "What is real? Using problem-based learning in virtual worlds" also investigates using virtual world technology to create contexts and provide communication spaces to create "collaborative immersive tutorials". The final two chapters focus on both how students see technology being useful and how online resources might be helpful. Taking the student perspective in, "How do health sciences students use their mobile devices in problem-based learning?", Chan and colleagues examine data from student surveys about how they use their mobile devices in PBL tutorials and what might and might not be appropriate. One of those uses is to look for information. In "Are Wikipedia Articles Reliable Learning Resources in Problem-Based Learning Curricula?", the author examined the quality of information in Wikipedia articles related to the nervous system and raises some concerns in this regard. Together these chapters consider technology as it provides context, spaces, and tools for communication, and information sources that can support online and face-to-face PBL.

1.3 Part 2. Exploring Educational Technologies in Clinical Contexts

The chapters in this section explored how educational technologies can support learners' transitions to the clinical care of their patients. In the chapter "Dealing with different perspectives: Technologies for health sciences education", the authors examined how wiki and online forums can help students develop skills for communicating adequately with colleagues and patients who have different therapeutic health concepts. In the chapter "Utilising Mobile Electronic Health Records in Clinical Education", the authors investigated students' learning of skills needed in the use of Electronic Health Records (EHR) in clinical environment. They also examined the use of a mobile EHR system as a learning tool in an undergraduate medical programme. In general, students were quite positive on using the mobile EHR system, because it helps them in taking and organizing the history, links easily to drug information, and prompts students to reflect. However, they also found students would avoid using them in front of the patient and that most records were created at home. The findings of these authors on the use of technologies in the clinical learning context can potentially inform teachers in pedagogical design.

The use of technology also makes it possible to probe into learning in clinical contexts in ways not possible before. In the chapter "Measuring emotions in medicine: Methodological and technological advances within authentic medical learning environments", the authors discussed the methods and technologies for measuring emotions, which can have an important but rather unexplored functional role in learning and performance, especially in medicine and health sciences. Such data allow educators, teachers, and researchers to look at learning in clinical contexts with a new set of lenses.

Although educational technologies offer so many new possibilities, we are also in a race with them, which perhaps can be called the "Red Queen Effect", a term borrowed from evolutionary studies hypothesizing that organism must keep evolving in order to survive in competition with other evolving organisms. The terms came from the Red Queen in Lewis Carroll's "Through the Looking-Glass", who said that "Now, *here*, you see, it takes all the running you can do, to keep in the same place". Educators must also be flexible in the adoption of new technologies, not only because technology is moving fast, but also because the students are moving fast too in the technology landscape. Therefore in the chapter "The Deteriorating Patient Smartphone App: Towards Serious Game Design" the authors described the evolution of the pedagogy used in learning the management of deteriorating patients, from live face-to-face, to web-based, to a mobile app. In the chapter "Mobile Just-in-time Situated Learning Resources for Surgical Clerkships", the authors described the development of a surgical anatomy review resource in multiple formats (as webpages for viewing in web browsers on PC, as ebook, mobile apps, as well as printed book). The key message is the need for technological flexibility in developing electronic learning resources because of the rapid evolution of electronic platforms on which these resources can be presented to support student learning. Trelease, the author of that chapter said it well: “The challenge thus continues for medical educators and instructional designers to evolve and to assess new appropriate methods for using changing learning technologies to address societal needs for training more physicians most effectively in time- and cost-effective ways”.

1.4 Conclusions

This innovative collection of contributions provides a unique view of research activity across both problem-based classroom and clinical spaces of learning. What we have learnt from the authors is that educational technologies, indeed, retain the potential to engage and motivate medical and health sciences students as 21st century learners. More than this, however, by drawing these studies into one coherent volume, we feel that we have achieved a new, collective, and more holistic understanding of how embedding educational technologies across all aspects of health sciences curricula is accomplished. Conceptually, this is framed in terms of supporting authentic learning in context—a technology enabled vision of situated learning.

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Part I

Educational Technologies in Problem-Based Learning (PBL) Contexts

Chapter 2
How e-Learning Can Support PBL Groups: A Literature Review

Daniëlle M.L. Verstegen, Nynke de Jong, Jean van Berlo, Annemarie Camp, Karen D. Könings, Jeroen J.G. van Merriënboer, and Jeroen Donkers

2.1 Introduction

Problem-based learning (PBL) is a powerful student-centred educational approach, where learning is based on authentic problems (e.g., Barrows, 2002; Barrows & Tamblyn, 1980; Moust, Bouhuijs, & Schmidt, 2014). E-learning can be defined as "learning facilitated and supported through the use of information and communications technology" (JISC, 2014). E-learning includes a range of technological tools and facilities employed to support or improve the learning process of students, for example to support the learning of specific knowledge and skills, to support communication and group work, and to support assessment and reflection (Donkers, Verstegen, de Leng, & de Jong, 2010). E-learning is widely used to support distance learning and face-to-face learning, but can e-learning also support the learning principles of PBL? Or do some e-learning implementations weaken the PBL principles?

This chapter focuses on how e-learning has been described to support PBL in groups working either face-to-face or online, based on a literature review. After the introduction to important concepts and the research questions in Sect. 2.1, our methods for literature search and data collection are explained in Sect. 2.2. The description of characteristics of the included studies, common ways to support PBL groups, and examples of innovative support are given in Sect. 2.3. The last section of the chapter discusses the limitations of our approach, the conclusions and lessons learnt, including opportunities and challenges of implementing e-learning in PBL settings. The chapter concludes with directions for future research.

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2.1.1 Problem-Based Learning

PBL is based on the assumptions that learning is a constructive, collaborative, contextual, and self-directed process (e.g., Dolmans, De Grave, Wolfhagen, & van der Vleuten, 2005; Mok, 2009). Realistic, complex, and ill-structured problems are used to stimulate learners to actively construct knowledge. Discussions in small groups are an essential part of PBL (e.g., Hmelo-Silver & Barrows, 2008; Ng, Bridges, Law, & Whitehill, 2014). From a cognitive viewpoint these discussions foster learning by helping individual students to activate prior knowledge, to elaborate, and to stimulate the (re)structuring of knowledge (Moust et al., 2014; Moust & De Grave, 2000). From a sociocultural perspective these discussions foster joint negotiation of meaning and collaborative knowledge construction through social interaction (Hmelo-Silver, 2004). Often the PBL process is explicitly structured in steps, for example, the seven steps at Maastricht University (MU 2014) or the problem cycle in dental education in Hong Kong (Bridges, Botelho, Green, & Chau, 2012). In a broader definition also some forms of project-based learning or inquiry learning could be seen as PBL as long as learning is centred around authentic problems and involves learning in small groups.

Positive effects of PBL have been reported on graduation rates and study duration, and on the students' diagnostic reasoning, interpersonal and professional competencies (Schmidt, 2010; Schmidt, van der Molen, te Winkel, & Wijnen, 2009) and on the students' long-term retention of knowledge, problem-solving skills, higher-order thinking skills, self-directed/lifelong learning skills, self-perception, and confidence (Hung, Jonassen, & Liu, 2008).

2.1.2 e-Learning

Meta-studies into e-learning in general found positive, though small effects on student learning (e.g., Bernard, Borokhovski, Schmid, Tamim, & Abrami, 2014; Cook et al., 2010; Cook, Garside, Levinson, Dupras, & Montori, 2010; Schmid et al., 2014; Spanjers et al., 2014). There was a large variability, meaning that some implementations of technology were better than others and that some actually affected student achievement deleteriously. According to Schmid et al. (2014) learning with cognitive support tools involving strategies that include student-centred, dynamic, interactive techniques, appeared to produce larger effect sizes than learning with presentation-type tools.

In the context of PBL the use of multimedia in PBL problems is supposed to provide implicit contextual information, such as visual, auditory, or other nonverbal cues that are absent in paper or oral presentations (Hung et al., 2008). E-learning tools and facilities have also been used to enable distance-based PBL (e.g., De Jong, 2012; Ng et al., 2014; Savin-Baden, 2007). Not all forms of e-learning fit the learning principles of PBL, though. Many e-learning modules, for example, are based on information delivery and lead all students through the same materials in the same way, which is in contrast with the PBL principles of constructive and self-directed learning. Barrows (2002) also claims that many early online environments seemed to fail to deliver the promise of fostering collaborative learning (Barrows, 2002). To genuinely support PBL, e-learning tools and facilities should support or at least not hinder the PBL principles and processes identified above: activation of prior knowledge, elaboration, structuring, and restructuring of information, collaborative learning, learning in context, and self-directed learning.

2.1.3 Aim and Research Questions

The purpose of the research reported in this chapter is not to prove that e-learning works for PBL, but to get more insight in how e-learning can support PBL groups. More specifically, the aim of this literature review is to inspire teachers who are looking for ways to stimulate and support the PBL process and to provide a framework for future research on e-learning for PBL groups. The research questions are:

1. In which setting is e-learning used to support PBL groups (domain, place in the curriculum, number of students, etc.)?
2. Which reasons are given for the use of e-learning to support PBL groups and how is this evaluated?
3. In which ways is e-learning used to support the PBL principles and processes (i.e., activation of prior knowledge, cognitive elaboration, structuring and restructuring of information, collaborative learning, contextual learning, and self-directed learning)?

2.2 Method

A narrative literature review study has been conducted by a research team consisting of the seven authors of this chapter. Below we first describe the search strategy, selection of search terms, and the procedures for including studies in the review (Sect. 2.1). Then, in Sect. 2.2 we explain how the selected studies were analysed.

2.2.1 Search Strategy

A systematic search has been executed using EBSCO in the databases ERIC, PSYCHINFO/PSYCHARTICLES, CINAHL and MEDLINE.[1] Based on the definitions of PBL and e-learning given above, keywords were searched in the thesauri of the databases, in relevant articles from our own collection, and in a scoping search. For the final search the following search terms were used:

(problem-based learning OR problem based learning)

AND

(e-learning OR elearning OR electronic learning OR web-based OR online OR web-enabled OR blended OR interactive learning environments OR educational game OR serious gaming OR computer-mediated discussion OR computer-mediated communication OR technology-mediated OR technology-enhanced OR computer-supported collaborative learning OR CSCL OR interactive multimedia OR interactive multimedia OR electronic portfolio OR social media OR web 2.0 OR simulation OR simulator)

AND

Peer reviewed

The search period was set between 2005 and 2012. Eight secondary references, encountered when reading selected articles or from our own collection were added.

The first author inspected the abstracts and, when in doubt, full articles taking into account inclusion and exclusion criteria (see Fig. 2.1). Doubtful cases were discussed within the research team and if no clear conclusion could be reached, the articles were included. Included articles were subsequently read fully by at least one of the team members, checking them against the same criteria. If necessary a second opinion was given by a second reader (i.e., the first author, except when she had been the first reader in which case the last author). When articles described the same implementation in the same setting they were regarded as one study. One article was split up because it described two different studies. This resulted in a set of 151 separate studies. These were divided over the seven members of the research team.

2.2.2 Data Collection and Analysis

In order to collect rich descriptive data about the studies, a data collection form was designed, discussed in the team, and tried out in a pilot with a limited number of articles that were read by two team members each. The final form (see Appendix A) included open questions and closed questions (with comment fields):

– 11 questions to collect background information about the place in the curriculum, the domain, the tools that were used, the number of students and teachers

[1] PubMed has not been searched separately because virtually all peer-reviewed journals of PubMed are subsequently tagged with MeSH terms and put into Medline.

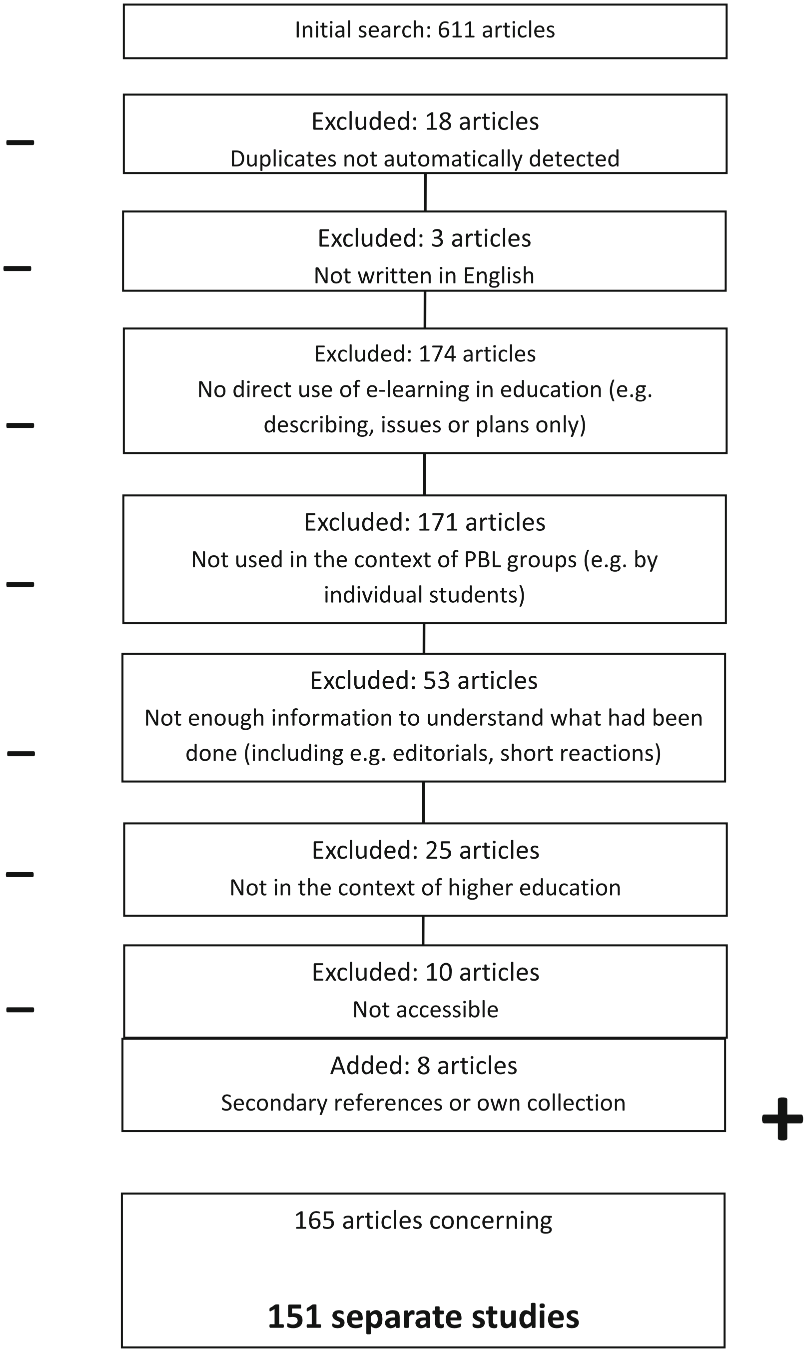

Fig. 2.1 Overview of the selection process

Table 2.1 Type of education

Type of education	Number of studies	Percentage of studies
University education (bachelor-master)	122	81
(Higher) Vocational education	6	4
Post-academic education	14	9
Education for teaching staff	11	7
Blank/other	3	2

Note that some studies concerned more than one type of education

involved, the timing of the e-learning support (before, during, and/or after group collaboration), and the motives for using e-learning.
– 4 questions regarding evaluation of the described use of e-learning, i.e., whether and how evaluation was performed, which kinds of data were collected and what the main results were.
– One question asking to categorize the use of e-learning in terms of the function of tools in the PBL process according to the categories in Table 2.1.[2]
– The reader's opinion about whether the described e-learning did support PBL groups and the option to indicate that an article described a special or innovative use of e-learning to support PBL groups.

For each study a form was filled by one of the team members. Since, the focus of the form was to collect rich descriptive data about the studies, interrater reliability was not calculated. However, to ensure consistency, the team met twice during the reading process to discuss experiences and preliminary results. When all data had been collected the first, second, and last author analysed and described the results regarding background information, the didactical/pedagogical use of e-learning and the implementation and evaluation respectively. These results were then discussed during a final team meeting.

2.3 Results

General characteristics of the selected studies are briefly summarized in Sect. 2.3.1. Subsequently, in Sect. 2.3.2 the focus is on describing the different ways that e-learning was used to support PBL learning principles and processes.

[2] Two other ways to categorize the use of e-learning were included in the form, but subsequently not used for analysis.

2.3.1 Characteristics of the Studies

2.3.1.1 Curriculum, Domain, and Tools

The majority of studies concerned university education, more often with undergraduate students than with graduate students (although this was not always specified). The domain of education was most often medicine or health science, followed by education or teaching, engineering, and science.

Almost half of the studies involved 50 students or less. A minority of studies involved more than 200 students (up to 2000 students). The number of teachers that participated is often not reported. In four studies, no teachers were involved (Table 2.2).

A large number of tools were used. These were classified in the following categories:

– Multimedia, ranging from visual materials to interactive cases/environments
– Simulations and serious games, including e.g., simulators, first-person and multiuser online games
– Tools to communicate and share information synchronously or asynchronously, often embedded in a Learning Management System (LMS) such as Blackboard™, Moodle™, WebCT™ and ClassFronter™ (such as file-sharing, discussion fora, chat, videoconferencing, journals, wikis, blogs, and e-portfolios) but also standalone applications (e.g., plain e-mail or other web 2.0 tools such as Diigo™, Zotero™, or Facebook™)
– Tools to perform specific tasks or produce artefacts (e.g., Matlab™, video-creation tools, 3D-modeling tools, or even hardware such as educational robots)
– Other tools, e.g., notepads or scheduling tools

Most of the tools were existing tools, commercially available or freeware. In a few studies, tools had been developed specifically to support PBL, for example, to guide students through PBL steps or to provide scaffolding, automated feedback, tutoring, or self-assessment. Examples of how tools were used are given in Sect. 2.3.2.

Table 2.2 Number of students involved

Number of students involved	Number of studies	Percentage of studies
50 or less	65	43
51–200	43	28
More than 200	21	14
Unknown	22	15

2.3.1.2 Goal and Evaluation

The reasons given to use e-learning with PBL groups differed across the included studies and they were not always clearly described. When e-learning was aimed explicitly at supporting or improving the PBL process, the following specific goals were mentioned often: enhancing authenticity (mostly in an online setting but also in a face-to-face setting), making PBL and/or learning more attractive (for example by adding competitive elements or a fun factor), increasing flexibility or efficiency, enhancing specific learning skills (such as problem-solving, argumentation, cooperation, self-directed learning, reflection, or critical thinking), or offering automated scaffolding or tutoring.

Often, however, it seemed that the main goal was not to support PBL principles and processes, but, for example to enable distance-based PBL or to introduce PBL as a new learning method replacing more traditional methods. Brodie (2009), for example, describes how e-learning support was used to enable PBL in "virtual teams" for distance-based students, mostly working professionals.

Some of the studies described implementations for specific research purposes, e.g., to compare PBL with other learning methods or to learn more about specific aspects of PBL or learning in general, for example to examine which (synchronous or asynchronous) tools work best in a distributed course (Overbaugh & Casiello, 2008), to compare the quality of videoconferencing discussions with face-to-face discussions (Andres & Akan, 2010; Andres & Shipps, 2010; De Jong & Verstegen, 2009), to compare examining real patients or digital photographs in the field of dermatology (Amri, ELHani, & Alkhateeb, 2012), or to examine how 3D attributes affect social, cognitive, and teaching presence (Omale, Hung, Luetkehans, & Cooke-Plagwitz, 2009).

In the majority of studies (92%) evaluation results were reported. The focus of the evaluation and the kind of data that were presented depended on the reasons for using e-learning with PBL groups. About two-thirds of those studies were descriptive studies or case studies; about one-third (38 studies) had an experimental or quasi-experimental design. Table 2.3 gives an overview of the kind of data that were collected. Descriptive and case studies provided innovative ideas and indications of the potential value of e-learning tools and facilities, but no hard evidence that e-learning did improve PBL principles and processes. Most of the (quasi-)experimental studies are focused on very specific research questions, sometimes not even directly related to PBL (see above). Occasionally, the results of this research can inform the design of online PBL learning. Some researchers have, for instance, found that, when students are asked to work on PBL problems using only text chat, ill-defined problems evoke more interaction than well-defined problems, but that the participation was then more inequitable. It seems that scaffolding in the early stages of exchange is particularly important to stimulate more equal participation (Kapur & Kinzer, 2007; Suebnukarn & Haddawy, 2006; Suebnukarn, Haddawy, & Rhienmora, 2008). Similarly, Thomas and McGregor (2005) reported that computer-mediated communication led to earlier and better communication in high achieving groups, but that low achieving groups did not do so well. Even then, though, the

Table 2.3 Kind of evaluation data reported in the studies

Kind of data	Number of studies	Percentage of studies
Data/experiences about implementation process	8	5
Data about use of an application (e.g., log data)	45	30
Attractivity to students (questionnaires and/or interviews)	100	66
Attractivity to teaching staff (questionnaires and/or interviews)	23	15
Efficiency: use of resources	5	3
Efficiency: involving students (or others) at distance	18	12
Effectivity: learning results	44	29
Effectivity: reducing drop-out	3	2
Other	19	13
Blank/I don't know	17	11

Note that some studies concerned more than one type of education

results are difficult to generalize because of the diversity in settings, domains, target groups of students and tools that are used.

2.3.2 *Ways to Use e-Learning to Support PBL*

Two ways of supporting PBL principles and processes were more prominently present in the included studies: e-learning to support contextual learning and e-learning to support collaborative learning. This is visible in the results of the categorization in Fig. 2.2 and in the more elaborate descriptions of about the implemented learning activities on the data-collection forms. Below, these themes are discussed and elaborated, using representative examples drawn mostly from the team discussions and from the set of articles that had been marked as special or innovative by team members. Subsequently, in Sect. 2.3.2.3, examples of the other categories are given. Please note that examples are meant to illustrate the different ways of using e-learning to support PBL groups. They are not meant to be exhaustive, nor to be necessarily the best examples.

2.3.2.1 e-Learning to Support Contextual Learning

One way to support contextual learning is to use existing digital tools and facilities that are or could be used on the work floor, also in authentic learning tasks (Table 2.4). In Ellis et al. (2008), for example, students were expected to use professional pharmacy databases during and in between tutorial sessions. Lovell and Baker (2009) described how students produced digital narratives (using video,

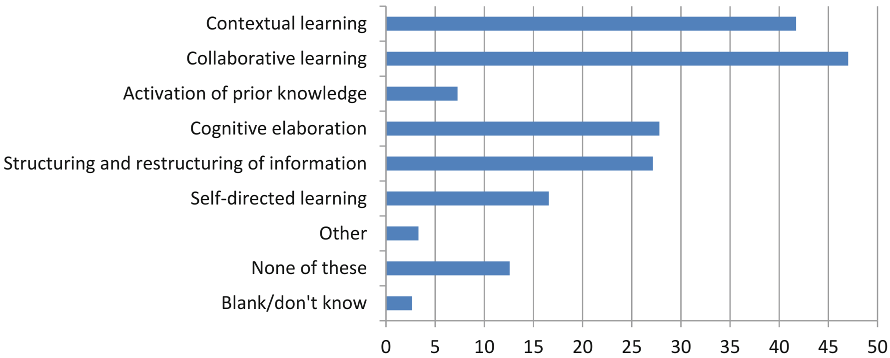

Fig. 2.2 Categorization in terms of support for PBL processes in percentages of the total number of studies (*note*: more than one answer was allowed)

audio, text, animations, etc.) to show what they learned about youth transitions, thus engaging them to relate to their own experiences.

Another frequently used way to support contextual learning is to enhance authenticity by enriching PBL problems with multimedia. Sometimes it was possible to use real digital information, for example X-rays from patients (Bridges et al., 2012). Pulman et al. (2012) described how the impact of illnesses like dementia on all aspects of life was illustrated with a range of resources including podcasts, stories, and poems. In Beadle and Santy (2008) all the PBL problems in a course were presented as taking place in one "virtual" town called Aisling; the town's library contained the learning resources for the students.

Interactive cases allowed students to gather additional information or to explore options, often simulating an authentic role, e.g., with virtual patients, authentic interactive patient cases that allowed students to practice clinical reasoning in a similar way as they would in real life. Virtual patients were sometimes discussed in tutorial group meetings, but also used as self-study material. A range of software tools was used to implement interactive patient cases; some have even been implemented in Second Life (Savin-Baden et al., 2010, 2011).

In a simulation or game, students could take on authentic roles and perform authentic tasks that they would not (yet) be able to perform in real life. Hallinger et al. (2010) replaced the PBL problem with a game for change management that students played in teams of two to four. The aim was to provide an authentic context, but also to give students opportunities for elaboration and restructuring, thus stimulating critical thinking. Sancho et al. (2009) described Nucleo, an environment where students, as avatars, learnt programming in a simulated software design team. In an effort to improve group dynamics, Nucleo assigned roles to students based on their learning style profile. In some studies, high-fidelity simulators were used to integrate skills training in PBL. In Harris et al. (2012), for example, more traditional PBL tutorial group meetings were alternated with sessions with a "Human Patient Simulator" in the simulation centre.

Table 2.4 Different ways to use e-learning to support contextual learning

e-Learning support	Aim	Examples
Using real tools and facilities	Authentic learning tasks	Ellis, Goodyear, Brillant, and Prosser (2008), Lovell and Baker (2009), Stanimirovic and Trifunovic (2011)
Adding multimedia to the PBL problem	Illustrate problem, authentic context	Beadle and Santy (2008), Bridges et al. (2012), Pulman et al. (2012)
Interactive cases	Authentic information gathering and reasoning	Bakrani, Poulton, and Beaumont (2010), Savin-Baden et al. (2010, 2011), Wünschel, Wülker, and Kluba (2009)
Games, simulations, and simulators	Authentic learning tasks, role-playing, realistic interaction	Good, Howland, and Thackray (2008), Hallinger, Lu, and Showanasai (2010), Harris, Ryan, and Rabuck (2012), Liaw et al. (2010), Sancho, Moreno-Ger, Fuentes-Fernández, and Fernández-Manjon (2009), Schiller (2009), Winston and Szarek (2005)
Communication facilities for role players	Authentic role-playing scenarios	Candela et al. (2009), Chen, Li, and Wang (2012), De Nooijer (2013), Edwards (2005), Gwozdek, Klausner, and Kerschbaum (2008), Peterson (2009)

Mediating all communication was used to simulate the way that teams would collaborate in the workplace, thus enabling authentic role-playing scenarios. Chen et al. (2012) described a set-up where students can take on the roles of project manager, (assistant) team leader, or team member. The groups used a wiki to manage team activity, and to share knowledge and information. In each cycle, roles were divided anew, based on performance, peer review, and teacher observations. In Edwards (2005) the role-play also involved communication between PBL groups. In an expert-team approach students in a PBL group all took on a different role in the life of "Laura," a child just placed in custody. The problem case developed week by week, and in between sessions the students that were placed in the same role (in different PBL groups) could discuss with each other using asynchronous communication tools. Staff members were sometimes involved as role players. In Candela et al. (2009), for example, the focus was on developing leadership skills. A website and asynchronous discussion facilities were used to create a virtual nursing school where the students played the role of staff and the teacher played the role of dean. In Gwozdek et al. (2008) dental hygiene students used a blog to interact with a patient played by a staff member. De Nooijer (2013) described how a more advanced 3D virtual environment was used to enable students to take on the authentic role of a consultant and to visit stakeholders in their "offices" in the virtual world. Interaction with stakeholders was partly pre-programmed in "bots," but students could also make appointments for interviews with human role-players. Peterson (2009) involved external tutors from relevant industries to enhance the authenticity of the learning experience.

2.3.2.2 e-Learning to Support Collaborative Learning

Table 2.5 shows examples of how different tools could be used to support e-learning. The most commonly encountered form of supporting collaborative learning was to provide students with tools to communicate in between face-to-face sessions and share resources for self-study, often using discussion boards or wikis and, more recently, other Web 2.0 tools such as Diigo™, Zotero™, or Facebook™ (e.g., Buus, 2012). Sharing information digitally, for example in a wiki, also made everyone's contributions more visible and allowed teachers to react promptly and adequately. Ng and Lai (2012), for example, described how student teachers used wikis to work on problems and produce teaching material for their own students, receiving feedback from peers and course instructors (which led to frequent revisions, as shown by logs). Students were also encouraged to exchange references and other resources that they had found. In practice, however, students often preferred discussing face-to-face or they used other communication tools, such as plain e-mail (Zorko, 2009). Lan et al. (2012) found, however, that mobile access to asynchronous discussions led to more interaction, information sharing, and reflective thinking and to better participation.

Communication tools were also often used to enable PBL in online settings when students and teachers were not (all) at the same place at the same time. Distance-based PBL courses were opened up to, for example, working professionals who were not able or willing to attend face-to-face meetings. For synchronous discussions in online PBL groups videoconferencing or virtual classrooms were used more often in recent years, replacing text-based facilities like chat rooms. With suitable synchronous communication tools online tutorial group sessions could be very similar to face-to-face meetings. De Jong and Verstegen (2009) found that—with motivated participants, good technical facilities, and careful preparation—the quality of the discussions can be equally good in synchronous online PBL sessions. This was, however, not always the case (Van Tilburg, 2014). In a laboratory experiment, Andres and colleagues showed in 2010 that the quality of interaction (and the resulting team productivity) was higher in face-to-face discussions than in synchronous videoconferencing discussions, suggesting that meeting face-to-face may still be preferable if there are no reasons to use online options (see Table 2.5 for references).

Using asynchronous tools for discussions in online PBL groups, such as discussion boards or wikis changed the procedure and the form of discussion. This often led to less interaction between students. Labelling messages was reported to lead to more and more effective communication (Chanlin et al., 2009). Some studies also reported positive effects of asynchronous communication. Beadle and Santy (2008), for example, found that students can be more outspoken and blunt in discussion forums, which in their case was not seen as a disadvantage, because it enabled the teachers to address issues related to social inclusion which was the focus of the course. Hawkes (2006) found that asynchronous communication showed more signs of reflection, although the communication was less interactive compared to face-to-face communication. There were also some indications that less verbal or

Table 2.5 Different ways to use e-learning to support collaborative learning

e-Learning support	Aim	Examples
Communication tools for face-to-face PBL groups	Sharing resources, communication in between face-to-face sessions	Alamro and Schofield (2012), Buus (2012), Lan, Tsai, Yang, and Hung (2012), Ng and Lai (2012), Tambouris et al. (2012), Varga-Atkins, Dangerfield, and Brigden (2010), Zorko (2009)
Communication tools for online PBL groups	Synchronous or asynchronous discussions within PBL groups	Anderson, Mitchell, and Osgood (2008), Andres and Akan (2010), Andres and Shipps (2010), Beadle and Santy (2008), Bozic and Williams (2011), Chagas, Faria, Mourato, Pereira, and Santos (2012), Chanlin, Chen, and Chan (2009), De Jong and Verstegen (2009), Hawkes (2006), Pack (2010), Rienties et al. (2012), Tseng, Chang, and Lou (2012), Tseng, Chiang, and Hsu (2008). Van Tilburg (2014), Yeh (2010), Zhu, Valcke, and Schellens (2009)
Communication tools for mixed groups	Collaborative learning with students from different institutions, countries, professions, etc.	Annerstedt, Garza, Huang-DeVoss, Lindh, and Rydmark (2010), Brodie (2009), Ioannou, Brown, Hannafin, and Boyer (2009), Miers et al. (2007), Nerantzi (2012)
Combination of tools, specifically developed/ composed for PBL	Guiding the PBL process in explicitly structured interactions or steps	Garcia-Robles, Diaz-del-Rio, Vicente-Diaz, and Linares-Barranco (2009), King et al. (2010), Rienties et al. (2012)
		STELLAR: Jeong and Hmelo-Silver (2010), Hmelo-Silver, Chernobilsky, and Jordan (2008), Hmelo-Silver, Derry, Bitterman, and Hatrak (2009), Derry, Hmelo-Silver, Nagarajan, Chernobilsky, and Beitzel (2006)

less extraverted students may communicate more freely online (De Jong & Verstegen, 2009; Tseng et al., 2012). In a study by Zhu et al. (2009) Asian students were less positive about participating in online PBL discussions than Western-European students, but it did have a positive impact on their motivation and learning strategies.

Using distance-based PBL groups allows students from different institutions to learn together, either between groups or within groups. In the GlobalEd project, for example, groups of students were assigned to represent a real-world country. After a period of preparation where they learned about the country they represented, they negotiated a treaty on a real-world political issue with at least one other group from another country (Ioannou et al., 2009). Nerantzi (2012) described a small-scale study where ten participants from seven different institutions worked in two PBL groups for using Web 2.0 tools. She found that participants valued working in online, multidisciplinary groups, although they missed face-to-face contacts and reported some problems around structuring the communication using new tools.

Finally, in some studies combinations of communication tools were used to organize the PBL process into explicitly structured "scripted" interaction. The Stellar platform (Jeong & Hmelo-Silver, 2010, see Table 2.5 for more references) offered a set of video cases and online learning resources and supports a set-up where the PBL process is organized in eight steps, which were partly online, e.g., studying video cases, research and design activities, and partly face-to-face, e.g., discussions and presentations. Some of the online activities were individual and others were collaborative. The explicitly scripted interaction was meant to function like scaffolding for students. It was also used to make it possible for tutors to facilitate several groups of students at the same time. Another example was described by King et al. (2010) where interdisciplinary groups engaged in PBL at a distance using a virtual classroom with videoconferencing and shared whiteboard facilities, amongst others. Their set-up included the participation of (human) standardized patients and a combination of large group and small group activities in break-out rooms. They found that this use of technology created novel forms of interaction, but there were quite some technical issues as well. Garcia-Robles et al. (2009) described a blended learning format where (small) PBL groups worked on problems without a tutor; only the chairpersons interacted with the facilitator and the other chairpersons using different communication tools in the Virtual Learning Environment (VLE). Rienties et al. (2012) compared two conditions of online asynchronous PBL where one condition was more explicitly structured. Although one would, in general, expect this to improve the discussion, Rienties found that this is not always the case and that it is much influenced by student characteristics, such as autonomy and motivation. The structured design triggered more equal levels of activity of autonomous and control-oriented learners, but also a decrease in input from the autonomous learners.

2.3.2.3 Other Functions of e-Learning in PBL Groups

Studies focusing exclusively on supporting only one of the PBL processes were relatively rare. The other categories (activation of prior knowledge, cognitive elaboration, structuring and restructuring of information, and self-directed learning) were seen more often in combination with the two largest categories described above. Stimulating cognitive elaboration was often claimed to be a side effect of computer-mediated communication. Lu, Lajoie, and Wiseman (2010), for example, claimed that a shared workspace on an interactive whiteboard supported the discussions during face-to-face sessions and Yeh (2010) claimed an online learning and working environment makes the collaboration explicit and facilitates a community of practice. Yet, not all studies reported positive effects of computer-mediated communication on cognitive elaboration. Owens, Dearnley, Plews, and Greasley (2010), for example, reported that experienced status differences and rivalry might have influenced the learning process in a negative way. The effects seemed to be moderated by group composition and dynamics.

In a few studies facilitating elaboration during PBL group sessions was the main focus. Lan, Sung, Tan, Lin, and Chang (2010) gave an example of how mobile devices were used to make notes and share them during face-to-face discussions. Mok, Whitehill, and Dodd (2008) argued that mind mapping and concept mapping techniques are suitable to support PBL. Indeed, mapping tools have been used, sometimes in combination with interactive whiteboards, to visualize concepts and explicitly structure group discussions. Verstegen and Roebertsen (2013) used mapping tools both in the brainstorming phase, to collectively activate and structure prior knowledge, and in the reporting phase to synthesize and integrate newly found knowledge. The advantage of digital mind and concept maps is that they can be easily shared between members of a PBL group. Thus, mind maps that were made collectively during a brainstorm discussion could be used to provide directions for self-study; and concept maps made individually during self-study could be used as an advance organizer for reporting sessions (e.g., Bridges, Botelho, & Tsang, 2010; Bridges, Dyson, & Corbet, 2009). Fonteijn (2015) used concept mapping tools with the additional goal to allow one tutor to guide several PBL groups simultaneously.

Similarly, a side effect of mediating communication between PBL group members may be that the structuring of information and/or cognitive elaboration is stimulated, for example by using specific formats or protocols, or by using visualization tools. However, only in a few studies this was an explicit goal. Chang et al. (2012) described how students used MobiTOP, a mobile tool that helped them to collect geographical data in a systematic way during field trips. In the context of PBL this could be seen as a scaffold to stimulate structuring information and elaboration. Stewart, MacIntyre, Galea, and Steel (2007) described the use of FRAP, a tool that was used in a PBL group (without tutor) to track investigative pathways, results, and reflections in a series of nodes. This track was used later by tutors/mentors to check what had been done and discussed. Kazi, Haddawy, and Suebnukarn (2009) described their efforts to let an Intelligent Tutoring System automatically check the causal graphs of a PBL (medical) case created by students, thus assessing the quality of the students' discussion.

Implicitly, some of the e-learning implementations may also enhance ownership or self-directed learning, for example by sharing resources in a VLE or wiki. Rossiter, Petrulis, and Biggs (2010) introduced online quizzes to support self-study so that students would come to the face-to-face discussions better prepared. Other efforts to support PBL groups by supporting the self-study period may exist, but were not found in this review study (see Sect. 2.4.3).

2.4 Discussion

The aim of the literature study reported in this chapter was to gain further insights into how e-learning can support PBL groups, to inspire teachers, and to provide a framework for future research on e-learning for PBL groups. The research questions for this literature review were:

1. In which setting is e-learning used to support PBL groups?
2. Which reasons are given for the use of e-learning to support PBL groups and how is this evaluated?
3. In which ways is e-learning used to support the PBL principles and processes (i.e., activation of prior knowledge, cognitive elaboration, structuring and restructuring of information, collaborative learning, contextual learning, and self-directed learning)?

After discussing the limitations of this study in Sect. 2.4.1, discussion of the research questions will be provided in Sect. 2.4.2, followed by directions for future research in Sect. 2.4.3.

2.4.1 Limitations of This Literature Review Study

A recurring discussion point in the research team was the term PBL. What should be considered PBL and what not? The descriptions in the articles did not always give much detail and that made it hard to make decisions on inclusion or exclusion. The decisions of different team members were not always completely consistent and this had to be resolved in the group discussions. Given the exploratory nature of this review study, focusing on getting an overview of how PBL groups are supported, this was considered acceptable. Naturally, the search strategy and search terms that were used in this literature study limited the studies that were considered. Some interesting and innovative applications of e-learning were excluded because they were not (yet) used in PBL groups, for example the Idea Storming Cube which can be used as a game in a group to stimulate a brainstorm: participants are first asked to brainstorm individually and then to react to the brainstorm results of others (Huang, Yeh, Li, & Chang, 2010); or only used in primary or secondary education, for example, Connection Log, a computer-based scaffold that is designed to structure the individual and group activities and to help students to construct arguments explicitly (Belland, 2010). We may also have missed e-learning that supports and stimulates students to better prepare for PBL group meetings during their self-study time. Some articles described guidelines or general experiences but not one specific application of e-learning and were, therefore, also excluded.

2.4.2 Using e-Learning to Support PBL Groups

The results show that studies regarding the use of e-learning with PBL groups in higher education mainly took place in the domains of medicine and health science, education and teaching, engineering, and science, presumably because this is where PBL is most often applied. In about half of the studies relatively small groups of students were involved (i.e., 50 or less), but there were also large studies involving up to 2000 students. A wide variety of e-learning tools and facilities were used, mostly existing tools that were not specifically developed to support principles and processes underlying PBL.

The main goal of the studies was not always to improve student learning. Often, for example, the reason to use e-learning was to enable PBL in distance learning or to do research regarding specific aspects of learning. The majority of the studies provided evaluation data, quite often in the form of log data or opinions of students. Even when quantitative data regarding learning results or efficiency were given, these were hard to generalize, given the diversity of implementations and settings. Similar interventions can have positive effects in one case and negative effects in another.

The studies in this literature review provided insight in how e-learning was used to support PBL processes and principles. Two aspects were supported most explicitly: contextual learning and collaborative learning. Contextual learning was stimulated by illustrating PBL problems with multimedia that show the context, but also by enabling students to execute authentic learning tasks, taking on authentic roles so that they learn and apply new knowledge in an environment that is similar to their (potential) future workplace, sometimes also using real or simulated equipment. Applications of e-learning made it possible to offer students (immersive) learning experiences in a safe and controlled environment that would not be possible otherwise. Integration between theory and practice was further stimulated in some studies where students could study problem cases and practice-related skills together in a virtual environment.

Some e-learning tools had been specifically developed to guide and improve collaborative learning by explicitly structuring the interaction between students in a group and between students and teachers. This was a way to support (inexperienced) PBL students and tutors, but also led to novel forms of interaction. More often, however, existing communication tools were used to support collaborative learning, to share resources or communicate in between face-to-face sessions or to enable online PBL. When face-to-face discussions are difficult to arrange online synchronous discussions can—when carefully organized—be acceptable replacements. Online discussions can help to enrich the learning experience, for example when it is possible to organize interprofessional learning or to involve real stakeholders (or role-players) like domain experts, patients, or customers in the PBL discussions.

2.4.3 Risks of Applying e-Learning in PBL Groups

PBL is a coherent educational approach. Various factors and underlying principles seem to influence each other in subtle and expected ways. Changes in one element can seriously damage other elements and have a negative impact on student learning (Barrows, 2002). Some salient risks observed during this literature study are:

- Technical problems: e-learning tools did not work as intended or not at all.
- Tools changing communication in a negative way, e.g., in some asynchronous discussion tools it is difficult to follow the thread of the conversation.
- Tools taking too much time and attention: even if tools work well they may become a distraction, cause cognitive overload, or learning to use them may take valuable time and attention away from PBL discussions.
- Offering digital learning resources for self-directed learning becomes prescribing the same resources to all students, which leads to poorer discussions.
- Proceduralising PBL: prescribing a sequence of interaction forms in detail may lead to a teacher-led, directive processes rather than student-centred learning.

Furthermore, we noted during the selection of studies that in a number of studies the introduction of e-learning had led to PBL being changed into students solving problems individually with a computer rather collaborative small-group learning.[3]

2.4.4 Future Directions

In this literature study, there are only a few examples of e-learning used to stimulate cognitive elaboration and the structuring and restructuring of information. This is surprising since the lack of “deeper” discussion and the skipping of vital steps in cognitive elaboration are reported as potential problems in PBL groups (e.g., Dolmans, Wolfhagen, van der Vleuten, & Wijnen, 2001; Moust, Berkel, & Schmidt, 2005). Although supporting these processes was claimed to be a side effect of using communication tools such as discussion fora or wikis, the experiences seem to be mixed. Our own experience is that such online communication tools are hardly used when face-to-face meetings are relatively close in time. More promising for future research seem to be tools to stimulate brainstorming, tools to (visually or otherwise) structure information, argumentation tools or other tools to stimulate critical thinking. It is, however, not clear yet how these tools can be optimally used in face-to-face and online settings. It would also be interesting to investigate whether the combination of verbal and nonverbal interactions could stimulate shy or less verbal students to contribute more to the group discussions or could support intercultural PBL groups. Lajoie et al. (2014), for example, explore how online PBL can support

[3] These studies were subsequently excluded because this was one of the exclusion criteria.

intercultural learning facilitating a mixed group of students from Canada and Hong Kong learning about giving bad news to patients from different cultures. It would also be worthwhile to study the limits of structuring interactions, as Dillenbourg (2002) claims that scripting does not always lead to the expected results and over-scripting may have disadvantages too, e.g., disturbing natural interactions or increasing cognitive load.

Almost all studies in our sample describe applications of e-learning at the micro-level of supporting PBL groups in one activity or one course at the most. This may explain why we have found very little about supporting self-directed learning, a competence that develops over a longer period of time. Our search strategy may have led to exclusion of some studies in this area (see above). It also seems likely, though, that self-directed learning is still a "black box," i.e., both teachers and researchers have little insight in what students do and how this works (Bridges et al., 2012). It is a challenge for instructional designers, teachers, and researchers to start thinking about e-learning to support PBL at the curriculum level, to employ different forms of e-learning at different moments in time in order to provide extra scaffolds for PBL group meetings and self-study early on and to help students gradually develop self-directed learning skills up to a level where they can function in PBL groups with less tutor support.

A number of papers used e-learning to be able to collect data for educational research. The use of computers makes it easier to collect group discussions, to register student activity, and so on. Although recommendations were given for improvement based on the analysis of these data, continuous monitoring and analysis of such data would allow PBL to be constantly improved and adapted to the needs of the groups. Within the learning analytics community, the areas of social learning analytics (Shum & Ferguson, 2012) as well as dispositional learning analytics (Shum & Crick, 2012) might be relevant starting points for PBL applications.

2.5 Conclusions

E-learning is used to support PBL with different goals, not only to improve student learning, but also to enable PBL in distance learning or for research purposes. From the literature review above, it was evident that a wide variety of e-learning tools and facilities are being used in PBL. These are often adaptations of existing tools used to support contextual and/or collaborative learning. Some e-learning tools have been specifically developed to guide and improve collaborative learning in PBL by explicitly structuring the interaction between students in a group and between students and teachers. The review also yielded examples of how e-learning tools and facilities can be used to stimulate cognitive elaboration and the (re)structuring of information, thus helping to counteract known bottlenecks in PBL such as superficial discussions in tutorial groups or "PBL fatigue" resulting in the skipping of vital steps. Other areas indicating growth potential are learning analytics and the support of self-directed learning, but this would require a longitudinal approach supporting the development of students over a longer period of time.

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Chapter 3
Technology and Group Processes in PBL Tutorials: An Ethnographic Study

Susan Bridges, Jun Jin, and Michael Botelho

3.1 Introduction

Educational technologies in their many forms can provide a diverse array of multimodal information. They may also provide novel spaces for new forms of learning collaborations—both virtually and face-to-face. When problem-based learning (PBL) in the health sciences was conceived, the original available spaces for learning were the tutorial classroom and self-study spaces such as university medical libraries. As technological affordances have grown, new opportunities have arisen to support a technology-enhanced notion of the inquiry process—PBL2.0 (Bridges, Botelho, Green, & Chau, 2012; Bridges, Botelho, & Tsang, 2010) which takes a blended approach to infusing face-to-face interactions with educational technologies. This emerging field has grown in research interest with a recent systematic review (Jin & Bridges, 2014) indicating three broad areas of implementation: (a) learning software and digital learning objects: (b) learning management systems and (c) large-screen visualizations such as plasma screens as well as hardware with additional functionalities such as Interactive Whiteboards (IWBs).

Some technological innovations have explored how PBL in the health sciences can be enacted as a totally online, distance education experience using either synchronous (Hmelo-Silver et al., 2015; Ng, Bridges, Law, & Whitehill, 2013) or asynchronous

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(Bridges, Corbet, & Chan, 2015) facilitated interactions. Others, however, have sought to enhance the traditional on-campus problem cycle (Barrows, 1988; Lu, Bridges, & Hmelo-Silver, 2014) with new technologies to further support, scaffold, and manage the inquiry process. Digital affordances such as video and virtual cases (Antoniou, Athanasopoulou, Dafli, & Bamidis, 2014; Chan, Lu, Ip, & Yip, 2012; Chi, Pickrell, & Riedy, 2014), including interactive virtual patients and 3-D models (Poulton, Conradi, Kavia, Round, & Hilton, 2009; Savin-Baden, Poulton, Beaumont, & Conradi, 2015; Silen, Wirell, Kvist, Nylander, & Smedby, 2008; Yang, Zhang, & Bridges, 2012) have been introduced to support learner engagement and cognition in PBL curricula. Purpose-designed tools such as concept mapping software (Novak & Cañas, 2008) enable scaffolding of knowledge building processes (Bridges et al., 2015, Bridges, Dyson, & Corbet, 2009) in PBL and further establish conceptual or epistemological links by interconnecting meaningful knowledge construction and its application to clinical contexts (Kinchin, Cabot, & Hay, 2008). Creative adaptations of traditional learning management systems (Tedman, Alexander, & Loudon, 2007), embedding online facilitator and curriculum evaluations (Tedman, Loudon, Wallace, & Pountney, 2009) as well as electronic curriculum mapping systems (Willett, 2008; Wong & Roberts, 2007) have also supported the management of complex, integrated PBL curriculum designs. An earlier study (Kerfoot, Masser, & Hafler, 2005) on the installation of hardware within PBL tutorials in the form of computers and wall-mounted plasma screens was found to have impacted positively on the tutorial process but indicated issues as to how these technologies may affect tutorial dynamics.

Whilst prior work has examined the consequential nature of online resources from face-to-face tutorials to self-directed learning (Bridges, 2015), of interest to the study reported here is how new educational technologies influence face-to-face interactions in PBL tutorials, particularly where infrastructure such as IWBs are installed. The use of IWBs is a new phenomenon in education with early adoption being in school settings (Beauchamp & Parkinson, 2005; Higgins, Beauchamp, & Miller, 2007; Schmid, 2008) and a 2005 review indicated their potential for enhanced interactivity (Smith, Higgins, Wall, & Miller, 2005). Criticisms of their implementation in schools indicate the key issue of teacher uptake with some concerns that IWBs are utilized as 'a visual textbook' without a radical change of pedagogic approaches (Miller & Glover, 2010a, 2010b). However, little work has examined the role of IWBs in higher education. In particular, even less research is examining their use in small, group, problem-based health sciences curricula. The emerging work on IWB implementation in PBL curricula indicate the positive effects of using IWBs on student learning and collaborative discussions (Bridges et al., 2010; Bridges, Botelho, et al., 2012; Lu & Lajoie, 2008) but more research is needed in this new field.

Of specific interest to this study is the space of learning and how PBL group dynamics can be inhibited or enhanced when new technologies are introduced to face-to-face tutorials. As part of a larger ethnographic research programme examining PBL in situ, classroom video data was collected for the same technology-rich PBL-problem scenario over two separate time points. The first PBL group worked with uneven distribution of mobile devices and a standard, nonelectronic whiteboard (printboard) while the second PBL group worked fully with laptops and an IWB. This data trail enabled comparison of group dynamics pre-and post-redesign of the PBL classroom spaces whereby IWBs linked to a laptop controlled by the group scribe/clerk were installed in each room. The research question for this study was, *How are group dynamics affected by the introduction of an IWB in a face-to-face health sciences PBL tutorial?* Analysis aims to provide a unique account of shifting group processes as undergraduates and tutors adapt over time to a technology-infused PBL curriculum at a time of educational innovation and change.

3.2 Background

Educational technologies can provide rich PBL problems/cases in virtual spaces (Hanson, 2011) to facilitate a range of inquiry-oriented designs where students construct their own understandings. They can also provide access to and structure information by embedding expert knowledge and skills with multimedia in virtual spaces made available for self-directed learning (Lechner, Thomas, & Bradshaw, 1998; Schultze-Mosgau et al., 2004). Finally, educational technologies can provide a platform to elicit articulation, collaboration, and reflection (Quintana et al., 2004). Such affordances can scaffold teaching and learning by allowing students to learn in complex domains (Hmelo-Silver, 2013; Hmelo-Silver, Duncan, & Chinn, 2007) and by assisting learners to construct explanations by making tasks manageable (Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006). Whilst yielding promising results indicating potential fitness for educational purpose in healthcare education settings, more research into PBL and educational technologies is required. The classroom applications of IWBs have seen a growing focus in educational technology research. An IWB is a large, touch-sensitive electronic board that connects to a laptop and a data projector. The laptop's desktop is projected via the board enabling any software, digital materials, and learning platforms accessed on the laptop to be displayed. The board's touch-screen function allows direct input via finger or stylus and can replicate the keyboard functions. IWB interactive tools evident in use in the research team's experience in health sciences education include: drag and drop; hide and reveal; highlighting; spotlighting; and annotation of digital objects displayed using the overlay function. The latter annotated images are then converted to PDFs and distributed amongst PBL group members.

Smith et al.'s (2005) critical review of IWBs in learning indicated two core arguments in favor of their introduction in classrooms—motivation and visualization; however, a limitation to the research studies reported was their reliance on perception rather than learning outcome data. Critics of claims as to the effectiveness of IWBs (Schroeder, 2007) have called for a more principled analysis of their effects on student learning, particularly indicating a need for longitudinal studies. A more recent review by Miller and Glover (2010a, 2010b) indicates the key role of IWBs in encouraging a pedagogic shift from presentational to interactive approaches and methods.

One large-scale study (Lewin, Scrimshaw, Somekh, & Haldane, 2009; Lewin, Somekh, & Steadman, 2008) examining achievement effects of the introduction of IWBs into primary school literacy and numeracy classrooms in the UK found a direct impact of IWBs on student performance in national test scores in mathematics and science and indicated length of time in IWB-embedded teaching was key to improvement. Their investigation of classroom practices indicated a shift from teacher-centeredness to a collaborative pedagogy whereby the IWB acted as a mediating tool. Evident pedagogically was the added value of IWBs in that teachers were able to make tacit knowledge visible through explicit probing questioning. Curwood (2009) also indicated the possibilities of IWBs for differentiated learning for both higher level and special needs of students. The study of IWBs in higher education undertaken here sought to explore inside the 'black box' of IWBs in classrooms by undertaking ethnographic exploration of interactivity and pedagogy with higher level students in situ, in this case, in undergraduate dental education. First, however, a review of the use of IWBs in the health sciences, and particularly in PBL will situate the study more closely to the research context.

3.3 Interactive Whiteboards in the Health Sciences and PBL

As noted above, the majority of current studies have been based on the views of teachers and pupils in school settings and research into the implementation of IWBs in higher education (see, for example, Knight, 2003) is scant, with even less work in the health sciences. One area of particular paucity in the literature is how IWBs are used in small group, inquiry-based contexts such as PBL in higher education and this remains a site for ongoing investigation. Among the limited studies of IWBs in universities, the literature is generally positive about the effectiveness and potentials of using IWBs. Al-Qirim's (2011) study of IWBs in a technology programme reported barriers such as the compatibility and complexity of IWBs as well as users' inexperience with their different features and made a series of recommendations for pedagogical reform. In the health sciences, Murphy et al. (1995) reported an innovative experiment using an IWB to teach clinical cardiology decision analysis to medical students. The LiveBoard in their study allowed the integration of decision-analytic software, statistical software, digital slides, and additional media. Such multimedia aspects and digital interactivity were conducive to extensive student participation with medical students indicating positive feedback about this teaching innovation.

While early studies on the introduction of large-screen displays for computer-augmented PBL groupwork have been conducted (see, for example, Koschmann, Myers, Feltovich, & Barrows, 1994), the use of IWBs is a relatively new phenomenon in PBL curricula (Lu, Lajoie, & Wiseman, 2010). In small group, collaborative contexts in higher education, Schroeder's (2007) case study of IWB utilization by freshmen students engaged in inquiry-oriented learning in a US college library environment found that "IWBs and the activity they encourage can positively influence affective learning in the classroom" (p. 1). Two of the authors (Bridges et al., 2010) adopted an interactional ethnographic (IE) framework to analyze video recordings and student learning artefacts of student engagement with digital materials within and across a problem cycle. This study of a PBL group's use of an IWB across tutorials and self-study found that multimodal application and integration with IWBs was "seamless and supported whole-group engagement in the process" (p. 1131). In another study in undergraduate dentistry, they (Bridges, Bridges, Botelho, Green, & Chau, 2012) adopted IE to trace knowledge construction across a problem cycle and explored how students engaged with online learning during independent study. They noted that the use of multimodal texts and mediating tools supported learning within and between tutorials. Lu et al.'s (2010) study described the nature of scaffolding of collaborative problem solving under the two conditions—a traditional whiteboard (TW) group and an IWB group. They concluded that IWBs can help by expanding the scaffolding choices for students' learning. Their earlier 2008 study identified relationships between medical students' collaborative decision-making and communicative discourse and found that IWB group participants engaged in more adaptive decision-making behavior earlier than the TW group, which led to shared understandings and subsequently to more effective patient management in a simulated medical emergency (Lu & Lajoie, 2008).

3.4 The PBL Model

Before embarking on analysis of tutorial discourse in blended learning environments, it is important to clarify the model of PBL utilized at the time of this study. This has been described in detail elsewhere (see for example, Bridges, Green, Botelho, & Tsang, 2014); however, in brief terms, the model enacted in this study more closely follows the 'closed-loop' model (Barrows, 1986; Walker & Leary, 2009) with two face-to-face tutorials acting as bookends opening and closing the learning cycle. The initial tutorial exposes students to the problem statement and related inquiry materials for activation of prior knowledge, establishment of facts and ideas, hypothesizing, and determining topics (learning issues) for independent research. The second tutorial collects and reviews the information researched. This is then synthesized and applied to the problem at hand. Between the two tutorials are dedicated sessions for student research (self-directed learning), workshops, and experiential learning such as clinical sessions and field trips, etc.

3.5 Materials and Methods

3.5.1 Approach

Within the framework on an ongoing Interactional Ethnography (IE) (Bridges, Bridges, Botelho, Green, & Chau, 2012; Bridges et al., 2014), classroom video data was collected to examine PBL knowledge co-construction in situ. As an approach, Interactional Ethnography allows principled collection of classroom data (Castanheira, Crawford, Dixon, & Green, 2001; Green & McClelland, 1999) by documenting and analyzing events and incidences over time. This can then be explored in terms of consequential progression, i.e., how one "anchor" event or one participant or group's actions can be consequentially significant to events prior and post. Analysis can therefore build a chain of logic in understanding pedagogic processes. Given the collection of a cumulative database of PBL tutorials over time, we were able to undertake comparative analysis to examine the same technology-rich PBL problem scenario across multiple years. Of interest to the guiding research question for this study was that the 2008–2009 group context was non-IWB whilst the 2012–2013 group context was after the learning space had been redesigned including, among other features, the installation of IWBs. Ethical approval was gained by the Hong Kong West Cluster Institutional Review Board.

3.5.2 Data Collection

A comparative study between a nonelectronic whiteboard (WB) group and an IWB group was conducted. First-year PBL groups in a 5-year Bachelor of Dental Surgery (BDS) curriculum were recruited over a period of 4 academic years. The WB group ($n=8$) were in the 2008–2009 cohort prior to the redesign and remodeling of the PBL learning spaces, including installation of new IWB hardware. The second, IWB group ($n=9$) were in the 2012–2013 cohort following a major upgrade of all PBL tutorial rooms. Two cycles of PBL tutorials based on the same PBL problem/scenario were video and audio recorded in the second semester of 2008–2009 and 2012–2013 respectively. For the first-year undergraduate dental curriculum in the second semester of both the 2008–2009 and 2012–2013 academic years, 13 problem cycles were conducted across two 'modules'—instructional blocks of 6–8 weeks. The PBL problem/scenario on epidemiology and regional oral health in China was selected as an anchor for comparative analysis. This occurred as the final problem in Module IV in 2008–2009 and the third problem in Module IV in 2012–2013. Only the first tutorial (T1) of these two specific problem cycles was selected for analysis of interactional discourse given the significant focus on problem exploration. The problem itself was multimodal in that the sequential disclosure of the narrative structure of the scenario was embedded with links to three key web-based resources, including a public health database. One of the web links was also provided at each tutorial in the form of a hard copy booklet.

Data is represented in Excerpts 3.1–3.5 with time stamps (hours: minutes: seconds), de-identified speakers (S1 = Student 1; Ss = Students; F = Facilitator) (See Appendix B for transcription conventions used (Jefferson, 2004)). The de-identified video frame grab indicates key interactants (Facilitator—solid Red; Scribe/clerk—outlined Yellow (including IWB and linked laptop); Student speakers—outlined Green).

3.5.3 Analysis

3.5.3.1 Technology and Group Fragmentation (2008–2009)

In 2008–2009, eight students and one experienced facilitator engaged in the traditional PBL process of identifying the facts, ideas, and learning issues of the paper-based problem scenario at hand (Barrows, 1988). The problem scenario inquiry materials intended to stimulate the learning process were in the form of a hard copy of a public health booklet and URLs for students to search online datasets. Resources in the room included students' own mobile devices (5 laptops), a traditional whiteboard (WB) (also referred to as a printboard) and wireless internet connectivity. Excerpt 3.1 illustrates how students began the first stage of the problem process—identifying the facts. The facilitator, seated in red, listens to S1 read out the problem scenario while the scribe/clerk (yellow) begins recording on the WB. The ensuing activity is analyzed below.

Excerpt 3.1 Identifying facts (2008–2009 WB group)

Time	Speaker	Discourse
00:39:45[a]	S1	Alice is a final year student (4.0) in English journalism
00:39:55	Ss	((S6 writes fact on whiteboard; Ss read problem inquiry materials separately; S4 looks at his laptop screen and booklet))
00:40:45	Ss	((S6 checks with S1; Ss read their booklet separately; S2 checks his laptop, S1 looks at S2's laptop screen; S6 walks toward S3 and looks at S3's laptop screen and then looks at the booklet))
00:40:49	Ss	((Ss browse on their laptops))
00:42:37	S3	Research ((unclear)) public ((unclear)) indi:ces::

[a]Initial 35 min of tutorial devoted to wrapping up the previous case

In the above excerpt from the nonelectronic whiteboard (WB) tutorial, student discussions are focused around the problem scenario, information in the problem inquiry booklet, accessing and reading the online information given as problem-specified URLs. The transcriber's notes in double parenthesis within the excerpt combined with the contemporaneous video frame grab illustrate the multiple physical activities students are engaged in either individually or in conjunction with peers. Those individuals with laptops ($n=5$) are checking online information separately (see video frame grab above). S1 identifies a fact after reading the scenario and then the scribe lists this fact on the whiteboard. Significant to group interactions is the lengthy silence (~3 min). During this time, 5 of the 8 students have used their own laptops to access various web links provided to support the problem scenario. The video frame grab indicates the physically fragmented nature of this problem exploration phase. The group has fractured into two subgroups and four individuals with this fracturing driven by access to laptop screens. All are engaged in a similar activity, i.e. examining problem-related web pages; however, group cohesion is disrupted not only physically and socially due to distribution of screen access but also cognitively in terms of collaborative knowledge construction. Screens were displaying different materials or different pages of the same URL with each subgroup potentially navigating through different online information. The long silence and information accessing activity can be seen as counter-productive to group discussion as each screen was leading students to a different subset of information. In this case, therefore, rather than being a resource for collaboration (Jin, 2012, 2014) the lengthy period of silence can be viewed as an example of cognitive conflict inhibiting collective thinking and group discussion. For the facilitator, the challenge becomes how to focus student attention and manage the lack of synchronicity due to this accessing of various mobile devices simultaneously. In Excerpt 3.2 below, the facilitator responds to this challenge by physically repositioning himself as seen in the red image in the video frame grab.

Excerpt 3.2 Generating ideas (2008–2009 WB group)

Time	Speaker	Discourse
01:12:56	F	So:: you go to the World Health W-H-O web(.)page::: ((facilitator stands up and walks clockwise to look at S2's laptop screen)) ((silence))
01:13:09	S4	And there is a:no:ther:: [file]
01:13:11	F	[Is there](3.0)W-H-O?
01:13:17	S8	D::de:cayed::, missing, and filled ((facilitator walks back toward S8 and examines her laptop screen)) (3.5)Decayed::, [missing, and filled]
01:13:25	S3	[Doesn't really ma]tter if it's really decayed, or [just a little]
01:13:28	F	[This is for] Hong:: Kong::: ((facilitator briefly points to S8's laptop screen)) (5.4)This is only giving(0.5)giving you all these er::: da:ta. It does not actually tell:: you how::: ((facilitator briefly points to S7's laptop screen then walks back to his seat)) (2.0)What is the standard use? (.)How do you de:fine:: a <u>missing tooth</u>? (2.5)You don't see a tooth in the jaw. ((facilitator looks at Ss))
01:13:53	S3	Yeah.(.) Isn't that:[((unclear))]?
01:13:56	S5	[But it may not] be:: because of caries=
01:14:00	F	=It may not be because of car:ies::=
01:14:03	S3	=It maybe congenital
01:14:04	F	It maybe congenital, (.)it may be?
01:14:06	S1	Congeni:tal:?=

(continued)

Excerpt 3.2 (continued)

Time	Speaker	Discourse
01:14:07	F	=Trau:ma::. (2.0)So if you include that in your stu:dy::, it would distort your pic:ture::. So there is::(.) some:where (0.5)in the W-H-O page:: ((facilitator holds his handout and shows to Ss)),(3.8) something like this ((facilitator looks at the handout))
01:14:34	Ss	((Ss start to search online; S4 passes the laptop to S6; facilitator gives the handout to S1; S1 reads this handout with S2 together and S2 starts to search in his laptop))
01:14:39	F	It::(.) should be accessible(1.5) in one of your W-H-O(.) s::ites. ((facilitator walks clockwise to check S3's laptop screen, and waves his hand to ask S3 to scroll down the screen; S1 looks at S2's laptop screen while S2 searches online)) ((facilitator looks at S3's laptop screen)) (8.0)Homepage, (3.0)alright::, ((facilitator points out the laptop screen)) if you go to the homepage,(1.3) you see the methods and indices (4.3) Methods and indices, alright? ((individuals check online using separate laptops)). So here you see a number ((facilitator points at laptop screen)) of links which give will::(1.0)may have some reference reference to to to the present studies like(.) dentition status, C-P-Is::. (5.4)That is telling you how::(2.0)you can get access
01:15:09	Ss	((S2, S3, S6, S7 check online by using separate laptops, S1 gives the handout to S8; S4 looks at S3's laptop screen; S5 looks at S6's laptop screen))
01:15:36	S3	Different indices, different ((unclear)) site. ((facilitator looks at S2's laptop screen and then walks toward S7)
01:15:40	F	Alright, find the website? (.)The the the site?= ((facilitator checks S7's laptop screen))
01:15:42	S7	=Yeah.=
01:15:44	F	=So this is on ca:ries::: prevalence. (6.0) But there is another site (0.4) which gives you actually the me:thod:ology. ((facilitator points out the screen; S8 briefly looks at S7's laptop screen))

Excerpt 3.2 illustrates further group fragmentation when accessing inquiry materials online while these first-year undergraduates generate ideas. In seeking to manage the growing lack of coherence amongst the group, the facilitator physically moves from his seat and joins one subgroup to examine what they are viewing. He then suggests all students access the provided WHO webpage in order to include some data presented in references. Given that just over half the students have mobile devices, the group becomes slightly more cohesive as indicated by the image displayed in Excerpt 3.2 (see video frame grab above) with a shift to paired activity on a shared screen. In order to support whole-group cohesion, the facilitator walks around the table checking the 5 laptop screens and providing whole-group tips for searches. The discourse from 01:12:56 to 01:15:44 is dominated by facilitator talk in managing and directing the group through online searching processes for 'methods and indices' in the WHO webpage. At this stage of the problem process, the group is still focused on complex information searching and its management rather than generating ideas based on the accessed information. Noticeable in contrast to the 2012–2013 group below, when the website is not synchronously visible to every group member, students engage in facilitator-directed activity rather than independent self-navigation in their information accessing.

3.5.3.2 Technology-Enhanced Collective Cognition (2012–2013)

In the 2012–2013 tutorial, the same public problem was provided. In this instance, it was accessed on the designated PBL group scribe's laptop linked to an IWB. The problem scenario was accessed via timed release on the Learning Management System as a PDF with URLs provided as hyperlinks. As in 2008–2009, the hard copy of the booklet was also provided to the group. An immediate observation was that, by utilizing an IWB, student discussions were collectively focused around the data displayed on the common large screen. This finding concurs with one of the earliest studies of introducing laptops to PBL (Koschmann et al., 1994) which indicated student preference for a single, large-screen display. Although the number of mobile devices utilized had increased to one device per student, large-screen IWB visualization mediated their collaborative learning experience and supported group talk. The scribe's control of the screen display scaffolded the group's accessing of the various inquiry stimuli (the public health websites and databases) and collaborative construction of group notes.

Excerpt 3.3 below illustrates the discourse surrounding the shared website displayed for large-screen viewing. S4 (center of image, outlined in green) generates a hypothesis regarding epidemiological data on dental caries amongst 12 year olds. She discusses making comparisons and uses nonverbal gesture pointing to the IWB to support her hypothesis (see video frame grab below). The ensuing 1 min of silence leads to the response from S2 who requested an evidence-base for the point. S4 seeks to reconcile this possible difference of opinion and used the IWB as a mediating tool to progress the discussion about 'according to age group…'. From 23:36 to 24:15 the group is engaged with collectively examining a statistical table.

Turns are taken without the disruption of asynchronous and disconnected screen representations on separate laptops as in the 2008–2009 non-IWB tutorial. The group then quickly resolves the hypothesis of ‘service provided for students’ and determines that the percentage of tooth decay is related to region, ‘rural area’.

Excerpt 3.3 Shared visualization (2012–2013 IWB group)

Time	Speaker	Discourse
00:22:11	S4	Ac:tual:ly for mainland Chi::na(.) the percentage of:(.) tooth decay does not drop er when, when the children go to 12 years old. I think it’s due to they have no er dental ser:::vice provided for student, students… ((silence))
00:23:28	S2	°So how can you explain::°, which table °are you referring to°?
00:23:36	S4	Er:::Go to the website(3.0) This one, 12 years old, 48% °to°, 40%
00:23:49	S5	But in the upper(1.0) table…
00:23:51	S4	Go to 5 years old
00:23:53	S5	But in the countryside, this is a rural area, 21. This one says it’s 21. And then, the lower percent is that=
00:24:02	S4	=Lower one, ((gestures at screen and scribe scrolls down)) lower one first, lower one first. Dental caries of::
00:24:08	S5	Rural area=
00:24:09	S4	=According to age group=
00:24:10	S8	=Then we are referring to the rural area.(1.3)The countryside has different::
00:24:15	S4	O::kay(2.8)Oh, maybe maybe the countryside has, er, student den:tal↑ service

In the IWB tutorial, the students self-manage the group discussion using the IWB display as a specific strategy to move the PBL process forward. In Excerpt 3.4 below, S3 offers the suggestion that they ‘look at the second website’ (00:35:23). This is an important action supporting group cohesion and S7 confirms this as such. After agreement from S7, the scribe shifts from the website displayed on the IWB to another URL and S3 continues with data analysis from this site (see video frame grab below). This type of group self-regulating activity illustrates the heightened centrality of the scribe as a key player not only in the clerical role of recording and organizing facts, ideas and learning issues into coherent notes (cf. Yew & Schmidt, 2009). The IWB scribe’s information-seeking process drives what is available for collective view.

Excerpt 3.4 Shared mediation (2012–2013 IWB group)

Time	Speaker	Discourse
00:32:50	S7	What is our ideas? Have some data(.) inside ((laugh)) Do you think those are valid? I am wondering::
		((silence))
00:34:14	S8	Maybe um:: We can take a look at the::(.)another website—the °Hong Kong website
		((silence)) ((scribe navigates to website))
00:35:23	S3	So, do, do we look:ing at the second website?=
00:35:26	S7	=Yes
00:35:27	S3	You, you're sure:: °the° second website is, all talking about Hong Kong? Oh, okay: here:: ((scribe stops scrolling)). ((Silence 1 min 11 s))
		Er, okay, from these:: da::ta, we can conclude that (0.5)percentage with history of tooth decay is same as the::percentage affected because the figure is the same

Significant to both group dynamics and the PBL process is the fluidity of the intervisual shift (Kress, 2000) where students recall prior visualisations to inform their understanding of ensuing images and visual content from one screen to the next (see also Bridges, Botelho, et al., 2012). The group has seamlessly employed the IWB as a shared learning tool in the Vygotskian sense using the large screen to mediate and enhance collective argumentation. Indeed, in the intervening time between Excerpts 3.4 and 3.5, a student requests the scribe to scroll 'lower, lower, please' to navigate the group's attention to the data he wished to discuss. As such, a new, multimodal self-regulating strategy is enacted. The inclusion of a large-screen visualization via, in this case, an IWB, has supported collective argumentation and inquiry. This would be seen as generalizable to other large-screen visualizations from other data projection technologies or from a large plasma screen.

The use of the IWB as an enabler for social mediation to support a PBL group's engagement in collaborative argumentation is also illustrated in Excerpt 3.5. Once they have compared the first two datasets, the students turn to the third website for more evidence to reconcile issues surrounding survey design and sampling in public health. After posing two possible rationales for why the data from China and Hong Kong differ, the group reaches a small impasse indicated by the silence at 00:48:06 (see video frame grab below). The suggestion by S3 to then navigate to the third URL provided in the problem statement leads to further discussion of the types of variables that can be included in an oral health survey. As in Excerpt 3.4, the group's shift in discussion is self-facilitated and mediated through the IWB. S3 suggests navigating and once the website is visible, S8 recognizes it as the government booklet publishing oral health survey results.

Excerpt 3.5 Shared mediation (2) (2012–2013 IWB group)

Time	Speaker	Discourse
00:47:41	S2	Or, we can simply put er ((gestures to IWB)) that the sampl°ing° methods, is different for China and Hong Kong.=
00:47:48	S1	=Yes::
00:47:48	S2	Sampling method is different for (2.5)Hong Kong and China. ((scribe records on IWB word document))
00:48:06	S1	May:be:: to be more accurate, it is the distribution of the(1.5)peo:ple:: performed the survey
		((silence))
00:48:55	S3	Oh? We have(.)we have(.)we have web:site
00:48:59	S8	This is the, actually, the:: booklet=
00:49:01	S3	=Oh::, booklet
00:49:12	F	So, any more ideas from this website?
00:49:17	S8	I think we have missed out um the° number of oral diseases° because I found that tooth mor:tal:ity was::
		((silence; scribe changes screen to word doc then returns to website))
00:49:45	S3	((pointing at scribe's laptop screen))
00:49:54	S2	Seems strange that, ah, for the web:site: place no such disease of periodontal disease, which is, quite::(0.3) a big concern of the dental aspect. So I guess, but the tooth mor::mor:the tooth mor:::mortality, is it related?
00:50:16	S8	The missing teeth are:: ((unclear))
00:50:29	S8	There are also other information (.)like the::, sugar consumption. (2.8) Maybe we can °look at it°. (3.8)Information on(2.5) sugar consumption, (6.5)((unclear))

The facilitator moves into the recognized strategy of pushing for explanations and generating further hypotheses thus prompting the contributions from S8 and S2 highlighting the impact of variables on survey design and results. This is consistent with what have been identified previously as effective facilitation moves by Hmelo-Silver and Barrows (2006, 2008).

3.6 Discussion

3.6.1 Collaborative Inquiry in Groups

A central feature of PBL is the group. Studies in higher education exploring collaborative learning processes in small groups, in contrast to student and staff perception or satisfaction surveys, have examined facets of the group learning dynamic in terms of group size (Lohman & Finkelstein, 2000); the social context of learning (Imafuku, 2012, Smith & MacGregor, 1992); motivation and group function (Skinner, Braunack-Mayer, & Winning, 2012); social cohesion in cross-cultural contexts (Woodward-Kron & Remedios, 2007); the role of silence (Jin, 2012, 2014); and interprofessional interactions (Imafuku, Kataoka, Mayahara, Suzuki, & Saiki, 2014). These studies have indicated how the complex, highly variable, and nuanced nature of small-group interactions influence the processes and outcomes of this form of inquiry-based learning. What was evident in the analysis above was that the two groups operated quite differently. The argument proposed is that, while acknowledging the difficulty of cross-group comparisons due to the variability of many of the factors listed above, the way technology was accessed and utilized within the face-to-face learning space became critical to the different ways the two groups functioned. Shared visualization controlled by the 2012–2013 group's scribe was seen as supporting group cohesion during the inquiry process.

Another central feature of PBL is the problem/case/scenario itself. While designs of different problem types and the structuring of their delivery has been extensively discussed in the literature on paper-based cases, the impact of new, emerging multimodal cases drawing on heightened images and internet capabilities has only recently become the focus of attention. Research in secondary education has examined the implications for learning when teachers are designing new text types for IWBs (Jewitt, Moss, & Cardini, 2007). The literature on PBL video cases is building; however, research on the new types of demands of problems using hyperlinks to websites has received scant attention. Certainly, the issue of information management was an obvious challenge for the groups in the problem scenario above. Their negotiation of three websites within the narrative of the problem structure placed high demands on individual and collective information processing. While the debate regarding cognitive load in complex cases has been recognized in the PBL literature (Kirschner, Sweller, & Clark, 2006), the counter-argument is that there are multiple scaffolds evident within the PBL process (Hmelo-Silver et al., 2007) with one of these being the traditional whiteboard.

Evident in the small-scale study above is the positive effect of using an IWB as a scaffold for a problem/case/scenario which includes embedded links for navigation to multiple websites. Large-screen IWB visualization served as a mediating tool in students' collaborative learning process. The scribe recorded group members' key ideas based on these multiple websites, which helped to scaffold their collective argumentation and inquiry. The group notemaking as displayed via a word document on the IWB was composed, edited, and stored in a more elaborated format than on the traditional whiteboard. In addition to this new form of text creation was the scribe's key role in physically controlling the navigation of the various websites. She not only navigated upon instruction from a group member, but also autonomously engaged in on-screen resource sharing, often anticipating or interpreting contemporaneous group discussion. Future analysis of the scribe's role in controlling the IWB display should provide further emic insights into PBL learning with IWBs.

The relationship between a multimodal problem design and the affordances of the physical space of learning are not to be underestimated. Whilst following a narrative structure, the triggers embedded in the problem design were hyperlinks to the internet. In the 2008–2009 context where just over 50 % of the group had access to a laptop with wireless internet connection, the accessing of different web links and online resources led to fragmentation. Social cohesion was reduced with subgroups forming in dyads or triads around a single laptop screen. Collective cognition was inhibited by the lack of common focus or being 'on the same page'. Facilitator behavior was then focused on supporting cohesion. The facilitator did this physically by moving to share a screen with a subgroup and by directing the group to explore specific web pages. For the 2012–2013 group, the varied, individual accessing of multiple resources continued; however, the IWB linked to the scribe's/clerk's computer provided a collective focus for discussion and this time they were literally 'on the same (albeit virtual) page'. In this instance, the facilitator and students worked collectively from the central IWB display whilst recognizing the space for the differing displays on individual screens and drawing these into the discussion.

Finally, a third key component of PBL is the facilitator. Of the strategies identified as employed by an expert facilitator (Hmelo-Silver & Barrows, 2006), three are particularly relevant to the use of whiteboards: (a) checking consensus that the whiteboard reflects discussion; (b) cleaning up the board; and (c) encouraging construction of visual representations. The use of an IWB is a logical technological extension of these strategies; however, while studies on PBL facilitation skills are still gaining attention (Shankar & Malhotra, 2010), there are, to date, no existing studies in healthcare education on facilitation strategies where educational technologies such as IWBs are employed. The challenge for future research is to provide more detailed analyses to examine what new strategies are required for PBL facilitation with IWBs. McCaughan (2015) elaborated on the theoretical foundations of the "nondirective" tutor role as espoused by early proponent, Howard Barrows who saw the tutor role as critical to the group process. While the two facilitators in the study reported above may, arguably, have had different styles and levels of nondirective behavior in their usual practice, evident from the textured analysis of video recordings was that the fragmentation of the 2008–2009 group led to specific facilitator behaviors such as walking around the group to view screens and steering website navigation across multiple laptops. Evident in the 2012–2013 tutorial was that the facilitator and the student members of the group used the central, scribe-controlled, large-screen display as the locus of attention and discussion.

3.6.2 Theoretical Implications

This study is intimately concerned with thinking and knowledge acquisition processes in small-group inquiry. It has examined tutorial discourse and nonverbal behaviors to uncover how PBL groups are brought forward towards new individual and collective understandings. As Mercer and Howe (2012) elucidate, sociocultural theorists

> would never argue against the study of individual processes of thinking and learning, but we believe that the relationship between social activity and individual thinking is a vital, distinctive characteristic of human cognition, and one which underpins cognitive development (p.12)

The focus of this study has taken up this position to examine the relationship between a technology-mediated social activity in the form of blended PBL group tutorials and the individual thinking that is evident in the transcribed student and facilitator discourse. In further considering the role of IWBs in health sciences education, the epistemological stance of the sociocultural perspective views knowledge as

> not just an individual possession but also the creation and shared property of members of communities, who use 'cultural tools' (including spoken and written language), relationships and institutions (such as schools) for that purpose (ibid p.12).

Evident from the analysis of facilitation strategies and the use of IWBs above, is support for a view of knowledge becoming 'shared property' after being created in a collaborative context. The cultural tools drawn upon to support and develop this knowledge is both the spoken discourse of learners, the written and multimodal curriculum inquiry materials and, in a new 21st century environment, the appropriation of an IWB.

3.7 Limitations

The discussion of the results should be seen in terms of their limitations. First, the study is restricted to video recordings of two PBL tutorials with two separate cohorts. Although the two PBL problem scenarios were the same, the tutors and composition of the year 1 PBL groups differed. Additionally, the only affordance of the IWB that was utilized in this dataset was large-screen visualization of the scribe's laptop screen. Other functionalities of IWBs and their affordances for learning should be examined in more complex PBL interactions.

3.8 Conclusions

This study illustrates how integration of an interactive whiteboard (IWB) as a mediating tool into face-to-face PBL tutorials can positively reshape the learning dynamic, particularly when the PBL problem/case/scenario draws upon multimodal sources to support and stimulate the inquiry process. From the comparative study above, new practices are seen to be emerging in technology-infused, blended approaches to face-to-face tutorials in undergraduate health sciences education. The incorporation of an IWB was seen to play an important and synergistic role with other key components of PBL. While it has been established that facilitators draw upon a repertoire of strategies that can be flexibly adapted to meet the goals of PBL (Hmelo-Silver & Barrows, 2006), where an IWB is introduced, expansion of this repertoire is evident as (a) gaining students' joint attention for collaboration and reflection; (b) eliciting articulation of ideas via IWB visualization; and (c) managing the recording of multimodal group notes in digital formats. Despite the limitations to generalizability from two single cases, the findings from this detailed, ethnographic study have the potential to extend opportunities for exploring changing group dynamics, including facilitation strategies, where IWBs and other forms of shared visualization are employed in PBL and other inquiry-based learning contexts.

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Chapter 4
Video as Context and Conduit for Problem-Based Learning

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4.1 Introduction

An important role for video in education has been to create context-rich cases of practice for learners. It can allow learners to see the complexity of knowledge in use as they learn to bring their conceptual and theoretical ideas together with the world of practice. In particular, this research has explored the use of video triggers to help medical students learn about culturally competent communication. To help support the goal of learning to consider culture in medical communication, we connected teams from Hong Kong and Canada via video conference. In this way, we found that video technology could play a second important role, by serving as a conduit, or a means for learning and communication. This conduit role was particularly important in dealing with the emotionally laden issue of delivering bad news. In this study, medical students and faculty from Hong Kong and Canada came together to consider two cases of telling a patient that they were HIV positive. The goal of the PBL was to help the students learn about the SPIKES protocol for delivering bad news and to consider how that might be affected by patients from different cultures. The synchronous video proved important in helping students to become a community of inquiry at an accelerated pace. Moreover, using both the video and chat tools provided opportunities for just-in-time professional development. Although this was a short PBL implementation, it provided many lessons for future research and practice:

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- Problem-based learning mediated by video triggers and web conferencing provided opportunities to study medical students' social and emotional regulation.
- Video triggers created context for cross-cultural communication.
- Web-based video conferencing systems provided opportunities to learners to discuss and to facilitators to scaffold discussion.

As a proof-of-concept study, we reviewed how researchers of computer-mediated learning had used the existing community of inquiry (CoI) framework (Garrison, Anderson, & Archer, 2000). Then, examining the role of culture in learning in general and in computer-supported collaborative learning (CSCL), we suggested an extended CoI framework with cultural overlays. An example of how the new CoI framework could be used in a culturally diverse CSCL situation (specifically when emotionally laden issues, which empower learners to unpack their cultural assumptions, are targeted for learning) is presented.

4.2 CoI Framework for Computer-Mediated Learning

First published in Garrison et al. (2000), the CoI framework is designed to examine the presence level of learners from cognitive, social, and teaching dimensions in computer-mediated learning environments. According to the authors, the framework follows John Dewey's work, in which participating in social activities should lead to an educational experience of inquiry toward meaning-making (Garrison, Anderson, & Archer, 2010; Garrison & Arbaugh, 2007). In a physical classroom, such social activities are present. The degree in which individual participants perceive its presence, therefore, should predict their engagement in learning. Meanwhile, such assumptions can be challenged in situations where social activities are largely or entirely mediated by computers. In this regard, the concept of presence becomes more important for online learning. Table 4.1 shows the categories and indicators of the CoI framework.

Garrison and colleagues' framework became popular as it provided a useful methodological tool for research in a particular context of computer-mediated teaching and learning in higher education (Garrison et al., 2010; Garrison & Arbaugh, 2007). In essence, the framework views presence from three different dimensions: cognitive, social, and teaching (Garrison et al., 2000). These three components interact with each other to constitute a meaningful learning experience of an individual (Garrison et al., 2010; Swan & Shih, 2005). The key participant actions that constitute the three presence components are: constructing meaning through sustained communication (i.e., cognitive presence); projecting learner's personal characterization (i.e., social presence); and selecting, organizing, and presenting learning content (i.e., teaching presence). Research suggests cognitive presence and social presence have gained more attention from researchers (Garrison et al., 2010), whereas teaching presence was mainly examined to identify the pre-

Table 4.1 Community of inquiry (Akyol & Garrison, 2008; Garrison et al., 2000)

	Categories	Indicator (examples)
Cognitive presence	Triggering event	Sense of puzzlement
	Exploration	Information exchange
	Integration	Connecting ideas
	Resolution	Applying new ideas
Social presence	Affective response (personal/affective)	Emotions
	Interactive response (open communication)	Risk-free expression
	Cohesive responses (group cohesion)	Encouraging collaboration
Teaching presence	Instructional design and organization	Defining and initiating
	Facilitating discourse	Discussion topics
	Direct instruction	Sharing personal meaning
		Focusing discussion

requisites of fostering higher cognitive and social presence (Akyol & Garrison, 2008; Bangert, 2008; Swan & Shih, 2005).

Specifically, cognitive presence has been most targeted for investigation and has generated a consistent set of categories (triggering event, exploration, integration, and resolution) for examination (Garrison et al., 2010). Moreover, one unique aspect of cognitive presence is that these categories indicate the evolving nature of the inquiry discussion that the researchers use to examine cognitive presence. Although a group could have multiple iterations of such discussion, cognitive presence categories suggest a beginning and an end to the collaborative inquiry activity. Moreover, empirical studies using these development categories point out how online learners struggle with arriving at integration and resolution, compared with relatively easily achieved triggering event and exploration phases (see Garrison, Anderson, & Archer, 2001).

Social presence, on the other hand, reflects what creates a sense of community in online learning (Tu & McIsaac, 2010). Although its long history as a stand-alone academic concept resulted in different definitions by schools of researchers (Lowenthal, 2010), the dynamic nature of social presence within the CoI framework suggests different empirical findings (Akyol & Garrison, 2008; Annand, 2011). Lowenthal summarized that the effects of social presence have been demonstrated in relation to student satisfaction, interaction, and learning in general. For example, Swan and Shih's (2005) mixed method study revealed significant relationships between social presence and perceived learning, perceived interaction and satisfaction with instructors. Particularly, the study examined how perceived presence of peers vs. instructors differently predicted the three independent variables. Although many studies have replaced the actual measure of learning with perceived learning, the concept of knowledge community building justifies findings using such indirect measures (Lowenthal, 2010).

Finally, teaching presence is defined as “the design, facilitation, and direction of cognitive and social processes for the purpose of realizing personally meaningful and educationally worthwhile learning outcomes” (Anderson, Rourke, Garrison, & Archer, 2001, p. 5). Similar to other components, teaching presence is a conception of what learners perceive. However, it is more directly related to the instructor, tutor, or those who design and provide the learning experience. Unlike presence component indicators, teaching presence indicators primarily reflect instructor actions (Table 4.1). In other words, it conceptually yields more leverage to instructors to plan and adjust their actions according to learner needs. Prior studies have found evidence supporting that teaching presence is highly correlated with student satisfaction and their perceived learning using self-report measures (Garrison & Arbaugh, 2007; Garrison & Cleveland-Innes, 2005). A more recent study treated teaching presence as a grouping variable to examine instructors transferring their knowledge and skills for teaching across online and classroom settings (Wisneski, Ozogul, & Bichelmeyer, 2015). These studies exemplify the instructor-oriented characteristic unique to teaching.

As such, there are multiple ways to use the CoI framework to examine the learning that takes place in online or computer-mediated learning situations. Each component—cognitive, social, and teaching—seems to have sub-components that are either developmental over time (i.e., cognitive presence) or multidimensional (i.e., teaching presence), or both as in the case of social presence (Table 4.1). For example, an early conception of social presence includes affective, interactive, and cohesive aspects (Rourke, Anderson, Garrison, & Archer, 2001), but Tu and McIsaac (2002) later claimed that social presence is composed of dimensions such as social context, online communication, interactivity, and privacy. More recently, these dimensions were revisited to conceptualize the intimate connection between social presence and interaction (Tu & McIsaac, 2010). While the argument is not explicit, the former categories assume its loosely developmental characteristic, given Akyol and Garrison’s (2008) description: “The accepted doctrine [of social presence] was to focus on affective expression *to* establish a climate for learning with open communication and cohesion *following*” (p. 5, bracket and italics added).

Moreover, the sociocultural nature of knowledge construction in a community of inquiry invites considering cultural perspectives for examining learning. Cultural practices and norms can be observed in different groups, different communities, and, most obviously, different countries (Brown, Collins, & Duguid, 1989). For example, in different communities, participants use jargon, demonstrate similar behaviors; in different countries, people speak different languages and have different ideologies and perceptions. If one believes learning is sets of activities of enculturation, adaptation, and adoption of one community’s norms, values, and standards (Brown et al., 1989; Greeno, Collins, & Resnick, 1996), then, it is likely that culture has a mediating role in learners’ cognitive process, while it might not directly associate with the learning outcomes (Vatrapu, 2008).

4.3 Making Culture Explicit

4.3.1 The Role of Culture in Learning

Culture is a complex concept that shapes human learning in multiple ways. In their report on institutional culture, Kuh and Whitt (1988) defined culture as:

> persistent patterns of norms, values, practices, and assumptions that shape the behavior of individuals and groups in a college or university and provide a frame of reference within which to interpret the meaning of events and actions on and off the campus (p. iv).

Kuh (1990) later summarized three levels of analyzing student culture—that is, national, institutional, and subculture levels, with the subculture being the closest in the meaning and scope of analyzing group compositions in CSCL research. A slightly different definition of culture that focuses more on its collective nature has been discussed in organizational learning research. For example, Hofstede (2011) defined culture as "the collective programming of the mind that distinguishes the members of one group or category of people from others" (p. 3). His view informed a number of computer-mediated communication research studies (Hewling, 2006; Wang, 2007). More recently, Matsumoto and Juang (2012) discussed culture as having many different meanings and usages:

> Culture can be used to describe activities or behaviors, refer to the heritage or tradition of a group, describe rules and norms, describe learning or problems solving, define the organization of a group, or refer to the origins of a group (Berry, Peoortinga, Segall, and Dasen, 1992; Kroeber & Kluckholn, 1952/1963). Culture can refer to general characteristics; food and clothing; housing and technology; economy and transportation; individual and family activities; community and government; welfare, religion, and science; and sex and the life cycle (Murdock, Ford, and Hudson, 1971; Barry, 1980; Berry et al., 1992). Thus, we use the concept of culture to describe and explain a broad range of activities, behaviors, events, and structures in our lives. It is used in many different ways because it touches on so many aspects of life. (p. 7)

Nonetheless, bringing a cultural perspective to a social phenomenon enables researchers to coherently interpret meanings of human actions or social events in their particularity by foregrounding the shared—or collective—beliefs, assumptions, norms, rituals, customs, and practices associated (Geertz, 1973; Kuh & Whitt, 1988). Moreover, Nisbett, Peng, Choi, and Norenzayan (2001) argued cultural difference not only affect people's specific worldviews, but also "(a) their naïve metaphysical systems at a deep level, (b) their tacit epistemologies, and (c) even the nature of their cognitive processes—the ways by which they know the world" (p. 291). The authors explained metaphysics as "beliefs about the nature of the world and about causality" and tacit epistemology as "beliefs about what is important to know and how knowledge can be obtained." This is to say that one's culture functions as a frame of reference when individuals use language to negotiate meanings (Kramsch, 1993). In this regard, analyzing such cultural aspects more explicitly help researchers to better interpret their online discussions.

There is more than one research perspective toward the nature of culture that shape particular research assumptions. For instance, building onto the intercultural communication research (Scollon & Wong-Scollon, 2001), Hewling discussed two alternative views on culture—that is, culture as a product of people from two or more cultural backgrounds engaging in a shared process of negotiating meaning (thus, the emergence of a "third" culture; for more information, see Raybourn, Kings, & Davies, 2003) and culture as a process that evolves over time and is understandable only within the particular context and time of observation (Gee, 2000). The current study follows more closely with the latter view on culture.

4.3.2 Examining Culture in Computer-Support Collaborative Learning

In the context of collaborative learning, culture has been studied with regard to student grouping strategies that mediate learning. In particular, issues of culturally heterogeneous and homogeneous groups have attracted many researchers' attentions (Hobman, Bordia, & Gallois, 2004; Watson, Johnson, & Merritt, 1998). However, different research studies have different results. Some researchers (e.g., Ledwith, Lee, Manfredi, & Wildish, 1998) have claimed that a homogeneous group tends to have more harmonious interactions than a heterogeneous one, thus leading to improved learning. However, other researchers have argued that heterogeneous grouping would improve learning by enhancing diverse communication styles, thus having the potential to foster cognitive elaborations (van Boxtel, van der Linden, & Kanselaar, 2000). As such, although disagreements exist as to whether heterogeneous or homogeneous groups better foster learning, both assume that student culture plays an important role in collaborative learning and it affects the manner in which students collaborate with others.

The perspective of culture as affecting human behaviors or actions remains the same in collaborative learning studies conducted in computer-supported settings (Gunawardena & LaPointe, 2007; Vatrapu, 2008). For example, Gunawardena and LaPointe's review that introduced design principles for online distance learning showed that most empirical studies reviewed compared learner perception or behaviors—under the themes of social presence, conflict resolution, meaning of silence, help-seeking behaviors—across multiple culture groups. Typically, countries or languages of participants were used as proxies for culture in these studies. In other words, the authors assumed that online distance learners who are from the same country or using the same language have a predisposition to certain behaviors or actions that affect learning.

Seeing culture as communication, Gunawardena and LaPointe (2007) pointed out the importance of language in understanding culture. Based on their synthesis, cognition takes the form of verbal and/or nonverbal cues/languages and constitutes a message, a meaningful unit of communication constructed in situ, and is delivered to others via media. In this cyclical process, language is considered to shape one's thinking (c.f., the Sapir-Whorf hypothesis). From this perspective, research on language has generated useful bodies of knowledge that are applicable to research on culture—for instance, various ways to classify language (e.g., verbal vs. nonverbal and spoken vs. written), different branches of studying language and meaning (e.g., semantics and semiotics), and different methods of analyzing language data (e.g., content analysis and discourse analysis) can be adopted in research on culture. However, understanding and explicating particular assumptions about language should precede borrowing the tools and techniques from such research.

Use of mediating technology adds further complexity to understanding culture and communication. Such studies tend to be conceptually associated with affordances, or "opportunities for action" (Kirschner, Strijbos, Kreijns, & Beers, 2004, p. 49) that are provided by the learning technologies used. For instance, Vatrapu (2008) examined the influence of culture on participants' appropriation of socio-technical affordances and creation of technological intersubjectivity (based on perception of themselves and other participants), and on performance from individual learning outcome assessments in a CSCL environment. Vatrapu commented that culture is "an abstract antecedent that denotes the ways of thinking, acting, saying, behaving and believing that participants bring to any interaction" (p. 168). As such, examining culture in CSCL can be more challenging than in natural settings due to the additional constraints that technology introduces. At the same time, use of mediating technology can invite new opportunities for creating supportive learning environments once such additional considerations are fully understood.

4.4 An Extended CoI Framework with Cultural Overlays

In this study, participants in the existing online data came from two institutions, each from Hong Kong and Canada. While both parties were similarly past their second year in medical school, the fact that they originated from and were attending institutions from geographically distant countries, with different first languages suggests that there may be distinct patterns of norms, values, practices, and assumptions that shaped their behaviors and frames of references they used to interpret meanings during interaction (Kuh & Whitt, 1988).

Moreover, we concluded that the CoI framework is appropriate for analysis as the data was collected from an online learning community. However, the existing CoI framework did not explicitly address the cultural aspect of online communities. Therefore, we propose an extended CoI framework with a cultural overlay to make the cultural aspect of the data explicit.

In fact, several studies have empirically focused on the cultural aspect in analyzing online teaching and learning data from people from multiple cultures. For example, Williams et al. (2014) have identified challenges online facilitators face in a cross-cultural online environment and suggested strategies to address such challenges. In action research including five faculty members, who have had experience facilitating a culturally diverse online class, the results identified areas in which challenges and strategies were discussed. They included (1) framing, asking questions, and reframing information, (2) online group participation, (3) absence of face-to-face meetings, (4) learning the interpersonal and group dynamics of online work, (5) expectations of students, (6) facilitator expectations, and (7) facilitator anxieties. Ideally, employing such strategies would increase teaching presence perceived by learners.

Nevertheless, it is difficult to discern implications that are attributable from cultural diversity specifically from the existing CoI framework, as culture cannot simply be another addition to the existing framework or an external factor that is linked to only a single presence component. As a relatively new issue for researchers who study online learning, particularly those who are using the CoI framework, only limited research is available on the role of culture is building a CoI or managing, better supporting, or enhancing learning where cultural diversity plays a role. Research suggests culture may be associated with social presence more directly than other CoI components (Gunawardena & LaPointe, 2007); yet, other possibilities may simply be under-investigated. In fact, studies that connect culture with social presence also indicated its potential connection with learners' interaction with others that are human (peers or tutors; see Swan & Shih, 2005) or nonhuman (the mediating technology; see Vatrapu, 2008). These connections may affect not only social but also cognitive or teaching presence.

To allow for exploring all possibilities, we integrated one's culture as an overlay to the existing CoI framework (Fig. 4.1). Given that three presence components are mostly measured collectively from learner-generated data in context and the assumption that with high level of all three components the learning quality will increase—hence, the learning outcomes—the presence components are visualized as three overlapping spheres that are reflective of learners' collective level of

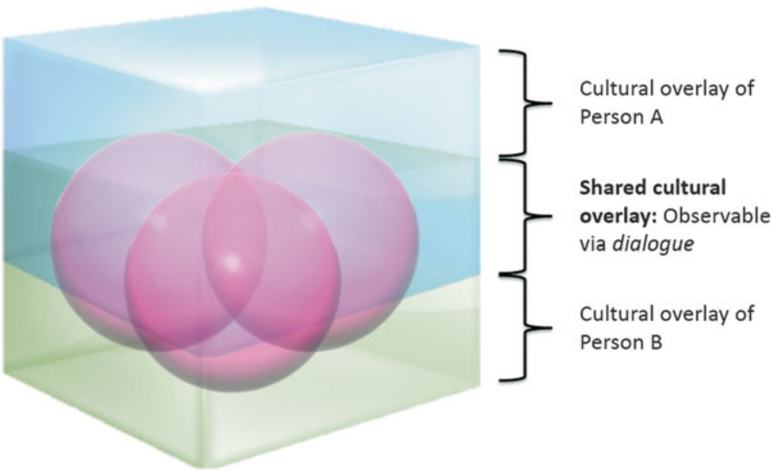

Fig. 4.1 An extended CoI framework with cultural overlays

presence in three areas. With examining collective knowledge building requiring interaction data from at least two participants (who could be playing either a learner or tutor role) and with their cultural difference made explicit in the conceptualization, the new framework has two cultural overlays from each participant.

The new framework does not require entirely new methods or methodological considerations for research, as it is based on the same assumptions as the existing framework. For instance, the goal for high quality learning remains in the cognitive domain, unless stated otherwise. Therefore, researchers will still seek evidence of cognitive change as evidence for learning. Moreover, the learning in the cognitive domain can be promoted via increased cognitive, social, and teaching presence. Nevertheless, the cultural overlays are meant to invite at least the following opportunities for understanding quality learning in a computer-mediated CoI.

First, it visually signals researchers to consider the role of culture in distance learning as mediating the link between factors that are external and internal to learners (e.g., external: interface design, peer learners, facilitator; internal: presence components). Treating culture as a thin and translucent layer that covers the existing presence spheres enables exploring all possible associations the presence framework yields. Second, the overlays of the new framework offer two ways to focus on the cultures of the CoI participants in relation to the concepts of situated meanings and cultural models (Gee, 2011). Compared to the previous use of the framework where the focus is on the measurable changes attributable to culture, the second use emphasizes the better understanding of the role of culture in shaping what is learned among participants of a CoI. This process is encouraged by the overlapping area of the two cultural overlays (hereby referred to as the "shared" cultural overlay), which symbolizes manifestation of the "third" culture (Kramsch, 1993; Raybourn et al., 2003).

Compared to the existing framework where such co-construction is largely explained through the sub-components of cognitive presence (thereby validating the assumption that target knowledge is mostly in the cognitive domain), the new framework extends the traditional boundary to learning through co-constructing new culture. Nevertheless, it should be noted that while the emergence of a third culture might be expected as one outcome of learning, the primary goal for learning in designing such space would still focus on quality learning in the cognitive domain. The following case study is the example of the second use of this cultural overlay framework.

4.5 An Example: A Case Study on Multicultural Online Medical Learning

This example case study is meant to serve two purposes. First, we would like to demonstrate how the new framework can be used to analyze computer-mediated interaction data amongst multicultural CoI participants. Second, we examine the role video played in PBL. We briefly review the use of video in PBL.

4.5.1 Problem-Based Learning and Video

Problem-based and inquiry-based learning have been argued to be effective ways to promote students' learning in complex domains as they are highly scaffolded (Hmelo-Silver, 2004, 2006; Hmelo-Silver, Duncan, & Chinn, 2007). However, studies suggest successful design and implementation of PBL is also challenging. For example, Hung, Bailey, and Jonassen (2003) identified that PBL effectiveness studies have produced conflicting findings in the following areas: depth vs. breadth of curriculum, higher-order thinking vs. factual knowledge acquisition, long-term effect vs. immediate learning outcomes, traditional roles of professors vs. the role of PBL tutors, and students' initial discomfort vs. their positive attitudes. Their finding suggests that a careful design and implementation is critical in arriving at the desired learning outcomes with PBL approaches (Jonassen, 2000, 2011).

Efforts have been made to better support implementing PBL with available technology (Choi & Hannafin, 1995; Hannafin, Land, & Oliver, 1999; Kim & Hannafin, 2011). For example, researchers have worked closely with instructors and teachers to help them more easily create effective PBL curricula and support their students in class (Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006). Moreover, a frequently discussed way to use video is to provide rich contexts for learning. For example, typical forms of studies on video include video vs. text comparison studies (e.g., Balslev, De Grave, Muijtjens, & Scherpbier, 2005), exploratory video use effectiveness studies (e.g., Schrader et al., 2003), and different kinds of video use studies (e.g., Tawfik & Jonassen, 2013). In a recent comparison of paper and video as PBL problem triggers, Lu and Chan (2015) found that video led to greater question asking and elaboration by a group of second year medical students. While these studies focus on identifying the effect of video in learning in complex domains, studies that provide detailed accounts of what the multiple roles of video looks like in such environments are seldom found. Understanding the role of video is particularly important when the learning takes place in even more technologically complex learning environments such as the web-based conferencing that serves as the platform for the current study.

4.5.2 Study Design

To describe the role of video in PBL, we used a naturalistic qualitative case study design, targeting the shared cultural overlay as the major construct to explore with Gee's (2011) discourse analysis method.

Participants. A purposeful sample of four students and two instructors from two institutions participated in the study, from either Hong Kong or Canada. All names are represented in pseudonyms. Instructor W, Student M and E are from a medical school in Canada. Instructor L, Student K and V are from a medical school in Hong Kong. All but Student M are male. All students are past their second year in medical school.

Table 4.2 Instructor-guided activities by class sequence

Sequence	Guided activity
Pre-video discussion	Discussion norm setting
	Role assignment (Leader, Scribe)
	Discussion
	–Sharing thoughts (notes taken by Facts, Ideas, Issues)
	–Reviewing the notes
	Instructor summarizing and giving comments on the discussion
During video (10 min)	Note-taking for post-video discussion
Post-video discussion	Analyzing by Facts, Ideas, Issues
	Summarizing discussion
	Sharing reflection

Research context. Two video-triggered PBL sessions were implemented over 2 days via a commercially available video conferencing tool, scaffolded with a chat feature (see Lajoie et al., 2014). The session focus was physicians delivering bad news to patients. This problem was considered ill structured and emotionally laden to solve, as it dealt with affective constructs, such as empathy, ethics, and professionalism (as a doctor). Each session consisted of instructor-guided activities that followed a similar class sequence (Table 4.2). Participants communicated in English in both sessions. Two video triggers were used, one for each day, and although the content of the video triggers was the same (i.e., a doctor delivering bad news to a patient), one was taken in English-speaking context and the other was taken in Cantonese-speaking context and delivered with English subtitles. Instructor W facilitated the first session. Student M led the discussions, and Student V scribed on the chat room in the video conference system. Instructor L facilitated the second session, where Student K led the discussion and Student E scribed. Transcripts for each session were created and referred to as Transcript 1 (Session 1) and Transcript 2 (Session 2). Figure 4.2 illustrates the overview of the research context.

4.5.3 Analysis Procedures

Initial review of transcripts. Two researchers who are also authors individually reviewed the transcripts multiple times to situate themselves in the scene. During the initial review, each researcher sectioned the transcripts by labeling class sequences (including major class events, such as starting and managing technical or logistic issues—introduction of class topic, pre-discussion, role-assignment for video watching—watching video—post-video class discussion) to better understand how each session developed. The researchers also highlighted directly on the transcript to identify areas where they thought the role of cultures were observable and took annotations about their initial thoughts about the role of cultures (Fig. 4.3).

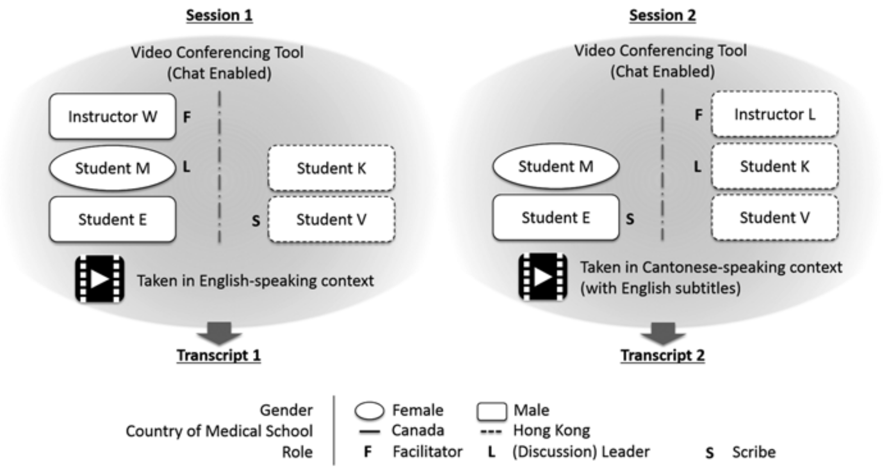

Fig 4.2 Research context overview

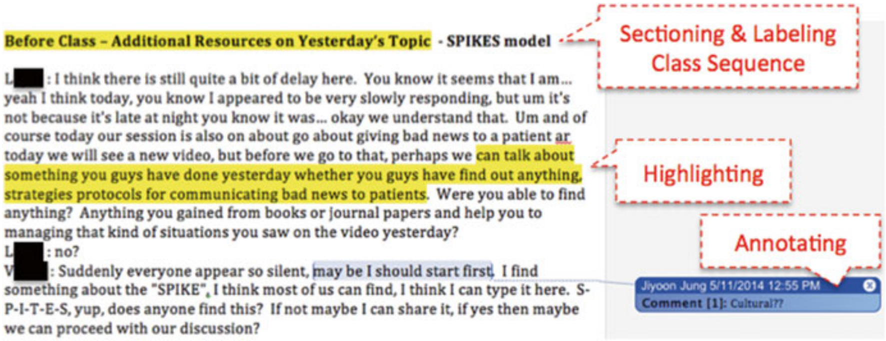

Fig. 4.3 Illustration of analysis: initial review of transcript

The researchers shared their individual findings to identify the internally agreed-upon areas in each transcript that suggest participants' cultures becoming an issue (c.f., explicit evidence of the third culture emerging). Within the identified areas of the transcripts ("the excerpts"), the discourse analysis method (Gee, 2011) was used to interpret cultural aspects of the data. It was chosen over the content analysis or thematic coding method, which are typical choices for the CoI research with qualitative data, to better capture the cultural nuances hidden beyond the sentence-level meaning of content. The researchers' iterative and collaborative effort in discussing and agreeing upon the findings is expected to serve as an external-to-data measure to improve the trustworthiness of the findings.

Discourse analysis. Languages serve as scaffolding social activities and human affiliation. Gee (2011) defined discourse analysis as "the analysis of language as it is used to enact activities, perspectives, and identities" (p. 4). This definition suggests that languages can function to create realities of significance, practice, identities, relationships, politics, connections, or sign systems and knowledge (referred to as "seven building tasks"). Following this, Gee also suggested six tools of inquiry, including social languages, Discourses, Conversations, intertextuality, situated meanings, and figured world. According to Gee, examining all 42 combinations would be ideal, but selectively focusing on a few of inquiry paths is how a typical discourse analysis is performed.

Two types of meanings are worth mentioning here (Gee, 2011): situated meaning and cultural models. Situated meaning refers to "an image or pattern that we assemble 'on the spot' as we communicate in a given context, based on our construal of that context and on our past experience" (p. 80). Because they are communicated in a given context, the meaning is "negotiated" (p. 81). On the other hand, cultural models are "'storylines,' families of connected images (like a mental movie) or (informal) 'theories' shared by people belonging to specific social or cultural groups" (p. 81). According to the author, "cultural models 'explains,' relative to the standards of the group, why words have the various situated meanings they do and fuel their ability to grow more. … [and are] distributed across the different sorts of 'expertise' and viewpoints found in the group" (p. 81). In other words, in CSCL with culturally diverse learners, situated meaning is conceptually similar to the shared cultural overlay negotiated in situ by participants assuming different cultures, whereas a cultural model is analogous to individual cultural overlays as it assumes informal theories shared within a single cultural group.

4.5.4 Illustrative Findings

The analysis of both transcripts suggested that one's individual cultural model could be portrayed by tracking individual participant's discourse over time. At the same time, the smallest unit of the shared cultural overlay (i.e., what is learned via co-construction of the third culture) was identified by attending to a particular cultural issue that was explicitly raised during participants' discussion on the learning topic.

As an example, we present an illustrative finding for a unit of what was learned by employing the concept of the shared cultural overlay. During analysis, we focused on what was inferable and interpretable based on the transcripts and not the direct observation of the PBL sessions. We also noticed the learning situation was contextually complicated due to technical issues (e.g., delayed, overlapping, or interrupted communication due to bad Internet connection) but this was not a focus of this analysis.

Shared cultural overlay. This example was excerpted from Day 1 post-video discussion facilitated by Instructor W and led by Student M, who are both from Canada. Once the instructor asked a guiding question, "What were the things that each of you selected as important points in the video? What was good about them? And what could be improved?" Students began the discussion. Note that each participant's gender and country of medical school origin is marked as F (female) or M (male) and C (Canada) or HK (Hong Kong) alongside their pseudonyms in the excerpts. Other linguistic and notational devices are not used. Italics in brackets are the inferred meanings of the pronouns based on the larger context.

On the instructor's cue, Student M spoke first. She commented about what she liked about what the doctor in the video did in telling the bad news:

Student M (F, C)	She [*the doctor*] ar explained a lot of the test that were done and that is, was, confirmed, you know. She's kinda bringing it up that whatever she is going to say is the result that is gonna be reliable, and ar, that it was verified. So I really liked she approached and brought up the topic of the diagnosis. Um… I don't think she, I don't see any negative point in that part. And I really like the beginning

Then, Student E, who is also from Canada, commented on what he perceived as "missing" from the video:

Student E (M, C)	The only ar—I really like everything that she [*the doctor*] like, she said and she did—but I really think that there's something missing, in which she didn't really have a sense of how he [*the patient*] was feeling then and that there were any—say, new symptoms or anything—like, anything wrong. And during the video, she says that "you're really young and don't have any problems," but how can she know about—unless she asked this really. Even if there were information on the referral notes, you need to ar, I feel like you—it is necessary to ask the patient about that [*the patient not having any physical problem*] and get that. But I, I, I still think she, everything she did was great, but there is just something there [*what the doctor did in the video*] is missing, I thought

This comment led Student K from Hong Kong to question about the typical required medical procedure of getting patient consent prior to any medical examinations in Canada. Student K foregrounded the assumed different cultural practices between Canada and Hong Kong as the focus of discussion, made explicit by his using of the phrase "from a Hong Kong view." Then, the discussion on how doctors should tell bad news to patient (c.f., emotionally laden) evolved into more culturally laden conversation amongst participants. In other words, video in this case had triggered discussion on cultural similarities and differences among participants.

The next example comes after Student E's previous comment:

Student K (M, HK)	Just asking, um… ar from a Hong Kong view, I am not sure ar..
Student M (F, C)	I agree with Student E (M, C). I think it is especially because ar…
Student K (M, HK)	I am sorry. Can you finish it—finish your sentence, please?
Student M (F, C)	Yes, I… No, I cut it you, you start
Student K (M, HK)	I am just wondering, the video I guess is taken in Canada, what are the procedures like ar about testing like for HIV. Is ar…, throughout the video, my thoughts in thinking cuz in Hong Kong what happens is we have to get consents from the patient when we test for HIV viruses. And so in that sense um so, so that the patient would already given consent for HIV to be tested, that means they would have some sort of expectation already, so I am not sure ar, is this the case in Canada? Or you have asked them some consensus or HIV testing? Or you just do it immediately and take them by surprise

Student K's reference to his country (e.g., "from a Hong Kong view," "in Hong Kong what happens is…") during his speech suggests that he had attributed the cause of his perceived cognitive dissonance during the discussion to the potentially different medical practice between Canada and Hong Kong. Notice that Student K also said if the patient had given consent for the HIV test, "the patient would have some sort of expectation already." His comment implies that the action of getting tested for HIV by itself is significant in his culture. In his perspective, only if the patient had a reason to be taken the test would she/he have taken it. Therefore, being told the bad test result by the doctor is not a "missing" thing.

The instructor then tried to facilitate by providing fact-confirming feedback on the suggested cultural difference, followed by Student M.

Instructor W (M, C)	So just to interject, that's a good point, Student K (M, HK). Ar, in Canada, like in Hong Kong, you must obtain patient consent before doing an HIV test
Student K (M, HK)	Ok… I managed to put ar—
Student M (F, C)	Is there—sure, to what point the patient would expect the result to be positive though because a lot of people from um what I think are just doing the ar STD test as a routine test or you know just done as a general picture. I don't actually think that most of the patients do expect positive result although they do order the test for them. Although the patient consents…

Student M's response to Student K's previous comment is layered by her culture. Cued by "from … what I think," she commented that in her culture STD (sexually transmitted diseases) tests are "a routine test." With such clarification Student K moves on to responding to the instructor's second guiding question, on improvement suggestions to the doctor in the video.

Student K (M, HK)	So maybe perhaps an improvement I could suggest to the doctor in the video is to start actually what Student V (M, HK) had mentioned about ICE, so just to get a a a a confirmed idea of what the patient really expects which I think um has been left out in the video, so just jump onto the report without actually clarifying what the patient expects to hear. So maybe an improvement would be just to do the ICE, the process of ICE

Here, ICE (idea, concern, expectation) is a concept that the participants had learned prior to watching the video. Student V introduced the concept during the pre-video discussion. He had described idea as "whether we [*doctors*] would ensure whether we have sufficient idea of what's going on," concern as "what is the major concern of the patient," and expectation as "how can we [*doctors*] help the patient or what is the patient expecting from us." In this regard, video has played the role of a conduit in conveying what was learned throughout the current discussion. Student V's subsequent comment illustrates another role video played during the session:

Student V (M, HK)	Um…, maybe I could talk a bit about—
Student M (F, C)	So, are there other important event that a you guys know?

Student V (M, HK)	Maybe I can try to talk about, um…, how to try to um talk about the um investigation procedure in the beginning. Because I have been noting down at the 40 second. Zero four zero, um there is um a moment that I can see the change in body language of the patient. When he was told that he has HIV, he puts his hand on his mouth, and I think it's a sign of strain that he is worried. But what I can note is that the doctor just go on and talked about whether it is confirmed test or whether it is a test repeatedly, I don't think the doctor has take care of the emotional change of the patient

Student V said that he could "see the change in body language of the patient." In other words, the video trigger provided a rich context that enabled the learners to attend to both the verbal and nonverbal information of the problem. This information was about the physical movements ("the body language") and made the temporal dynamics more salient (40 s). Without the video, such understanding of the context would have been more challenging—for instance, taking more time with a text trigger or unless the text were annotated, might never be noticed. Student K, who had previously questioned why getting a bad HIV test result was unexpected, agreed with Student V as he described the specifics of the video, again noting the gestural and temporal dynamics from the video.

Student K (M, HK)	I agreed with Student V (M, HK), I also noted at um 0.41, that his eyes actually looked away, so his hand shifted like that (puts hand on mouth), and his eye deviated from the doctor and um, that is the sign that is actually um yeah the doctor should address that immediately

4.6 Discussion

4.6.1 Adding a Cultural Overlay

In this research, we expanded the CoI framework to overlay a cultural dimension. We employed the new framework in order to better understand how the participants of the CoI had engaged with sensitive issues of culture in addition to the target knowledge (i.e., SPIKES model) of the PBL sessions. In the analyses presented here, it is clear that the learning environment supported discussions of cultural issues. Elsewhere, we have demonstrated how this also supported creating a shared culture of medicine (Lajoie et al., 2014). As seen above, one salient learning outcome attributable to the participant culture created during the session was the awareness that the socio-cultural significance is attributed to the action of taking an STD test in Hong Kong, whereas in the Canadian context, the result of the test was more significant. Full exploration of the data is expected to identify multiple units of co-constructed knowledge associated with culture. The finding can be further elaborated through connecting it to the larger body of knowledge on difference between the two countries.

4.6.2 Role of Video

Video triggers, or cases, can support learning by creating a rich common problem context to discuss (Derry, 2006; Derry & Hmelo-Silver, 2005; Lu & Chan, 2015). It was evident in the current case study that the video triggers effectively and efficiently created an opportunity for learners to negotiate meanings around an emotionally laden issue, despite its conceptual complexity. Furthermore, we found that the video played a second role as conduit that provided opportunities for productive discussions. Specifically, the example shared in the illustrative finding was that the information about ICE was conveyed to the post-video discussion through the video trigger. Here, the particular purpose of using the conduit metaphor for video in distance learning is to emphasize the potential for video to easily connect a series of sequenced learning activities and provide a social presence and fluent conversation that might not be possible in other online media (see Lajoie et al., 2014 for further discussion of social presence). Nonetheless, the conduit metaphor for the medium in communication theories is not entirely new.

For instance, it has been discussed in linguistics where language is considered the medium for thoughts (Reddy, 1979). When digital technology was considered as the medium, both Clark (1983) and Kozma (1991) discussed this extensively, with conflicting conclusions. Following this tradition, the conduit role of video postulates substantial affordances of video for co-construction of meaning, in addition to the role for creating context. In addition to creating a richer context that effectively becomes a source for learning, video as conduit emphasize on its function of allowing fluent interaction that needs to flow throughout the PBL learning experience.

4.7 Limitations

The current study did not report based on the entire set of data, but focused on one part of the data that illustrated the use of the new framework most effectively. Moreover, it also focused on presenting an example of the shared cultural overlay component of the new framework and did not examine the mediating role of the culture. In addition, the data are drawn from a single small study. The research presented here was used for theory development; further research will be needed to test this theory in other online contexts.

Finally, the current study did not necessarily account for the role of instructor facilitation during interpretation. In fact, there were a number of discussion facilitation strategies used during the sessions. For example, the instructors sometime cued what to focus on at the beginning of each major sequence in the session. They also guided the scribe to “write down in the chat area the following three types of information: Facts, … ideas …, issues …” during pre-video discussion and facilitated during the post-video discussion by playing the role of mediator between the two student groups from different cultures.

4.8 Concluding Remarks

In this paper, we framed cultural practices as collectively built and distributed in the learning environment. The nature of data of this study helps us to align cultural building activities with cognitive building activities as students were building their knowledge while comparing medical practices in two countries. However, even though under this backdrop, we did find some incidences from the data that showed students' exploring different cultures, integrating them, and building their common cultural values. Kramsch (1993) commented that in this process of creating a third culture "people become aware of the various frames of reference one can use to describe events … [and indeed realize] … the paramount importance of context and how manipulating contextual frames and perspectives through language can give people power and control" (p. 235).

Interpreting the data via the shared cultural overlay framework suggests that video plays the role of providing context as it promoted faster building of CoI by triggering the discussion on cultural differences amongst participants that made nonverbal information salient (e.g., time, gestures). Moreover, video functioned as a conduit for learning in that it supported discussing emotionally laden learning content, such as doctor's telling of bad news to a patient. Future studies must expand interpretation on larger data sets. Studies can also employ other components of the new framework, the individual cultural overlay, to describe the cultural model of a particular member of the CoI.

This is a proof-of-concept study, in which we examined the impact of different cultural practices on cognitive presence. Elsewhere we have described other elements of the CoI (Lajoie et al., 2014). Building on that work, we show how we can use video to present culturally meaningful and contrasting modes of communication as well as using it as a conduit for discussion that has cultural overlays.

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Chapter 5
What Is Real? Using Problem-Based Learning in Virtual Worlds

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Right now are we just inside a computer programme?

Your appearance now is what we call residual self image. It is the mental projection of your digital self

This isn't real?

What is real? How do you define real? If you were talking about what you can feel, what you can smell, and taste and see, then real is simply electrical signals interpreted by your brain

(Wachowski & Wachowski, 2000)

5.1 Introduction

Problem-based Learning (PBL) has become a central learning approach in many curricula, but this collaborative style of learning is threatened by the movement towards more self-directed and distance learning. Such was the concern that teams at Coventry University and St George's University of London sought to develop new approaches that would not only counter this movement but would also create new learning spaces for PBL. This project investigated, implemented and evaluated a user-focused approach to developing scenarios and materials, linking the emerging technologies of virtual worlds with interactive PBL online, to create immersive collaborative tutorials. The chapter begins by providing an overview of the research in this area to date, outlines the project and then presents the findings of the evaluations undertaken and discusses the impact on tutors and students.

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5.2 Background

PBL was popularised in the 1980s, partly in response to the predominantly content-driven transmission educative model of the time. It arose out of a desire to give students the opportunity to apply practical and theoretical knowledge to problems or scenarios within the professional or clinical setting, crucially in interactive collaboration with colleagues, thus replicating features of the real-life context of application. It has become an increasingly influential approach in curricula in a variety of settings, across a range of subject areas. The increasing adoption of PBL and the parallel growth in online learning each reflect the shift away from teaching as a means of transmitting information, towards supporting learning as a student-generated activity. To date PBL has been seen as a relatively stable approach to learning, delineated by particular characteristics and ways of operating. Most of the explanations of and arguments for PBL, thus far, have tended to focus on (or privilege) the cognitive perspectives over the ontological position of the learner. However, implementing this collaborative approach to participation and learning is considerably more challenging in self-directed and distance learning contexts, due to difficulties associated with effective discussion between geographically and spatially disparate learners.

5.3 Informing Literature

It could be argued, and increasingly is, that cyberspace has resulted in a sense of multiple identities and disembodiment, or even different forms of embodiment. The *sense* that is possible to remain anonymous and the assumption that this is possible through one's words rather than one's bodily presence, is becoming increasingly unmasked through worlds such as Second Life™. Second Life is a virtual world where it is possible to design learning scenarios that students can engage with using their own customised avatar. A pictorial example of problem-based scenario of a road traffic accident is presented below in Fig. 5.1

However, before issues of embodiment, and disembodiment as well as having a sense of multiple identities in virtual worlds, is explored it is perhaps helpful to explain virtual worlds and delineate current forms of PBL.

5.3.1 Virtual Worlds in Higher Education

Virtual worlds are 3D graphical online environments, which users can change and manipulate, as well as work simultaneously on specifically tailored or self-developed projects. The facilitation of teaching and learning through the use of technologies such as virtual worlds has expanded rapidly in higher education in recent years

Fig. 5.1 Second life street accident scenario (patient mannequin on the floor near his motorbike)

(Hew & Cheung, 2010; Wang & Burton, 2012). These developments have stimulated discussions about opportunities for educational change and the development of more flexible curricula that take account of the experiences and perspectives of students and tutors (Savin-Baden, 2008a). Reeves and Minocha (2011) argue that creating a learning space appropriate for students in SL is important to a large degree, but that it is important that tutors and students co-design spaces, so that the resultant SL spaces are ones in which students want to learn. In particular, they have suggested that there needs to be a relationship between the pedagogy and the design of learning spaces:

- Pedagogical underpinning (e.g. constructivist, exploratory) and the learning activity should guide the design of the learning spaces.
- Consider replicating real-life teaching methods and spaces in the first instance until the users are comfortable with the Second Life interface.
- Design learning activities that require students going to other islands for exploration and data collection. For example, the virtual world comprises different spaces that are denoted as islands, thus a company or university space would be an island.
- Design activities that promote active learning through role playing, reflection, 3D simulations and 3D modelling.
- Design activities that demonstrate the value Second Life provides in comparison with real life or 2D learning environments.

Exploit the flexibility and ease of bringing out objects from the inventory to set up learning spaces in real time in Second Life to match with the learning activity (Reeves & Minocha, 2011, p. 53).

The advantage of using Second Life in higher education is that it is a space in which experimentation can occur in ways that are not possible in real-life. For those in online and distance settings, it offers an opportunity to develop communities, create trust and increase the sense of presence in learning. Yet it also provides a place to play with roles and identity in that it offers an opportunity to undertake activities not normally physically possible, such as flying and changing identity. Further, activities undertaken in virtual worlds in general tend not to have real-life consequences—such as gender swapping or flying into buildings.

There have been many discussions about the uses and advantages of using virtual worlds (for example, Warburton, 2009) but it is perhaps more important to consider the particular values it might bring to a given course or module. Consider for example, if it will facilitate learning at a distance, or will offer more flexibility for the students or programme. In some ways, virtual worlds would seem to be an unusual platform (or world) to be adopted in higher education, but it is one that seems to have been embraced by many tutors who see that value of it as it offers a similar sense of interacting as face to face PBL because of the use of avatars. However, it is important to understand that different forms of PBL affects learning, student engagement and the way in which problem scenarios are designed. The next section delineates the differences between face-to-face PBL, PBL online and PBL in virtual worlds.

5.3.2 Face-to-Face Problem-Based Learning

PBL was an approach popularised by Barrows and Tamblyn (1980) following their research into the reasoning abilities of medical students at McMaster Medical School in Canada. In this early version of PBL certain key characteristics were essential. Students in small teams would explore a problem situation and through this exploration were expected to examine the gaps in their own knowledge and skills in order to decide what information they needed to acquire in order to resolve or manage the situation with which they were presented. The "problems", also termed "scenarios", are central to student learning in each component of the curriculum (modules/units). The lectures, seminars, workshops or laboratories support the inquiry process rather than transmitting subject-based knowledge. Whether it is a module or a whole programme that is being designed, the starting point should be a set of problem scenarios that enable students to become independent inquirers and help them to see learning and knowledge as flexible entities. To date there has been little in-depth discussion about the design of problem-based curricula. Instead the discussions have tended to centre on what counts as PBL, ways of implementing it and types of PBL (Savin-Baden, 2014).

5.3.3 Problem-Based Learning Online

PBL online is defined here as students working in teams of four to six on a series of problem scenarios that combine to make up a module or unit that may then form a programme (Savin-Baden, 2007). Students are expected to work collaboratively to solve or manage the problem. Students will work in real-time or asynchronously, but what is important is that they work together. Synchronous collaboration tools are vital for the effective use of PBLonline because tools such as Chat, Shared Whiteboards, Video conferencing and Group browsing are central to ensuring collaboration within the PBL team. Students may be working at a distance or on campus, but they will begin by working out what they need to learn to engage with the problem situation. This may take place through a shared whiteboard, conferring or an email discussion group. What is also important is that students have both access to the objectives of the module and also the ability to negotiate their own learning needs in the context of the given outcomes. Facilitation occurs through the tutor having access to the ongoing discussions without necessarily participating in them. Tutors also plan real-time sessions with the PBLonline team in order to engage with the discussion and facilitate the learning. A useful recent example of using and evaluating online PBL is provided by Ng, Bridges, Law, and Whitehill (2014) in the area of speech and hearing sciences.

For students, the shift to new forms of learning, different from the more traditional didactic approaches they have experienced in school and further education, is often challenging. PBLonline introduces students to two new elements of learning: PBL and learning online. Students' lack of experience with one or the other or both has an impact not only on their experience of and outcomes from PBL and online learning but also on other forms of learning within the curriculum. If other curricula components are lecture-based, students invariably find the management of PBLonline troublesome and challenging. This is because there are few curricula where PBL is used as the only approach to learning and thus students have to manage not only the interplay of knowledge across modules but also different approaches to learning. However, there are also issues about the reasons for using PBLonline in the first place. For example, it is questionable as to whether there is value in using real-time PBLonline for students undertaking the same programme at the same university, unless it is used because of long distances between campus sites where students are using the same PBL scenario. There also needs to be questions asked about whether having asynchronous teams adds something different to PBLonline. Certainly, in distance education, across time zones and campus sites, this would be useful and suit different students' lives and working practices. Yet this raises problems about how cooperative and collaborative it is possible to be, in terms of sharing learning and ideas and developing forms of learning that are genuinely dialogic in nature.

5.3.4 Problem-Based Learning in Virtual Worlds

Learning in virtual worlds (simulations and virtual worlds such as Second Life could become a central learning approach in many curricula, but the socio political impact of virtual world learning on higher education remains under-researched. Much of the recent research into learning in virtual worlds centres on games and gaming and is largely underpinned by cognitive learning theories that focus on linearity, problem-solving and the importance of attaining the "right answer" or game plan (Gee, 2004; Rieber, 1996; Savin-Baden, 2008b) Most research to date has been undertaken into students' experiences of virtual learning environments, discussion forums and perspectives about what and how online learning has been implemented. Although PBLonline combines problem-based and online learning, in doing so it is recognised that students learn collaboratively through web-based materials including text, simulations, videos and demonstrations. Resources such as chatrooms, message boards and environments have been purpose-built for PBL; both synchronously and asynchronously, on campus or at a distance. Practising skills within a virtual environment online offers advantages over learning through real-life practice, in particular the exposure of learners to a wide range of scenarios (more than they are likely to meet in a standard face-to-face programme) at a time and pace convenient to the learner, together with consistent feedback.

5.3.5 The PREVIEW Project

In 2008, Coventry University purchased an island in the virtual world, Second Life™ and then gained funding, with St George's Medical School, London to develop, test and implement PBL scenarios in virtual worlds. The PREVIEW project (PBL in Virtual Interactive Educational Worlds) investigated, implemented and evaluated a user-focused approach to developing scenarios and materials, linking the emerging technologies of virtual worlds with interactive PBL online, to create virtual collaborative tutorials. Coventry University has an innovative track recorded of PBL since 1999 in nursing and professions allied to medicine. In 2012, the Faculty of Health and Life Sciences also decided that all curricula in the faculty would become problem-based. The PREVIEW project sought to combine pedagogy with virtual world technology, which had been tested in health, medicine and social care and has since been tested and implemented in education, physiotherapy and psychology (for example, Parson & Bignell, 2011 and other examples may be found here: http://previewpsych.org/?page_id=148)

Research into learning in virtual worlds has tended to focus on cognitive learning theories. Laurillard (2002), in particular, has argued for an information rich environment in which the student has control in discovering knowledge, but the discovery is supported and scaffolded by extra guidance functions. Yet it is argued here that virtual world learning offers new perspectives about the socio-political impact of learning in higher education. This is because virtual worlds such as Second Life are universal, not bound by time or geography, and many now using such virtual worlds appear to adopt different learning values from other learning spaces. For example in a study on spatial practice in virtual worlds, Savin-Baden (2013) found that ownership, spatial violation and replication were concerns raised by participants in relation to spatial practice. However, in terms of proxemics, participants suggested that an understanding of social cues, spatial negotiation and spatial consideration were important considerations for effective teaching in Second Life. The findings of this study suggest there remains relatively little in-depth understanding of the way space is implicated in learning in Second Life and that spatial practice and proxemics require further research in order to understand the pedagogical implications of using Second Life as a learning space.

The PREVIEW project was implemented as it was recognised that existing campus-based PBL carries a legacy of limitations from its paper-based nature. The paper cases used in tutorials can only proceed in a single direction, and in so doing; they prevent the user from tracking through any wrong paths by immediate correction. Such cases, therefore, have limited use in developing clinical reasoning, and are often unrealistic for emulating real life, where there are often several ways to tackle a problem and mistakes are often not immediately obvious (Conradi Kavia et al., 2009). This approach is unlikely to engage online students particularly in the same way as more complex, multi-choice scenarios. The project team therefore created (1) specific PBL environments within Second Life, (2) PBL scenarios (3) strategies, guidance materials, and good practice guides, all of which was evaluated under the guidance of users, and made available to the higher education community. Practising skills within a virtual environment online offers advantages over learning through real-life practice, in particular the exposure of learners to a wide range of scenarios (more than they are likely to meet in a standard face-to-face programme) at a time and pace convenient to the learner, together with consistent feedback. It offers learners the chance to make mistakes without real-world repercussions. This project is investigating implementing and evaluating a user-focused approach to developing scenarios and materials, linking the emerging technologies of virtual worlds with interactive PBL online, to create immersive collaborative tutorials. This environment differs radically from that of a virtual learning environment, such as Blackboard or Moodle in that it draws on a primarily visual set of semiotic resources with each participant having an online presence, or avatar, to aid their communication. The aims of the PREVIEW project were to:

(1) Deliver problem-based learning in Second Life
(2) Develop eight interactive PBL scenarios
(3) Evaluate the scenarios from users' perspectives alongside users
(4) Develop guidelines and best practice for delivering PBL in virtual worlds
(5) Share open source materials and technology
(6) Publish findings in medical and higher education literature

5.3.6 PREVIEW in Practice

Based in two different health sciences curricula, the scenarios were created as the starting The curricula in which Second Life was implemented were: (1) the *Paramedic Foundation Degree* (Second Year) that is run by the Faculty of Health and Social Care Sciences (a joint faculty of St George's and Kingston Universities); and (2) the 2–3 year part-time *M.A. programme in Clinical Management* at Coventry University. The foundation degree is a 3-year in-service blended learning course with 70 % of its materials delivered via the institutional VLE (Blackboard). The M.A. programme is a distance and online curriculum for those wanting to be effective health service and social care managers.

In the context of this project, PBL scenarios were designed with reference towards the different types and modes of knowledge. For example, the question, "what is the matter with this man?" results in students seeking explanatory knowledge; knowledge that offers some reason for the symptoms the man is experiencing. Whereas if the students were asked, "what would you do if you were this man's physiotherapist?" then the emphasis becomes one of action rather than explanation. Thus the assumption is that the student always understands the explanatory knowledge and can take action, thereby using procedural knowledge. Such a distinction is important because it helps students to begin to understand how they recognise and use different types of knowledge. An example of these forms of knowledge is illustrated in Table 5.1, below.

Gibbons Limoges et al. (1994) argued for Mode 1 and Mode 2 knowledge: Mode 1 knowledge is propositional knowledge that is produced within academe separate from its use and the academy is considered the traditional environment for the generation of Mode 1 knowledge. Whereas Mode 2 knowledge is knowledge that transcends disciplines and is produced in, and validated through, the world of work. Knowing in this mode demands the integration of skills and abilities in order to act in a particular context. Barnett (2004), however, argues for Mode 3 knowledge, whereby one recognises that knowing is the position of realising and producing epistemological gaps. Such knowing produces uncertainty because, "No matter how creative and imaginative our knowledge designs it always eludes our epistemological attempts to capture it" (Barnett, 2004, p. 252). What is missing from the arguments and formations of knowledge and knowing is not only the way in which the spaces between these forms of knowledge are managed, but also what it is that enables students and tutors to make the connections between all of them. Such missing links would include capabilities such as knowing when to keep your mouth shut and the virtues of tact, which are forms of knowing that are required in many professions. Disregarded forms of knowledge then might have been termed Mode 4 knowledge since it transcends and overlays Mode 1, 2, and Mode 3 knowledge but is also a mode in its own right, since it involves not only realising and producing epistemological gaps but also realising the ways in which these gaps, like knowledge and knowing, also have hierarchical uncertainty. Mode 5 knowledge is a position whereby one holds a number of modes together in a complex and dynamic way.

Table 5.1 Types of knowledge and types of problems

Types of knowledge	Explanatory knowledge	Descriptive knowledge	Procedural knowledge	Personal knowledge
Types of problems	Explanation problem	Fact-finding problem	Strategy problem	Moral dilemma problem
Examples	People in the fifteenth century used to believe it was possible to fall off the edge of the earth	Following recent political changes relating to land use in Zimbabwe many internal borders have changed	A 43-year-old woman cannot lift her right arm more than 45° and she complains of pins and needles in her hand	A mother breaks into a chemist's shop at night to obtain life saving drugs for her baby. She contacts her local physician the next day to explain what she has done
Example of question	Explain why	What would a legal map look like?	If you were this client's physiotherapist what would you do?	What should the doctor do?

Reprinted with permission from McGraw-Hill. Savin-Baden M, Major C. Foundations of problem-based learning. Maidenhead: Open University Press/SRHE; 2004, p. 67

Table 5.2 Modes of knowledge (Savin-Baden, 2007 p. 82)

Mode 1	Propositional knowledge that is produced within academe separate from its use and the academy is considered the traditional environment for the generation of this form of knowledge
Mode 2	Knowledge that transcends disciplines and is produced in, and validated through, the world of work
Mode 3	Knowing in and with uncertainty, a sense of recognising epistemological gaps that increase uncertainty
Mode 4	Disregarded knowledge, spaces in which uncertainty and gaps are recognised along with the realisation of the relative importance of gaps between different knowledge and different knowledge hierarchies
Mode 5	Holding diverse knowledges with uncertainties

Gaps, like knowledge, have hierarchical positions and this makes both the gaps and the knowledge, and the knowing and the knower eminently uncertain and liquid. Table 5.2 summarises modes of knowledge

PBL is an approach to learning that challenges students to think beyond Mode 1 knowledge, propositional knowledge, often even in the first year of a programme and it is important for staff to be aware of this and to design scenarios in the first year and second year that allow for engagement with higher level Modes of Knowledge. In this project, PBL scenarios were developed within Second Life. The students' avatars would be directed to the appropriate scenario for that week through a Second Life (SL) URL, often referred to as a SLURL, in the institution's virtual learning environment. For each of the curricula, it was planned that two avatar-driven scenarios would be developed, as well as two information-driven scenarios. This has since changed and currently 7 out of 8 scenarios are avatar-driven:

Avatar-driven: The PBL is set in the appropriate surroundings (for example, at the patient's home, in the hospital ward) and the patient is represented by a non-player character (NPC). Initial information would be given by the NPC and the students would then discuss how to proceed, as in any PBL. Additional information may be presented on display screens (via text, image, video, animation or external links), notecards or sound streams or through the "chat" function of any NPCs involved in the scenario. An example of one of the PBL scenarios at Coventry University, based in a virtual care home for those with learning disabilities, is a difficult situation about an outbreak of disease within the facility.

Information-driven: The scenario is presented through multiple interactive screens in SL. These screens output text, images, sound and video footage as necessary. The information on display changes depending on the students' decisions, similar to the virtual patient model already used at St George's; the difference being SL allows multiple information screens and a collaborative environment so that the students can interact with one another as well as the scenario.

The role of the students, as a collaborative exercise, is to gather as much information about the situation and the disease as possible using a variety of information-driven methods before moving on to an avatar-driven method. Thus, in practice, students undertake the information-driven scenarios first to familiarise themselves with learning though PBL in Second life™. The students then undertake avatar-driven scenarios and are required to interact with a "chat bot" to distinguish what their next actions should be. Feedback suggested that the information-driven scenarios did not work as well as avatar-driven, and the scenarios were restructured slightly to compensate for the students' comments that they did not feel as immersed into the environment with information-driven scenarios. The decision was made to design all the health care scenarios as avatar-driven to provide for a truly virtual and realistic experience. An iterative process was used when implementing and evaluating the PBL scenarios. At several stages throughout the project, testing of each scenario was undertaken, and the feedback from the students' experiences was analysed to improve on the scenarios. The scenarios were then reviewed further alongside students to ensure the feedback had been beneficial to the project. The scenarios are exemplified in Table 5.3 below.

5.3.7 New Developments for PBL in Higher Education

Specific development emerged both during and as a result of this project, which have been developed in response to the need for pedagogically driven scenarios that fit with a virtual world. These include:

- Chat bots—These non-player characters (or chat bots) are artificially intelligent Second Life avatars, which respond to things said in local chat. These were used in two scenarios and took on the roles of a councillor and manager character respectively. These chat bots were programmed via a web service, which allows advanced detection of keywords and phrases. The chatbot was assigned a real Second Life avatar, and logged in to take part in the scenario.
- Machinima—Two other scenarios featured machinima videos, which provided an overview of the virtual situation for students. A machinima is a video created in world, in real time. These were made using screen recording software called Fraps and by enabling lip sync within Second Life so the characters' lips appeared to move when they spoke. The machinimas are then streamed into Second Life and shown on a large screen to participants.
- Holodeck—We used a Second Life object called a holodeck to allow dynamic redesign of the virtual space. The holodeck responds to commands from buttons in the virtual care home reception, and transforms the office space according to the choice made. In practice this meant that it was possible to have four different office spaces, each relevant to the specific scenario. The holodeck also generated content to the main care home building for one scenario, to give the impression of a post-fire situation.

Table 5.3 Problem-based scenario types for use in virtual worlds (adapted from Savin-Baden, 2010, p. 43)

Scenario type	Level of complexity	Example	Problem type	Type of knowledge	Form of knowledge students required to use
Avatar-driven scenario Type 1	Critical contestability	C-difficile	Moral dilemma	Contingent, contextual and constructed	Mode 4/3 Disregarded Knowledge and Knowing in and with uncertainty
Avatar-driven scenario Type 2	Knowledge (re)framing	The unhelpful manager	Strategy	Procedural knowledge	Mode 2/3 Knowledge validated through, the world of work/Knowing in and with uncertainty
Avatar-driven scenario Type 3	Guided discovery	Road traffic accident	Explanation	Explanatory knowledge	Mode 2, Knowledge that is produced in, and validated through, the world of work
		Heart attack			
Mixed mode Type 1	Critical contestability	Lions for Lambs	Moral dilemma	Contingent, contextual and constructed	Mode 3, Knowing in and with uncertainty
Mixed mode Type 2	Knowledge (re)framing	The commissioner	Strategy	Procedural knowledge	Mode 3, Knowing in and with uncertainty
Information-driven scenario	Linear trajectory	Alzheimers	Fact finding	Descriptive knowledge	Mode 1, Propositional knowledge
		Burns case			

5.4 Evaluation

The approach adopted was illuminative evaluation designed originally by Parlett and Hamilton (1972, 1976), originally due to concerns about traditional approaches to evaluation being used to examine innovations in education. The aims of illuminative evaluation were:

> … to study the innovatory programme: how it operates; how it is influenced by the various school situations in which it is applied; what those most directly concerned regard as its advantages and disadvantages; and how students' intellectual tasks and academic experiences are most affected. It aims to discover and document what it is like to be participating in the scheme, whether as teacher or pupil; and, in addition, to discern and discuss the innovation's most significant features, recurring concomitants and critical processes. In short it seeks to illuminate a complex array of questions.
>
> (Parlett & Hamilton, 1972, p. 144)

This move was away from psychology-based models of evaluation towards one that was based on sociology. This form of evaluation was designed to increase understanding of what is being evaluated. It focused on the explorations of the learning situation (Parlett & Dearden, 1977). The idea is that the evaluation is conducted through the three stages of observation, inquiry and explanation. Therefore, data collection involves:

1. Observation: the evaluator creates a portfolio of events that might at first appear to be on the edge of the study such as meetings, social events and seminars
2. Interviewing: the focus is to explore and examine the interviewee's perceptions from a clearly personal and storied perspective

5.4.1 Ethics

Ethical approval was sought from the relevant University ethics committees. Data collected was confidential. Safeguards to confidentiality included the coding of data and the code was kept separate from the raw data. All names used throughout were fictitious to preserve the identity of participants. However, it should be acknowledged that the individuals concerned might recognise some excerpts within the text used to illuminate the interpretation of data.

5.4.2 Data Collection

The evaluation was designed to increase understanding of what is being evaluated and focuses on the explorations of a learning situation. Data collection involved:

1. Observation by an evaluator whose role was to collect and collate data. He observed a number of events such as meetings, social events and seminars and sessions in the virtual world

2. Interviewing tutors ($n=8$ and students ($n=36$) to explore and examine the interviewee's perceptions from a clearly personal and storied perspective

The objectives of the evaluation were to:

- Explore the impact of problem-based learning scenarios in 3D virtual worlds on learning by observing session, interviewing tutors and students and undertaking focus groups
- Assess the usability of the learning environments and user acceptance analysing students' perspectives and the use of the scenarios by the students both within and outside classroom hours
- Evaluate the effectiveness of feedback mechanisms and guidance materials through interviews and focus groups
- Offer an analytic account of the experience of the project from the perspective of all the key stakeholders through feedback at meetings, creating an interactive feedback cycle to ensure best practice
- Be responsive and flexible enough to capture unintended outcomes and unanticipated effects
- Provide an overall summary of the project, highlighting strengths, weaknesses and areas of development
- Inform current and future developments, paying particular attention to their structures, procedures, working practices, relationships and practices through publications and conference presentations

5.5 Findings

The findings in many ways were more positive than initially anticipated, but there were also a number of challenges. The three themes that emerged for the data were Technological and Pedagogical challenges, Usability and Avatar identity, Collaboration and Interaction.

5.5.1 Technological and Pedagogical Challenges

Feedback suggested that the information-driven scenarios did not work as well as avatar-driven, and the scenarios were restructured slightly to compensate for the students' comments that they did not feel as immersed into the environment with information-driven scenarios. It was anticipated that the technological demands and initial lack of user friendliness of SL would be barrier to participation. However, the technology also had a strong influence on the pedagogical model, as explained one of the tutors,

> I don't feel it (Second Life) lends itself very well to a group (3–4)…– quite high boredom factor for those not directly participating with the non-player character, … they were checking email, adjusting appearance—so from facilitator's point of view it is a good decision making exercise but not for what we understand as traditional PBL (Tutor, paramedic programme)

Thus, the difficulties by tutors identified were not those that are particular to those mentioned in the PBL literature such a poor group work or team members not contributing significantly. When the PREVIEW project underwent testing by tutors and students, few access barriers were reported, although this may become more of an issue with wider implementation of this approach. However, students who were beginners to the Second Life environment needed more time than anticipated to explore and experiment with the virtual world, and familiarise themselves with the new environment; mock scenarios became an important strategy in this process.

> This is my greatest concern. In order to get the students close to a point where clinical reasoning/learning is both valuable and the prominent area of concern. It seems to take a large amount of effort to overcome the heavy interface of Second Life. (Tutor, paramedic programme)
>
> The only problem for me was that there were too many other things to do to distract you from the main objective. (Student, paramedic programme)

This suggests that a degree of initial strangeness and discomfort may have been experienced by the participants, which is significant when considering that they would need a tolerable degree of conformity with the visual/kinetic/semiotic resources of the world and their avatar identity, before they could devote meaningful attention to group collaboration around a problem. One of the difficulties with using PBL, designing interaction learning in virtual worlds and developing simulations is the ability to design and build effective complex and challenging scenarios. There is a tendency to focus on knowledge and content coverage, rather than the way learning will be managed and the design and complexity of the problem scenarios as discussed above in relation to forms and modes of knowledge.

5.5.2 Playing to Learn

Designing learning in higher education has often focused on covering content and ensuring that discipline-based pedagogies are adhered to. What these evaluation data appear to indicate is that the experience of learning with and through an avatar differs between people, and invariably relates to identity transitions and transformations in virtual worlds. Students remarked:

> I got distracted when my avatar was sitting on the cupboard instead of what I wanted 'her' to do. (Student, M.A. programme)
>
> It does distract you when your avatar gets in the way. Just as I wanted to pick up information she started flying and I got confused and it interrupted the experience since I had to deal with the tech. (Student, paramedic programme)

The sense of doing things differently, playing with learning, playing around and exploring were all seen as advantages to PBL in Second Life. Yet these advantages were often seen by tutors as troublesome in the sense that the learning boundaries were not necessary controlled and managed by them, but by the students. Yet for students it was the opportunity to play, which challenged the immutability of knowledge and the perception that learning was static and tutor centred. Findings indicate that SL held a great deal of potential for the development and extension of PBL.

Students seemed able to use their avatars to communicate, collaborate and problem solve effectively.

I liked it! It's more entertaining certainly! More fun. But I'm not sure that we'd have gotten different results if we sat around a table with a bunch of papers chatting (Student, M.A. programme)

I liked the team collaboration aspect to it… I think it's a different way of working out solutions to problems. I liked it and it was fun! (Student, paramedic programme)

Playing to learn seemed to enable an exploration of the ways in which past, current and future identities are present and embodied and multiply interacting with each other in these spaces. Students spoke of fun, of changing clothes and body shapes which indicated a sense of wanted to experiment and play with avatar identities. This raised the issues about the bodily markers that are used to present ourselves in life, clothes, ethnicity, gender and speech and the ways in which these may be re-presented (differently) but they also indicate choices about how we wish to be seen or the ways in which we might like to feel differently "in world" (i.e. in the virtual world). Yet the notion of playing to learn seemed to be at odds between tutors and students. Students saw play as part of or integral to learning whereas their perception was that tutors did not always see it as such. Two students both saw SL as space for play and experimentation which they felt was unexpected by tutors:

> I was instantly engaged. I like debating and this fitted the bill. I also don't mind a bit of humour and a few jokes and that is inevitably involved in SL … There is a real dimension there to do all sorts of creative things you might not have thought of … For some a few the whole thing is off putting, not really serious, you know odd boy, that sort of thing. When I speak to friends who are teachers you have to overcome their prejudice that it's all just a joke. (Student, M.A. programme)
>
> I think the course tutors, they are supportive but they can be quite directive on the course at points and I think their understanding of what education in an online space was quite different from mine. And also I was being quite experimental and in a way I think they hadn't expected and I think they were quite thrown by that. (Student, paramedic programme)

The sense of doing things differently, playing with learning, playing around and exploring were all seen as advantages to learning in virtual worlds. Yet these advantages were often seen by tutors as troublesome in the sense that the learning boundaries were not necessary controlled and managed by them, but by the students. Yet for students it was the opportunity to play, which challenged the immutability of knowledge.

5.6 Discussion

The evaluation of this project indicated that students respond to well-designed, pedagogically driven scenarios that have been specifically created for virtual world learning. The level of realism and immersion of the scenarios seemed to be enhanced by the virtual world environment, including the option to use voice in addition to text-based communication, and students reported that it felt like a more "authentic" learning environment than PBL based in virtual learning environments. Students responded enthusiastically to the Second Life environment, interestingly tending to initially treat it as a "game". This (common) association of the look and feel of SL with online gaming may arguably be a limitation in the educational setting - in that it could encourage individualism rather than collaboration, and may simplify scenarios in which more nuanced critical engagement is required and no one clear solution is available. However, it is likely to also be an advantage in that it may increase student enjoyment and motivation via memorably novel forms of participation.

Using PBL in Second Life embraces issues such as student diversity and improving student engagement (Wimpenny & Savin-Baden, 2013) connected with complex curriculum design and the need for complex PBL scenarios to be developed. All the planned scenarios were delivered and significant changes were made during development to take most advantage of Second Life. Students appreciated the value of Second Life as a collaborative environment, but also viewed such practice-based simulations as valuable for individual work. An interesting consequence of the richness and authenticity of the Second Life scenarios is the large amount of detail provided, which was much more than is usual in paper-based face-to face PBL sessions. Second Life can provide a more authentic learner environment than classroom based PBL and therefore changes the dynamic of facilitation, but at this stage it is not clear how this impacts on the way the scenario is used and facilitated. However, more recent work undertaken by Chan, Lu, Ip, and Yip (2012) examined paper-based and video scenarios and found that although they had hypothesised that as video-triggered cases tend to be less well defined, students were likely to need more discussion time on problem identification and description, this was not the case. They also had concerns that the video may provide information overload and distraction but this was also unsupported.

It has been pointed out that facilitation of PBL is itself a source of concern for many teachers (Savin-Baden & Wilkie, 2006) and that there are differences and tensions to be resolved between online and face-to-face facilitation. However, there were also technical considerations such as the relatively high specification computers/high bandwidth are required, and the interface is not as intuitive as might be hoped. Interface complexity can provide memory overload. Furthermore, it is essential to prepare users through structured, context-related orientation sessions prior to use as a learning tool. Yet the user-guided development process adopted by PREVIEW, involving the whole development team and students from the target course worked effectively in highlighting strengths and weaknesses in many aspects of the scenarios.

Developing open source, pedagogically-driven PBL scenarios such as these may offer a new liquidity to learning, combining technology with pedagogy in ways that are mutually beneficial not only in distance education, but also as a means to enrich the face-to-face learning environment. However, these environments must be examined not only in terms of the new freedoms they may afford, but also in recognition of their intermittently strange and "troubling" nature, which may in itself provide potential for creativity (Bayne, 2006). Virtual world environments have been considered as opportunities to move away from the scaffolding of teaching and learning in Higher Education (Savin-Baden, 2008a, 2010). In particular, these characteristics, alongside their creative opportunities, can support the adoption of different learning values from other learning spaces.

5.7 Conclusion

The case study presented here indicates that virtual worlds can provide: (a) greater realism; (b) active decision-making; and (c) a suitable environment for collaboration. These innovations and the evaluations of this project illustrate that it is vital not only to consider what "learning" means in such spaces, but also to address more fundamental questions raised, such as the nature of emergent modalities of educational communication, practices and identities in the "digital age". Such a vision however, will require that we stop seeing the curriculum as a predictable, ordered and manageable space, but instead re-view it as an important site of transformation where risk and uncertainty are central.

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Chapter 6
How Do Health Sciences Students Use Their Mobile Devices in Problem-Based Learning?

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6.1 Introduction

6.1.1 Millennial Learners and Educational Technologies

The Net Generation—also referred to as "Millennial learners" or "Generation Y"—has been described as the group of individuals born in or after 1982 to early 2000s (Chu et al., 2012). The Net Generation learners have been characterized as being

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comfortable with technology and relying heavily on technology in their daily lives (Montenery et al., 2013). They also have been reported as preferring technology, experiential learning, and active learning in an interactive learning environment with immediate feedback and peer collaboration (Montenery et al., 2013; Revell & McCurry, 2010). Since these students appear to readily engage in multitasking across modalities, their learning is often characterized by rapid shifts between websites and various mobile devices, such as mobile phones, laptops, and tablets (Montenery et al., 2013). Carlson (2005) described Net Generation learners as self-motivated and capable of looking up and sharing information to enrich their existing learning resources. The change in the role of mobile phones as an active educational tool and the changing learning preferences of today's learners, particularly the demand for the latest electronic hi-tech devices, have become the focus of a number of contemporary research projects assessing the pedagogical impact of mobile technology (Lightbody & McCullagh, 2009; Mermelstein & Tal, 2005). To be open to new learning practices, contemporary educators need not only to be familiar with the technologies but also need to reconsider the learning experiences they design as they incorporate new technologies into the educational environment in order to engage students and effectively support their learning (Lightbody & McCullagh, 2009).

There is a major opportunity to embrace the incorporation of mobile devices with wireless networking technology in learning. A study explored naval postgraduate students' note-taking practices and introduced a collaborative note-taking system to students. Although students favored using paper for note-taking as they reported writing manually helped retain the learning materials, many students still preferred to use their own laptops to access the collaborative note-taking system (Singh, Denoue, & Das, 2004). Mobile devices not only enable learning to extend beyond the traditional classroom, but also provide a portable means of information gathering and sharing (Corbeil & Valdes-Corbeil, 2007). In 2004, Duke University distributed Apple iPods to more than a thousand freshmen for portable access to course materials. These iPods were also used for learning activities such as recording lectures, jotting notes, and informal group discussions. These uses have led to a positive impact on students' performance in examinations (Carlson, 2004; Lightbody & McCullagh, 2009).

6.1.2 Problem-Based Learning

Problem-based learning (PBL) is most often employed as a pedagogical approach in which complex real-world problems are structured and presented to students in a way that encourages multiple perspectives and possible outcomes (Donnelly, 2010). By engaging students with real-world problems, PBL aims to equip them with the professional skills and competencies needed in the future workplace (Lehmann et al., 2008). PBL is also employed as a curriculum structure to support integration of knowledge across disciplinary boundaries (Lu, Bridges, & Hmelo-Silver, 2014). A recent synthesis of meta-analyses of studies found that PBL programmes outperform traditional programmes in student satisfaction, in long term retention of knowledge as well as clinical performance and application of clinical skills (Prosser & Sze, 2014).

In health sciences PBL curricula, PBL problems are traditionally presented with the written description of clinical cases with supporting inquiry materials such as clinical data. More recently, PBL problems are being designed using multimedia such as video clips, websites, images, or photos. During the PBL discussion, students can use their mobile devices to connect to other sources of information on the Internet, or even the other learners and the teacher (Zhou, Purushothaman, & Rongbutsri, 2013). They may search for the definitions of novel terms in the problem statement and other problem-related information in order to seek understanding of all of the dimensions of the problems at hand. Using mobile devices to access resources that are significant to the PBL discussion has been viewed as positive in facilitating collaborative knowledge building and creating new educational experiences (Zhou, Purushothaman, & Rongbutsri, 2013).

6.1.3 Problem-Based Learning and Educational Technologies

The infusion of digital media and learning technologies into PBL has posted both opportunities and challenges in student learning (Bridges, Botelho, & Tsang, 2010; Bridges et al., 2012; Chan et al., 2012; Lu, Bridges, & Hmelo-Silver, 2014; Zhou, Purushothaman, & Rongbutsri, 2013). Positive results have shown how Information and Communication Technology (ICT) can support PBL processes by combining pedagogies and technologies in educational practice (Bridges, Botelho, & Tsang, 2010). Recent work has shown positive results in connecting students to communities, networks, and resources of interest to facilitate information gathering and sharing, and therefore make learning more productive (Zhou, Purushothaman, & Rongbutsri, 2013). The use of more highly authentic video prompts/cases has been found to have a positive effect on PBL argumentation and student engagement to learning (Chan et al., 2012) while ethnographic work has found the consequential nature of Web2.0 technologies to PBL—both in groups (Bridges et al., 2012) and individually (Bridges et al., 2015). However, it has also been recognized that one of the greatest challenges for teachers is to engage in best practices in the use of educational technologies aligned with the characteristics, learning preferences, and learning needs of millennial learners (Revell & McCurry, 2010).

Certainly, the introduction of mobile devices may pose challenges for facilitators as they guide the knowledge construction process. While some facilitators welcome the opportunity of instant access to extensive resources on the Internet during PBL discussion thereby promoting more informed discussion and extending students' understanding, others have expressed concern that the use of these devices distracts students from productive discussions with other students which they see as key to the PBL knowledge building process (Chan et al., 2015). A concern is that students may be engaging in surface approaches to learning by surfing topics and relaying information read from the mobile devices, without understanding what they are reading.

Overall, universities in Hong Kong are facing an increasing use of mobile devices among students. A recent survey showed that the rate of mobile device possession among universities students in Hong Kong is 93.4 %, almost half of whom spend more than 20 h online per week and 26–50 % of that time is spent on study-related activities (Ang et al., 2012). The aim of the current study is to identify the students' patterns of mobile devices usage in one university in Hong Kong. A survey-based, self-report approach sought to identify the percentage of students who use mobile devices during PBL, whether they use these devices to enhance their PBL activities, and how they use them. The findings of the study will provide important information on how students perceive online learning within PBL curricula and will form the basis for further studies on the effects of mobile devices on the PBL process and on student learning in PBL curricula.

6.2 Methods

6.2.1 Participants

Students from three undergraduate healthcare professional programmes at The University of Hong Kong (HKU) were invited to take part in this study: Bachelor of Medicine and Bachelor of Surgery (MBBS); Bachelor of Dental Surgery (BDS); and Bachelor of Sciences in Speech and Hearing Sciences (BSC(SPEECH)).

In the 2012 curriculum reform, all undergraduate programmes funded by the University Grant Committee of Hong Kong, thus including the three mentioned above, were extended by an additional year. Therefore the previous 5-year-long MBBS and BDS programmes became 6 years and the previous 4-year-long BSC(SPEECH) programme became 5 years. In 2012, the last cohort of the 5-year programme and the first cohort of the new 6-year programme were both admitted. Therefore, in 2014, when this current project was conducted, both the 5-year and 6-year MBBS and BDS programmes and the 4-year and 5-year BSC(SPEECH) programmes existed. Since PBL is present only in certain years of these programmes, only students from selected years were invited to take part in this study (Fig. 6.1). The following is a brief description of the implementation of PBL in the three programmes:

1. Bachelor of Medicine and Bachelor of Surgery (MBBS) programme: Both the 5-year and the 6-year MBBS programme are problem based and system based, meaning that the first 2 years of the 5-year programme and the first 3 years of the 6-year programme are organized according to bodily systems, such as the cardiovascular system and respiratory system. In each system block, PBL on average occupies about 20 % of the curriculum time. Apart from the horizontal integration, the curricula are also vertically integrated with clinical exposure in early years and revisiting of basic sciences in later years. English is the sole language of instruction in these medical programmes (except in a Chinese language course and a small part of a clinical communication course).

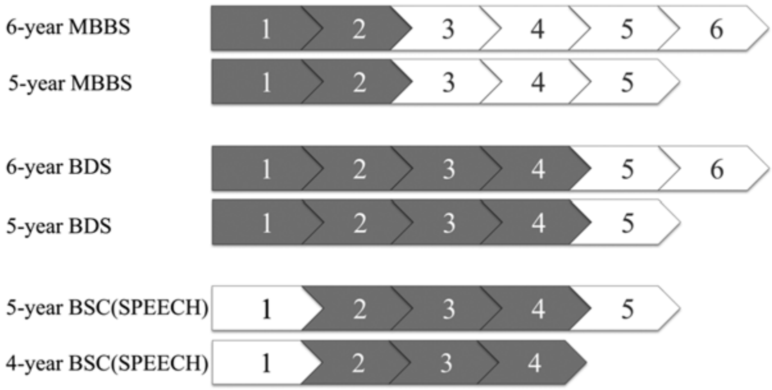

Fig. 6.1 Figure summarizing the years (the *shaded boxes*) of the three programmes from which students were invited to take part in this study. (*NOTE*: *MBBS* Bachelor of Medicine and Bachelor of Surgery programme*, BDS* Bachelor of Dental Surgery*, BSC(SPEECH)* Bachelor of Sciences in Speech and Hearing Sciences)

2. Bachelor of Dental Surgery (BDS): PBL is used as the organizing curriculum design in the BDS programme with learning issues mapped across the curriculum to support vertical and horizontal integration of content. As such it has been considered among the closest implementations of a "pure" PBL curriculum in dental education (Winning & Townsend, 2007). The inquiry-based framework sees classic PBL integration under a biopsychosocial model integrating basic sciences with clinical dental sciences. In the final year, journal-based learning (Botelho et al., 2013) maintains the small group inquiry structure but, rather than integrating, the focus is on evidence-based medicine and disciplinary clinical dental sciences.
3. Bachelor of Sciences in Speech and Hearing Sciences (BSC(SPEECH)): In essence, the programme adopts a pure PBL curriculum, in which no courses are offered to the students throughout the entire 4 or 5 years of training. However, each PBL problem is accompanied with 1–2 skills workshops that are tailored to provide students with relevant and sufficient skills to work towards solving the problem. The PBL curriculum is so designed that the simpler scenarios are discussed in more junior years, and vice versa. Internal and external clinical practices are provided in the final 3 years of training.

6.2.2 *Measurement and Data Collection*

Students in the three selected programmes ($n = 1085$) were invited through email to voluntarily complete the anonymous online questionnaire. The survey tool was constructed by the authors and was based on the focus group interviews with students and PBL facilitators (Chan et al., 2015). At the very beginning of the questionnaire, it was made clear to all respondents that, in this study, mobile devices include laptop or notebook computers, smartphones (e.g., iPhone and Galaxy Note), tablets (e.g., iPad, iPad mini, and Galaxy Tab), and eBook readers (e.g., Kindle and NOOK). The questionnaire was written in English and consisted of 23 closed- and open-ended questions, focusing on the following areas:

(a) Demographic information, such as gender, programme of study, and current year of study.
(b) How students use their mobile devices: the types of mobile devices the students used before they started their current healthcare professional programmes, type of mobile devices most frequently used in PBL, how much time they spend on their mobile devices during PBL, what kinds of learning activities and non-learning activities the students use their mobile devices for.
(c) Why some students do not use mobile devices during PBL.
(d) Students' degree of agreement to certain guidelines regarding the use of mobile devices in PBL using a 5-point Likert scale.

The original email invitation was sent once with a follow-up email sent 16 days later. The anonymous data were analyzed using descriptive statistical methods.

6.3 Results and Discussion

6.3.1 How Students Use Their Mobile Devices

A total of 346 students (MBBS: 228; BDS: 62; BSC(SPEECH): 56) completed the questionnaire. The response rate was 32 %. Table 6.1 shows the number of mobile devices they reported to possess. The vast majority of respondents (98 %) reported using mobile devices in PBL (for both learning and non-learning purposes). Of these, 98 % (or 96 % of all respondents) used them for learning purposes, mostly related to their PBL discussion. Figure 6.2 shows how much time these students reported using their mobile devices in an hour of PBL tutorial. It shows that students do not use their mobile devices all the time. In fact, 66 % of students reported that they used their mobile devices for less than half an hour in an hour of PBL tutorial, while only 35 % reported that they used more than that. Table 6.2 shows that students usually spend around 70 % (ranged from 62 to 76 %) of their mobile device usage time on activities related to PBL discussion, irrespective of the actual amount of time they spend using them.

Table 6.1 The number of mobile devices possessed by students who took part in this study

Number of mobile devices	Percentage of students
1	9
2	45
3	44
4	2
5	<1

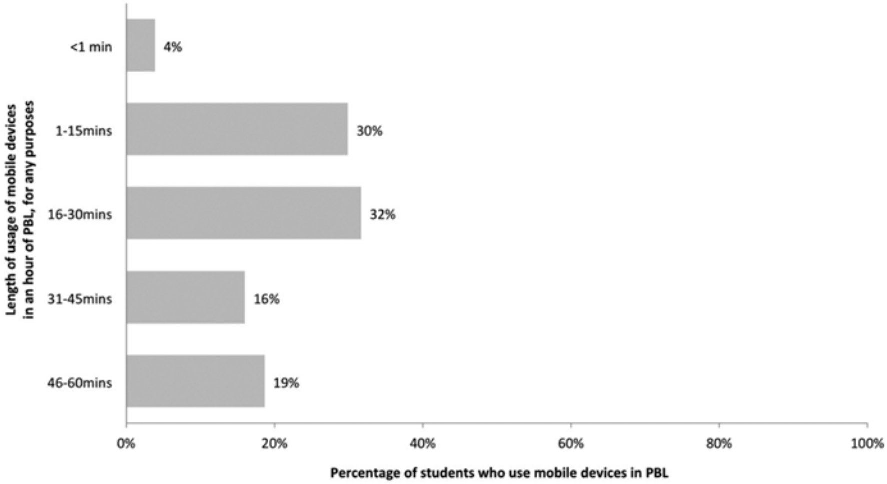

Fig. 6.2 Percentage of students using their mobile devices by amount of time used/hour PBL

Table 6.2 Percentage of students using their mobile devices for PBL discussion by amount of time used/hour PBL

Percentage of time related to PBL discussion Length of time that students used mobile devices/hour PBL	0–25 %	25–50 %	50–75 %	75–100 %
1 min or less (%)	31	0	0	69
1–15 min (%)	13	2	23	62
16–30 min (%)	5	8	16	71
31–45 min (%)	2	9	19	70
46–60 min (%)	2	8	14	76

Figure 6.3 shows the percentages of students who reported using laptop, smartphone, tablet, or eBook reader as their most frequently used mobile device. The majority (72 %) of respondents reported using a laptop most frequently in PBL tutorials. There are fewer students who reported the smaller mobile devices, i.e., tablets and smartphones, as their most frequently used mobile devices in PBL (20 % and 9 %, respectively). Smart phones have a number of affordances related to learning including playing audio files and videos, displaying and editing text documents, and accessing online information. On the negative side the size of the keyboard on smart phones can make note-taking difficult, and web browsing and reading on a tiny screen are also difficult (Corbeil & Valdes-Corbeil, 2007). Laptops and tablets have the most comprehensive functions of all the mobile devices. Whilst this means that students may find laptops powerful and capable of supporting them in a range of learning activities, the cost and weight of laptops and tablets are relatively higher among all types of mobile devices (Corbeil & Valdes-Corbeil, 2007).

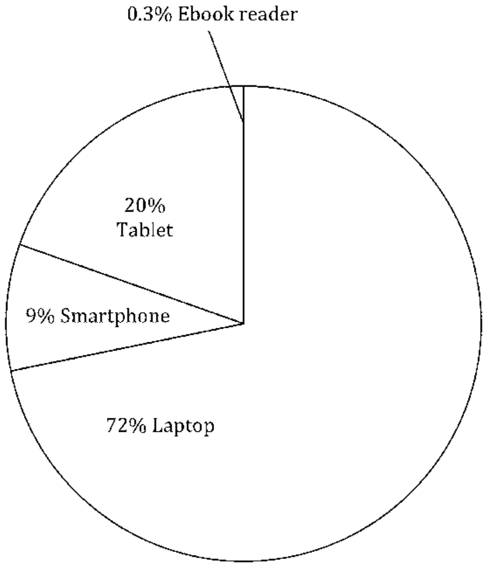

Fig. 6.3 Percentages of students using the following mobile devices most frequently

Figure 6.4 summarizes the learning activities that the respondents reported using their mobile devices for during PBL. Most of the activities can be grouped into three broad categories: information search, information synthesis, and the use of specific tools on their mobile devices. The information that the respondents searched using their mobile devices included definitions of terms, background information, or academic literature about the PBL case, either from the Internet or from the study materials provided by the teachers or the school. Respondents also indicated that they used their mobile devices to search for multimedia materials such as pictures, videos, animation, or sound files that can help the PBL discussion. These information search activities constituted more than half of all the reported learning activities using mobile devices (61 %). The respondents also reported using their mobile devices for information synthesis activities, such as completing self-directed learning during PBL (so that they will have less self-directed learning after school), presenting the results of their self-directed learning, creating their own notes of the PBL discussion, or in collaborating with their classmates on cloud-based platforms. These activities constituted 31 % of all the reported learning activities using mobile devices during PBL. Lastly, some respondents reported that they used their mobile devices for specific software for knowledge visualization, such as the anatomy atlases or software for the creation of concept maps. But this kind of activities only constituted 8 % of all reported learning activities.

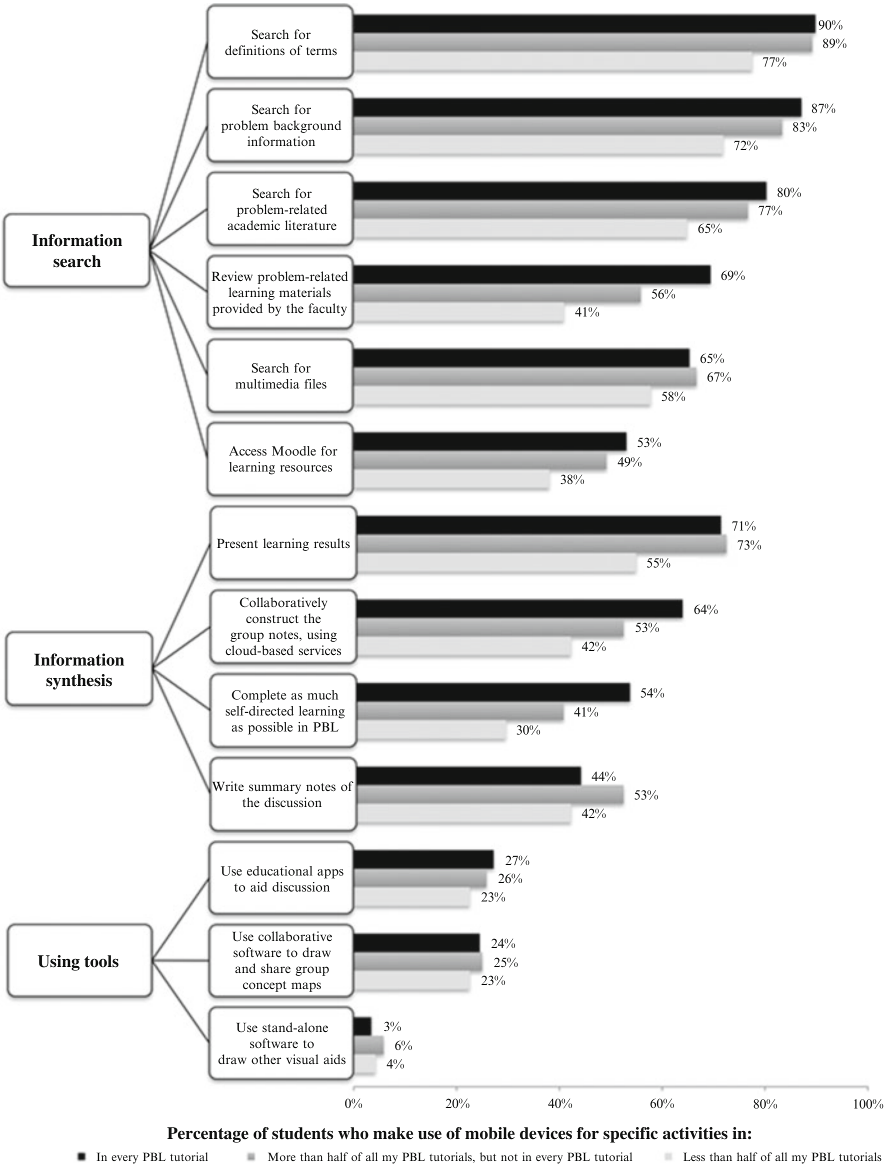

Fig. 6.4 Distribution of technology-enhanced learning activities in PBL tutorials

Apart from using their mobile devices for learning activities, the respondents who had reported using their mobile devices in PBL indicated that they also used the devices for non-learning activities (35 %), which include relieving boredom (28 %, by surfing the Internet, reading news, playing games, etc.), communicating with others (26 %, by email, WhatsApp, Facebook messaging, Twitter, etc.), or other, less frequent activities reported by single respondents, e.g., doing homework for other classes, checking or updating their schedules.

During self-directed learning outside of PBL tutorials, most of the respondents worked with their group members by sharing files through emails, Dropbox, Facebook, Google Drive, etc. (85 %), by online text-based discussion using Whatsapp, Facebook messaging, Twitter, etc. (69 %), by face-to-face discussion (52 %), by working simultaneously on the same files using cloud-based services such as Google Docs, etc. (48 %), or by online meeting discussions, e.g., Skype (5 %).

6.3.2 Why Some Students Did Not Use Their Mobile Devices

Only 2 % of all the respondents who said they owned mobile devices reported that they did not use mobile devices during PBL. Interestingly, no respondents indicated that it was because they did not have enough time to digest the searched information, i.e., they chose not to use mobile devices during PBL even though they might think that they have enough time to read and understand the found materials. The reasons for consciously avoiding using mobile devices included:

1. Issues related to lack of convenience or poor user friendliness: Some students did not use their mobile devices simply because they are too inconvenient to bring to or use in the PBL tutorials. So one student said, "laptops are too bulky to bring back to school." And another said that his/her "smart phone is too small for reading and searching for useful information."
2. Competition: Some students felt that the search for information using their mobile devices can turn into a competition. One student said, "I do not want to compete with my group members in the search for online information."
3. Impairment to group dynamics or critical thinking processes: Some students considered that using the mobile devices for searching during PBL tutorial can significantly distract them from engaging with their group members or in problem solving. For example, students said, "Searching distracts me from engaging with the problem," "My main goal is to discuss with my group," and "I prefer to spend my time thinking critically."
4. Tutor preference: Some PBL facilitators recognize the potential distraction caused by the use of mobile devices during PBL tutorial. For example, one student mentioned that "the PBL facilitator explicitly discourages the use of mobile devices in PBL."

Further to the issue of tutor preference was another student's observation that their tutors' preferred online searching outside the tutorial discussion space: "Tutors do not encourage the use of mobile devices for online searches during the (PBL) session. They encourage searching relevant information outside tutorials and then bring along with sufficient ideas to discuss in the (PBL) session." Indeed, PBL facilitator survey responses published elsewhere (Chan et al., 2015) indicated varied opinions on how mobile devices should be used during PBL. Facilitators are concerned with the mobile devices being distracting in face-to-face PBL tutorial, since students need to spend time interpreting the search results on their mobile devices, which may prevent them from effectively collaborating with their group members in the brainstorming of ideas and the co-construction of understanding and knowledge, an important process in PBL (Lu & Chan, 2015). One of the PBL facilitators reported in that study explicitly encourages his/her students to leave their mobile devices behind after they have used them to search for definitions of novel terms and to focus on brainstorming of ideas.

6.3.3 Guidelines on Using Mobile Devices

When the respondents were asked whether they think there should be guidelines on the use of mobile devices by students during PBL tutorials, 61 % said no and 39 % yes. And when students were asked to indicate their degree of agreement (on a 5-point Likert scale) to more specific recommendations on the use of mobile devices during PBL (Table 6.3), they were divided in their views on whether its use should be regulated (recommendation 1 in Table 6.3), with 36 % strongly agree or agree, 28 % neutral, 35 % strongly disagree or disagree. These results are understandable since students are adult learners, who would like to be in charge of their own learning (Leung & Chan, 2003) and not to be told what to do. This is further supported by the finding that most respondents disagree or strongly disagree with the recommendations on who could use them (68 %, recommendations 2 in Table 6.3) and what devices could be used (64 %, recommendations 3 in Table 6.3). It is therefore not surprising that the suggestion of implementing guidelines and regulating the use of mobile devices in PBL were met with ambivalent responses. On the other hand, students are still grappling with the appropriate and effective ways of using their mobile devices in PBL, and therefore some students would still welcome recommendations from the school.

The majority of students agreed that, when mobile devices were used, they should be used for educational purposes, including the search for relevant information, multimedia files, and collaboration with other students using cloud-based services (recommendations 4, 5, and 6, respectively, in Table 6.3), but not for non-educational purposes such as chatting with friends or surfing the net (recommendation 7 in Table 6.3). The majority of students agreed or strongly agreed that PBL tutorial time should be used mainly for discussion, instead of searching for information (recommendation 8).

Summarizing the key points of PBL discussion is usually the task assigned to a student during PBL (called the clerk, secretary, or scribe). The task is not an easy one, because the students need to pay attention to the whole discussion, understand it, extract the main points, and record them, all done simultaneously. The task is especially daunting if the student is not good at typing or when he/she is not familiar with the medical terms used in the discussion. But the recent development of cloud computing has enabled the possibility of collaborating among students

Table 6.3 Respondents' degree of agreement to suggested guidelines on the use of mobile devices in PBL

To what extent do you agree with the following recommendations?	Strongly agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)
Roles					
1. The use of mobile devices by students should be regulated within PBL tutorials	9	27	28	26	9
2. Only designated student(s) should do online searching when the PBL group decides internet information is needed	5	12	14	45	23
3. Only laptops should be used in PBL tutorials (i.e., other mobile devices should not be used)	3	14	19	42	22
Processes					
4. The use of mobile devices to search for factual information (e.g., definitions of terms, specific laws, and epidemiological data) should be encouraged	31	58	9	1	1
5. The use of mobile devices to search for multimedia files should be encouraged in PBL tutorials, since they can facilitate visualization and co-construction of knowledge	28	58	12	2	1
6. The use of cloud-based services such as Google Docs should be encouraged for collaborative note-making in PBL	33	47	18	2	0
7. Mobile devices should not be used for non-educational purposes, such as chatting with friends and surfing the net	21	46	20	11	2
8. PBL tutorial time should mostly be spent on discussion, instead of searching for information	19	41	22	16	3

during PBL on such a task, which reduces the workload on the scribe and redistributes the responsibility. Students in the same PBL group can simultaneously log onto the same cloud document, which is displayed on the shared screen in the PBL tutorial. Students can contribute text, multimedia files, or other information resources such as the pdf file of a journal paper and a link to a website, and these contributions will be reflected in the cloud document in real time. Such sharing of responsibility can potentially allow the students to monitor their cognitive process and learn socially during the process of collaborative note-taking (Silander, Sutinen, & Tarhio, 2004). Therefore, our results suggest that 42–64 % of the students are practicing this (Fig. 6.4). But the authors, being PBL facilitators in the same faculties as the respondents, have noticed that the spread of the use of cloud computing for collaborative learning is a very recent phenomenon among the students. It was not frequently observed 1 year before this study but is now observed among almost half of the PBL groups.

6.3.4 Recommendations on the Student Use of Mobile Devices in PBL

Based on our findings, the following recommendations are proposed for the ever-changing mobile learning environment in PBL.

All students in PBL should be free to choose to use their mobile devices.

Our survey showed that students want to take control of their own learning during PBL. Therefore, all students in a PBL group should have the choice of using their own choice of mobile devices. Moreover, by having more than one student using mobile devices, they can share the responsibility of creating PBL notes, by contributing text, multimedia files, or further information sources.

*Mobile devices should be used for educational purposes only, such as the search for factual information (*e.g., *definitions of terms, epidemiological data) or multimedia files during PBL.*

Our survey data found that most of the learning activities done with mobile devices were concerned with the search for information or multimedia files (Fig. 6.4). The information sources can be the learning materials already provided by the teachers or the schools. These materials could be in an electronic form on the mobile devices of the students or stored in learning management systems like Moodle. Retrieving such information will help the students' reflection on previously learned material and should be encouraged. But even when the students are using their mobile devices to search the Internet for materials that they have not previously learned, the new information can also provide relevant materials that fuel the PBL discussion. Multimedia files are also useful during PBL because they can demonstrate new information or concepts visually or audibly. Illustrations of complicated ideas and processes, such as biochemical pathways or management protocols, can facilitate visualization and co-construction of knowledge. The visualization helps students better elaborate and expand their knowledge with the group.

To a certain extent, the self-directed learning, which was done mostly outside of the PBL tutorial before the advent of mobile devices, is now done by the students during the PBL tutorials. But simultaneously searching for (and reading of) new information and taking part in the PBL discussion could prevent the students from fully taking part in the brainstorming of ideas and the co-construction of understanding and knowledge. Such cognitive overload can negatively affect their learning (Mayer & Moreno, 2003), even if the tasks the students are engaged in are related to learning. Moreover, there is evidence that students engaging in using their mobile devices in activities not related to learning (such as instant messaging, using Facebook) do not do well in finishing their school work and in their academic achievements (Junco & Cotten, 2010, 2012).

PBL tutorial time should mostly be spent on discussion, instead of searching for information.

Learning is not merely about taking in new information (Leung & Chan, 2003). In a PBL tutorial in which students are busy searching information and the discussion is flooded with new information, learning does not necessarily occur. The situation is somewhat similar to that in a traditional didactic lecture aimed at transmitting information, which just promotes surface learning among the students (Trigwell, Prosser, & Waterhouse, 1999). It is through understanding how information can be used and applied to the problems at hand that higher level learning occurs.

The problem solving in PBL can be divided into five stages: problem identification, problem description, problem exploration, applicability, and integration (Chan et al., 2012; Kamin et al., 2003). The processes in each of these five stages include:

1. Problem identification: identify new problem-related information.
2. Problem description: discuss ambiguities or facts to clear them up; push limits of knowledge; drawing on personal experience.
3. Problem exploration: link facts or ideas; interpret data; synthesize available information; develop working hypotheses; justify, compare, and rank hypotheses.
4. Applicability: discuss practical utility or concerns about approach to the patient, laboratory orders, or treatment.
5. Integration: report or synthesize learning issues with application to the problem; link findings after self-study to hypotheses; generalize to broader application.

Although mobile devices allow students to gain immediate access to vast amounts of information, many of the stages in the problem-solving processes in PBL rely on discussion among the participating students, e.g., linking facts and ideas, synthesizing available information, compare and rank differential diagnoses, discuss practical approaches to patients and applying new information to problems at hand.

Moreover, excessive engagement in information searching during PBL can distract the students from the ongoing discussion. After students search for information on their mobile devices, they need to spend time to select the few more promising sources and then try to read and understand their contents. Then, they need to judge whether the new information is useful in relation to the PBL cases by trying to integrate the new information into the current discussion. The students need to achieve all these tasks while active discussion is going on among the other students. This is in fact the reason why some of the student in the survey deliberately chose not to use their mobile devices and why some facilitators explicitly discouraged the use of mobile devices in their facilitated PBL tutorials (Chan et al., 2015). The congruence is not coincidental and is supported by the evidence in the literature on the negative effects of multitasking on learning (Junco & Cotten, 2010, 2012; Mayer & Moreno, 2003).

Therefore during PBL, there is competition for the students' attention between searching on their mobile devices for information and focusing on the ongoing discussion. Since much of the learning of problem-solving skills depends on actively taking part in the ongoing discussion, information searching on mobile devices should be limited. Individual teachers will have to rely on their experience, judgement, and skill to help students use the information found on mobile devices in facilitating the discussion. This kind of approach, aimed at change student conception, instead of merely transmitting more information, will promote a deeper approach in student learning, resulting in achieving higher quality learning outcomes (Trigwell, Prosser, & Waterhouse, 1999).

Students should be encouraged to use cloud-based services for collaborative activities such as note-making and concept mapping in PBL.

Students should be encouraged to utilize cloud-based services or collaborative software to establish an environment suitable for group learning in PBL. The co-construction of group notes can draw students' attention to the ongoing discussion, and make them aware what has been discussed.

A recent study by Silander, Sutinen, & Tarhio (2004) reported that students think it is fun and easy to create the concept map together with other students using mobile phones. The collaborative concept map building can visibly present concepts and relationships between concepts during the construction process and is the basis for further knowledge building (Silander, Sutinen, & Tarhio, 2004).

6.4 Conclusions

The findings from the present study showed that almost all of the surveyed health sciences students are using mobile devices in PBL, mostly for learning purposes related to the PBL discussion. The students used their mobile devices mostly for the search of information, and less so for the synthesis of information and for specific software on these devices, especially those for the visualization of knowledge, such as atlases or software for the creation of concept maps. Although mobile devices can assist learning, excessive use can actually distract students from the ongoing PBL discussion, which is more important for the learning of problem-solving skills. Attempts to multitask by searching information on one hand and taking part in PBL discussion may have a negative effect on student learning, as supported by the literature on the effects of multitasking on learning.

Based on the findings of this study, we suggest that in PBL, students should be free to choose to use their mobile devices, but they should limit the use of the mobile devices for learning purposes only, such as the search for information that can provide substrate for the PBL discussion. Moreover, even such use should be limited so that most of the PBL tutorial time could be spent on discussion, on understanding the information, and how such information can be applied to solve the clinical case.

Collaboration among students during PBL tutorial in note-taking and concept mapping can be greatly facilitated by cloud-based services.

It seems inevitable that learning with mobile devices will become an essential process in PBL and we believe that educational technologies will continue to develop to cater for the learning needs of students in the twenty-first century. This study only provides an overview of the pattern of use of mobile devices among students of health sciences students, without examining in detail how students use their mobile devices in the PBL process and how the learning processes could be affected, positively or negatively, by the ways mobile devices are used. These could well be the direction for future research on the use of educational technologies in PBL. But this is a truly dynamic field since rapidly evolving technologies may mean mobile devices in the not too distant future may afford other learning opportunities not currently possible.

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Chapter 7
Are Wikipedia Articles Reliable Learning Resources in Problem-Based Learning Curricula?

Samy A. Azer

7.1 Introduction

Since its creation, Wikipedia has evolved as an important resource for patients, the general public, students and health professionals. Wikipedia is the largest online encyclopaedia with 4,541,520 articles in English (English Wikipedia, 2014). Important features of Wikipedia may include: (1) it is available free of charge for everyone without prior registration or membership; (2) it covers different aspects of knowledge and entertainment including arts, biography, geography, history, mathematics, science, society, technology, business and health; (3) it enables users to add their contributions and therefore these tools get enriched as more people use them; and (4) it has been seen by the general public, students, and health professionals as important sources for information.

With the changes introduced to medical curricula such as the introduction of problem-based learning (PBL) and the accommodation of self-regulated learning as part of the curriculum design, it has been noted that most medical students tend to search easily accessible online resources such as Google, and Wikipedia websites for their 'learning issues' (Alegría, Boscardin, Poncelet, Mayfield, & Wamsley, 2014; Patil et al., 2014; Petty, 2013). While the new changes in the curriculum aimed at enhancing students' skills to critically search for knowledge from several resources rather than study the content of a particular textbook, the development of technology and its availability have shifted students' search for knowledge from paper-based resources to online resources. Although several online resources have been created for medical and health professionals such as Medscape (eMedicine),

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UpToDate Inc., the Merck Manual Medical Library and PubMed (Azer, 2014; Tyson, 2000), there is evidence that medical students usually prefer to start by searching general online resources such as Google and Wikipedia to find answers for their queries (Kingsley et al., 2011). There is also evidence that physicians use the Internet far more than the general public (Masters, 2008). The work of Hughes, Joshi, Lemonde, and Wareham (2009) showed that 53 % of Internet visits were made by junior physicians and were directed mainly to Google and Wikipedia. Despite awareness of participants about information credibility risks related to these online resources and the risk of poor quality information obtained, the junior physicians in the study preferred easily accessed resources such as those provided by Wikipedia. They viewed Wikipedia and Google as important sources of medical information. These views have also been found to apply to medical and allied health students (Guarino et al., 2014; Kolski, Arlt, Birk, & Heuwieser, 2013; Prasannan, Gabbur, & Haughton, 2014).

However, these online resources may not be created by academics or qualified experts. Furthermore, both Wikipedia, and YouTube do not appoint expert editors to assess work submitted and materials are published online without prior peer-review or expert evaluation. The absence of prior review in assessing the quality and the scientific content of Wikipedia articles raises several questions regarding the adequacy and scientific accuracy of these resources. Two recent studies showed that physicians using online resources may become less vigilant towards potential errors even when it contradicts their existing knowledge (Lau & Coiera, 2008; Westbrook, Gosling, & Coiera, 2005). Recently Schmidt et al. (2014) demonstrated that media information about a disease gained from a source such as Wikipedia can cause internal medicine residents to misdiagnose similar-looking clinical cases. The problem of availability bias may arise from exposure to media-provided information about a disease, causing diagnostic errors (Schmidt et al., 2014). The bias's effect is apparently associated with nonanalytic reasoning and can be counteracted by reflection. By this, we mean the tendency of residents to make shortcuts and jump into conclusions without careful analysis, possibly due to the effect of fast knowledge obtained from media information.

Despite their wide use by medical students and junior doctors, there are limited studies exploring the accuracy of these learning resources and whether they have attained the standards required in scholarly/academic resources. To determine the suitability of Wikipedia articles for medical students as a source for information, it is important to determine whether articles are scientifically accurate, up-to-date, free from errors and whether there are no gaps or deficiencies in the information provided. Also, it is important to determine their suitability for medical students and whether they are written at a reading level appropriate for college students rather than for lay persons in the general public. Therefore, the purpose of this study was to evaluate the suitability of the nervous system articles available on the English-language Wikipedia that might be used by medical students as part of their learning resources. To answer this question Wikipedia articles were assessed with respect to: (1) scientific accuracy and comprehension; (2) frequency of updating and quality of references; (3) reliability; and (4) readability.

7.2 Methods

This study analysed the nervous system articles on the English Wikipedia database (http://en.wikipedia.org).

7.2.1 Wikipedia Articles

7.2.1.1 Study Design

To identify the topics on the nervous system and its disorders, five medical textbooks (Table 7.1) and eMedicine (Medscape) website (www.emedicine.com) were searched. These books were used because they are recommended by most medical schools, have been reviewed in peer-reviewed journals such as the British Medical Journal and the New England Medical Journal, have been written and edited by medical experts, are regularly updated every 3–4 years, and several editions have been produced over the past 30–60 years. eMedicine (Medscape) is a professional educational website written and regularly updated by medical consultants and eminent clinicians.

The aims of searching these resources were to: (1) ensure that topics needed by medical students in their undergraduate course in relation to the nervous system have been identified and included in the search; and (2) use these resources as standardized reference in the assessment of the accuracy and quality of information provided in Wikipedia articles. The chapters on the nervous system were revised and key topics were identified by three evaluators (the author, a medical consultant and professor of medical education, plus two medical graduates). The lists of identified key topics were discussed in a meeting. The three evaluators agreed upon a final list covering 42 topics.

Table 7.1 Medical textbooks used as a standardized reference in evaluating Wikipedia articles

Andreoli TE, Benjamin IJ, Griggs RC, Ewing EJ, Andreoli and Carpenter's Cecil Essentials of Medicine. 8th Edition, Philadelphia: Saunders, 2010
Colledge NR, Walker BR, Ralston SH. Davidson's Principles & Practice of Medicine, 21st Edition, Edinburgh: Elsevier, Churchill Livingstone, 2010
Kumar P, Clark M. Kumar and Clark's Clinical Medicine. 8th Edition. Edinburgh: Elsevier, 2013
Longo Dl, Fauci AS, Kasper DL, Hauser SL, Jameson JL, Loscalzo J. Harrison's Principles of Internal Medicine. 18th Edition. New York: McGraw-Hill, 2012
McPhee SJ, Papadakis MA, Rabow MW. Current Medical Diagnosis & Treatment. 50th Anniversary Edition, New York: McGraw-Hill, Lange, 2011

7.2.1.2 Searching Wikipedia

The Wikipedia website (http://en.wikipedia.org/wiki/Wikipedia) was searched on 20 May 2014 for the 42 topics. Topics were printed out and a photocopy was given to each evaluator. The aim of using a photocopied version of the articles rather than the electronic version was to ensure that all evaluators were using the same version. This is particularly important as Wikipedia articles undergo continuous changes.

7.2.1.3 Instrument Used in Assessing Accuracy

The rating instrument used in this study was a modified version of the DISCERN instrument (Azer, 2014, see Appendix C for the modified version used). The DISCERN project was funded by the British Library and the NHS Executive Research and Development Program from 1996 to 1997 (DISCERN Project, 1999). The instrument consists of 15 questions, plus a question about the overall evaluation of the document, and was designed for the evaluation of the different aspects of healthcare related websites and information about treatment options. For example, the DISCERN instrument was used in assessing online resources on epidural anesthesia (Jaffe, Tonick, & Angell, 2014), mental health (Grohol, Slimowicz, & Granda, 2014), colorectal cancer (Grewal & Alagaratnam, 2013), and inflammatory bowel disease (Van der Marel et al., 2009).

However, the original DISCERN instrument is not suitable for evaluating Wikipedia articles as it was not designed to assess scientific accuracy in given information, the inclusion of illustrations, figures, tables or multimedia to support the topics or whether there are gaps or deficiencies in the information given. These deficiencies drove the need to modify the DISCERN instrument as discussed in an earlier publication (Azer, 2014). The modified DISCERN instrument is comprised of ten questions and aims at providing a comprehensive assessment of Wikipedia articles in regard to: (1) aims of the article and the adequacy of subtitles used; (2) scientific accuracy of information provided and if there were any personal views; (3) degree of balancing of different parts, and whether sources of information were provided; (4) regular updating the article and if there were gaps or deficiencies in the article that need to be completed; (5) images, figures and tables provided; and (6) the overall rating of the article.

The original DISCERN scoring system has been used. Each question is rated on a 5-point scale, where 1 corresponds to ‘no’, 3 corresponds to ‘partially yes’, and 5 corresponds to ‘yes’. For the last question, 1 corresponds to ‘serious or extensive shortcomings’, 3 corresponds to ‘potentially important but not serious shortcomings’, and 5 corresponds to ‘minimal shortcomings’.

7.2.1.4 Piloting the Study

Prior to applying the instrument to the Wikipedia articles, the use of the modified DISCERN instrument was piloted with the aim to: (1) orient the evaluators to the different items of the instrument and the scoring system; (2) ensure that evaluators were able to use the instrument; and (3) enhance the evaluators skills in applying the instrument through feedback on their assessment. For piloting purpose, ten Wikipedia articles other than those included in the study were selected and each evaluator was asked to evaluate them using the instrument independently. Articles that were scored differently were discussed and a resolution was reached.

Ten additional Wikipedia articles were selected and were again evaluated by the three evaluators using the modified DISCERN instrument as described earlier. The agreement between the evaluators was in the range of 75–85 %, which was considered satisfactory.

7.2.1.5 Assessing Wikipedia Articles on the Nervous System

The 42 articles identified were evaluated independently by the three evaluators using the modified DISCERN instrument. Interrater agreement between the evaluators for each item in the modified DISCERN instrument was calculated using Cohen's kappa score (Kharbanda et al., 2012; Tsivgoulis et al., 2013).

7.2.1.6 Assessing References

The list of references at the end of each article was evaluated by the three evaluators independently. The aims of evaluating the references were to assess if the authors used appropriate resources to construct each article and what type of references they used. Therefore, the following points were considered in the evaluation: total number of references; number of peer-reviewed journals; number of educational guidelines and proceedings from professional societies, textbooks, professional and general websites; and others (such as news and media). Articles written for academic purposes need to rely on up-to-date, peer-reviewed references such as scientific/medical articles, educational guidelines and proceedings produced by professional societies rather than cite general references such as general websites, non-peer-reviewed articles, magazine articles, and news.

7.2.1.7 Frequency of Wikipedia Article Updates

Resources written for academic purposes are expected to be regularly reviewed and updated. Such reviews usually aim at enhancing the quality of content, adding up-to-date information and recent developments as well as related references. The frequency of updating articles was assessed through the 'view history' button next to 'search' at the top right part of each article. Information collected included: (1) date created; (2) total number of revisions; (3) total number of authors; (4) average time between edits; (5) average edits per month; (6) revisions in the last 12 months; and (7) average edits per user.

7.2.1.8 Assessing Readability

The aim of assessing the readability was to evaluate whether the reading level was appropriate for medical students. Two methods were used in assessing readability: Flesch-Kincaid grade level and Coleman-Liau index (Vargas, Chuang, Ganor, & Lee, 2014). The score of readability is an indicator of the number of years of education that a person needs to be able to understand the text on the first reading. For example, a score of ten indicates that a tenth grade student can easily understand the topic. An online calculator, provided by Readability Formulas (http://www.readabilityformulas.com/free-readability-formula-tests.php), was used. Based on the instructions given, a random sample of 150—60 words were copied from the beginning, middle and the end of each article and placed into the space provided by the programme. Headings, external links, images and numbers of citations were omitted from the text used prior to conducting the calculation. The reading scores for each part were recorded and the mean and standard deviation were calculated for each article.

7.2.2 Statistical Analysis

The mean, standard deviation, minimum and maximum were calculated. To assess the degree to which different evaluators agreed in their assessment, the Cohen's kappa interrater reliability was calculated. Correlation between the DISCERN scores and the number of updates and number of peer-reviewed references were also calculated. The aim was to assess whether the number of updates, the number authors/reviewers and references were related to the improvement of the article quality or not.

7.3 Results

7.3.1 Depth and Accuracy of Articles

Table 7.2 summarizes the number of pages, the scores calculated using the modified DISCERN instrument and the number of images, illustrations, tables and media/audios of each Wikipedia article. The number of pages ranged from one page for the article on smell to 36 pages for the article on stroke indicating that topics varied in regard to details given and depth of discussion. Also, this may be because some articles were incomplete, had gaps or deficiencies in their content and needed further work. Considering the number of pages of articles and the frequency of updating/reviewing since first created, there is evidence that some topics were of less interest to Wikipedians and were less frequently reviewed or improved compared to other articles.

Table 7.2 Accuracy score, number of images, illustrations, tables, readability scores and number of references of each Wikipedia nervous system article included in the study

Topic title	Number of pages	Accuracy score (mean ± SD)	Number of images/ illustrations	Number of audios/ media/videos	Number of tables	Total	Readability Flesch-kincaid grade level (mean ± SD)	Readability Coleman-Liau Index (mean ± SD)	Total references	External links (EL)/ Further reading (FR)
Amyotrophic lateral sclerosis	20	33.67 ± 1.15	1 Illustration 2 MRI scans	1	2	6	13.80 ± 3.40	13.00 ± 2.00	88	2 EL
Ataxia	12	26.33 ± 1.52	0	0	0	0	16.90 ± 1.60	15.00 ± 2.00	37	17 EL 2 FR
Autonomic nervous system	12	23.33 ± 1.15	1 Illustration	0	11	12	17.90 ± 1.65	14.33 ± 1.15	20	5 EL
Basal ganglia	14	29.00 ± 1.00	5 Illustrations 2 Pathology	1	1	9	15.56 ± 2.15	12.33 ± 2.08	24	4 EL
Brainstem	7	29.00 ± 1.00	9 Pathology	1 Media related	0	10	12.40 ± 0.55	12.67 ± 0.57	4	7 EL
Brainstem glioma	7	22.00 ± 1.00	0	0	0	0	12.23 ± 1.81	13.67 ± 1.15	28	6 EL 5 FR
Broca's area	9	18.67 ± 0.57	3 Illustrations	1 Media related	1	5	15.90 ± 2.94	13.33 ± 2.51	24	4 EL
Cerebellum	27	32.67 ± 1.52	18 Illustrations	1 Media related	0	19	15.10 ± 2.49	12.00 ± 1.73	69	2 EL 3 FR
Cerebral circulation	4	24.33 ± 0.57	3 Illustrations	0	0	3	15.03 ± 2.40	14.67 ± 2.51	0	2 EL
Cerebral hemisphere	6	22.00 ± 1.00	4 Illustrations	1 Media related	1	6	13.86 ± 1.58	15.67 ± 0.57	8	0
Cerebrospinal fluid	11	26.00 ± 1.00	1 Photo 5 Illustrations	2 Media related	0	8	11.80 ± 2.10	11.33 ± 1.15	25	3 EL
Coma	11	26.67 ± 0.57	1 Photos	2 Videos	1	4	15.26 ± 1.45	11.67 ± 2.08	26	0 EL
Cranial nerves	20	30.33 ± 1.52	27 Illustrations 1 Pathology	1 Media related	1	30	13.90 ± 1.64	10.00 ± 1.00	33	5 EL

(continued)

Table 7.2 (continued)

Topic title	Number of pages	Accuracy score (mean ± SD)	Number of images/ illustrations	Number of audios/ media/videos	Number of tables	Total	Readability Flesch-kincaid grade level (mean ± SD)	Readability Coleman-Liau Index (mean ± SD)	Total references	External links (EL)/ Further reading (FR)
Dementia	26	28.67 ± 0.57	2 Illustrations	0	1	4	11.46 ± 2.05	11.33 ± 2.51	79	1 EL
			1 Map distribution of disability-aged life year for Alzheimer							
Dizziness	4	24.67 ± 4.72	0	0	0	0	15.16 ± 5.68	15.67 ± 4.72	11	2 EL
Duchenne muscular dystrophy	16	35.33 ± 1.52	1 Illustration	1 Media related	0	3	12.63 ± 0.80	12.33 ± 0.57	45	5 EL
			1 Histopathology							
Encephalitis	5	21.00 ± 1.00	1 MRI Scan	0	0	1	16.40 ± 5.99	17.33 ± 2.30	7	4 EL
Encephalopathy	4	15.00 ± 1.00	0	0	0	0	17.30 ± 2.45	17.00 ± 2.64	3	1 EL
										1 FR
Epilepsy	26	33.33 ± 1.52	3 Photos	1 Media related	0	8	11.66 ± 1.96	11.67 ± 1.15	123	1 EL
			2 Illustrations	1 Video						2 FR
			1 Map-epidemiology							
Ganglion	3	16.67 ± 0.57	1 Histopathology	0	0	2	14.83 ± 0.47	14.00 ± 1.00	6	0 EL
			1 Photo							
Hearing	7	23.67 ± 1.52	2 Illustrations	0	0	2	11.7 ± 1.45	13.33 ± 1.52	15	3 EL
										2 FR
Lower motor neuron lesion	2	17.33 ± 0.57	1 Illustration	0	0	1	16.63 ± 3.35	17.00 ± 2.00	1	1 EL
Meningitis	22	27.00 ± 1.00	2 Illustrations	0	1	7	15.06 ± 1.74	12.67 ± 1.15	71	2 EL
			2 Photos							
			1 Microbiology							
			1 Histopathology							

Motor neuron	5	22.00 ± 1.00	1 Histopathology	0	1	2	17.00 ± 5.04	14.00 ± 2.00	5	2 FR
Multiple sclerosis	28	38.00 ± 1.00	2 MRI Scans	0	0	13	13.90 ± 1.65	12.00 ± 1.73	114	2 EL
			1 Histopathology							1 FR
			7 Illustrations							
			2 Photos							
			1 Map-epidemiology							
Myasthenia gravis	14	30.00 ± 1.00	2 Photos	0	0	9	15.96 ± 2.75	14.67 ± 1.15	30	4 EL
			5 Illustrations							
			1 Photo							
			1 CT-Scan							
Myelin	6	29.00 ± 1.00	2 Illustrations	0	0	3	12.06 ± 1.27	13.33 ± 1.15	13	9 EL
			1 Photo							
Myopathy	5	24.67 ± 0.57	0	0	0	0	11.00 ± 1.63	12.33 ± 0.57	5	2 EL
Neuromuscular junction	10	29.67 ± 1.52	1 Photo	0	0	3	15.10 ± 1.82	15.33 ± 2.08	16	1 EL
			2 Illustrations							3 FR
Neuron	19	31.67 ± 1.52	8 Illustrations	1 Media related	0	12	14.13 ± 2.00	11.33 ± 0.57	26	10 EL
			3 Histopathology							6 FR
Olfaction	13	24.67 ± 0.57	2 Photos	1 Media related	0	5	14.73 ± 0.90	13.67 ± 0.57	41	14 EL
			2 Illustrations							1 FR
Parkinson's disease	30	29.67 ± 1.52	4 Illustrations	0	0	14	15.93 ± 1.85	14.67 ± 1.15	111	4 EL
			7 Photos							
			2 MRI Scan							
			1 Map-epidemiology							
Peripheral neuropathy	10	26.33 ± 0.57	1 Photo	0	0	1	16.63 ± 4.30	15.67 ± 3.05	25	2 EL
Sensory neuron	5	15.67 ± 0.57	0	0	0	0	15.60 ± 2.35	13.33 ± 1.52	11	0 EL

(continued)

Table 7.2 (continued)

Topic title	Number of pages	Accuracy score (mean ± SD)	Number of images/ illustrations	Number of audios/ media/videos	Number of tables	Total	Readability Flesch-kincaid grade level (mean ± SD)	Readability Coleman-Liau Index (mean ± SD)	Total references	External links (EL)/ Further reading (FR)
Smell	1	10.33 ± 0.57	0	0	0	0	No enough text to test	No enough text to test	0	0 EL
Spinal cord	13	23.67 ± 0.57	16 Illustrations	1 Media related	0	21	11.53 ± 1.35	10.67 ± 0.57	2	7 EL
			4 Photos							
Spinal cord injury	20	31.00 ± 1.00	3 Illustrations	0	0	5	14.56 ± 1.38	12.33 ± 1.15	71	4 EL
			2 Photos							
Stroke	36	36.00 ± 1.00	1 Photo	1 Media related	0	12	13.66 ± 2.11	11.67 ± 0.57	158	1 EL
			1 Map-epidemiology							2 FR
			1 ECG							
			3 CT-Scan							
			1 Pathology							
			2 Illustrations							
			2 Histopathology							
Taste	21	23.67 ± 0.57	1 Illustration	1 Media related	0	2	10.96 ± 1.30	11.33 ± 0.57	87	3 EL
										21 FR
Upper motor neuron lesion	2	22.00 ± 1.00	1 Illustration	0	0	1	14.13 ± 1.85	12.67 ± 0.57	3	2 EL
Vertigo	9	27.33 ± 1.15	0	1 Media related	0	1	15.06 ± 4.45	12.00 ± 2.00	38	0 EL
Wernicke's area	5	22.67 ± 0.57	1 Illustration	1 Media related	0	2	16.00 ± 1.50	13.67 ± 0.57	14	0 EL

The minimum DISCERN score was 10.33 ± 0.57 (mean ± SD) for the article titled 'smell' and the maximum score was 38.00 ± 1.00 for the article titled 'multiple sclerosis'. The mean score for the 42 articles was 25.88 ± 5.97. To summarize the scores, there were 10 articles scoring 30 or higher, 26 articles scoring 20–29, and 6 articles 10–19 (the maximum score was 50). Top scored articles such as the article on 'multiple sclerosis' was covered on 28 pages, had 13 images, illustrations and photos, 114 references, 2 external links and one further reading. Also the article on 'stroke' scored 36.00 ± 1.00, was covered on 36 pages, had 12 images, illustrations, photos and media related, 158 references, 1 external link and 2 further readings.

On the other hand, articles with the lowest scores such as the article on 'smell' scoring 10.35 ± 0.57 was one page only, had no images, illustrations, tables, photos or multimedia. Also the article had no references or external links. The article on 'encephalopathy' is another example, scoring 15.00 ± 1.00, had no images, illustrations, photos or tables, only three references, one external link and one further reading. It was not possible to measure the readability for articles comprised of one page only.

Although the articles followed the template of Wikipedia for medical/health related articles, some articles were incomplete and most articles were deficient in the areas of: (1) disease pathogenesis; (2) clinical picture; and (3) management of nervous system diseases. Agreement between evaluators was calculated by Cohen's kappa interrater correlation; the range for the mean ± SD for the scores were 0.65 ± 0.10 to 0.79 ± 0.12.

7.3.2 Article References

Table 7.2 summarizes the total number of references, external links and further readings for each Wikipedia topic. The total number of references for the 42 articles was 1517 and the number varied from 0 to 158 references; 36.12 ± 38.82 (mean ± SD). There was weak correlation between the DISCERN scores and the number of total references. This suggests that the absolute number of references was not a good measure for assessing the quality of an article. This is particularly important as not all references were peer-reviewed articles and educational guidelines produced by professional bodies were lacking in the list of references in most articles.

Common problems found in citations and the list of references can be summarized as follows: (1) citation of wrong references, and failing to cite the appropriate references; (2) incomplete references (for example, missing journal or book title, missing year, volume or page numbers); (3) inconsistencies in the way the references are written; (4) failure to include guidelines of professional societies/associations; and (5) several statements in articles are missing appropriate references as in-text citations.

7.3.3 Frequency of Revisions

Table 7.3 summarizes key information about articles, their history in regard to date created, number of revisions, number of authors, average time between edits, edits per month and in the last 12 months. It is obvious from the article's history that the date of creation varied. For example, while the earlier article 'stroke' was created on the 16th of April 2001, the most recent article 'brainstem glioma' was created on the 25th of January 2008.

While there was moderate correlation between the DISCERN score and the total number of revisions ($R^2=0.38$) and the total number of authors ($R^2=0.42$), there was weak correlation between the DISCERN score and the average edits per month ($R^2=0.10$).

7.3.4 Article Readability

To calculate readability, two methods were used. Table 7.2 shows the readability scores (mean ± SD) for each article as calculated by Flesch-Kincaid grade level and Readability Coleman-Liau index. The range of readability using the first method was in the range of 10.96 ± 1.30 to 17.90 ± 1.65, while the second method showed a range of 10.00 ± 1.00 to 17.33 ± 2.30. The article on 'smell' did not have enough text to calculate readability. A good correlation was found between the scores calculated by the two methods, $R^2=0.650$. The mean score for all articles was 14.21 ± 2.91 on using the first method and 13.02 ± 2.74 for the second method. These scores of readability indicate that Wikipedia articles were geared to college level.

7.4 Discussion

The aim of this study was to evaluate the quality and accuracy of content of Wikipedia articles as learning resources commonly used by medical students. To evaluate these resources, we specifically evaluated the accuracy, clarity, quality of information and readability of Wikipedia articles on the nervous system. A total of 42 Wikipedia articles covering the nervous system diseases were evaluated using the modified DISCERN instrument (Azer, 2014).

Although Wikipedia articles followed the template created by Wikipedia for medical/health articles, most articles were deficient in addressing disease pathogenesis, clinical picture, and management of nervous system diseases. The accuracy of articles as measured by the modified DISCERN instrument had a mean score of 25.88 ± 5.97; only ten articles scored 30 or higher and over 50 % of articles scored 20–29 out of 50. Although images, illustrations, photos, and multimedia were incorporated in some articles to enhance the educational value of articles, the quality of

Table 7.3 Wikipedia articles on the nervous system: article history, date created, latest edit, number of revisions, number of authors, and frequency of revisions

Number	Topic title	Page size (Bytes)	Date created	Total number of revisions	Total number of distinct authors	Average time between edits (days)	Average edits per month	Revision in last 12 months	Average edits per user
1	Amyotrophic lateral sclerosis	75,414	28 January 2003	3267	1678	1.3	24	339	1.9
2	Ataxia	35,361	3 June 2001	666	419	7.1	4.3	41	1.6
3	Autonomic nervous system	31,031	6 January 2003	984	620	4.2	7.2	68	1.6
4	Basal ganglia	40,320	4 October 2002	829	366	5.1	5.9	76	2.3
5	Brainstem	15,309	25 May 2003	725	409	5.5	5.5	103	1.8
6	Brainstem glioma	20,187	25 January 2008	87	52	26.2	1.2	10	1.7
7	Broca's area	25,025	21 February 2002	428	265	10.3	3	29	1.6
8	Cerebellum	75,828	25 April 2002	1738	760	2.5	11.9	131	2.3
9	Cerebral circulation	6291	18 July 2004	51	34	70.5	1	2	1.5
10	Cerebral hemisphere	8864	18 December 2003	333	218	11.4	2.7	32	1.5
11	Cerebrospinal fluid	26,331	2 January 2002	589	377	7.7	3.9	54	1.6
12	Coma	34,236	2 June 2001	1156	814	4.1	7.4	93	1.4
13	Cranial nerves	47,486	3 February 2002	1263	710	3.6	16	286	1.8
14	Dementia	85,002	8 February 2002	2124	1142	2.1	10	248	1.9
15	Dizziness	6828	1 June 2004	326	221	11.2	2	17	1.5
16	Duchenne muscular dystrophy	45,210	10 September 2004	1627	860	2.2	5	43	1.9

(continued)

Table 7.3 (continued)

Number	Topic title	Page size (Bytes)	Date created	Total number of revisions	Total number of distinct authors	Average time between edits (days)	Average edits per month	Revision in last 12 months	Average edits per user
17	Encephalitis	11,287	25 February 2002	843	541	5.3	12	68	1.6
18	Encephalopathy	7163	7 December 2003	228	161	16.3	0	18	1.4
19	Epilepsy	82,991	20 January 2002	4074	1690	1.1	16	838	2.4
20	Ganglion	4135	28 May 2001	282	202	16.8	5	29	1.4
21	Hearing	15,794	29 September 2003	927	527	4.2	7	85	1.8
22	Lower motor neuron lesion	3089	6 May 2007	51	39	50.4	2	9	1.3
23	Meningitis	72,591	25 February 2002	3390	1573	1.3	4	122	2.2
24	Motor neuron	10,489	29 November 2002	410	247	10.3	6	51	1.7
25	Multiple sclerosis	85,774	20 October 2001	4979	1929	0.9	6	333	2.6
26	Myasthenia gravis	36,120	2 May 2001	981	522	4.9	3	38	1.9
27	Myelin	15,785	28 May 2001	555	353	8.3	20	53	1.6
28	Myopathy	8880	21 February 2005	161	112	20.3	0	4	1.4
29	Neuromuscular junction	29,492	26 May 2004	391	197	9.3	1	24	2.0
30	Neuron	52,220	6 November 2001	2904	1555	1.6	10	177	1.9
31	Olfaction	39,512	16 December 2002	925	568	4.5	4	63	1.6
32	Parkinson's disease	101,655	22 July 2001	6248	2003	0.8	3	73	3.1
33	Peripheral neuropathy	27,879	20 April 2004	509	255	7.3	1	78	2.0

34	Sensory neuron	11,178	27 July 2004	290	175	12.3	1	28	1.7
35	Smell	275	25 November 2002	665	410	6.3	6	22	1.6
36	Spinal cord	30,613	30 January 2002	1382	842	3.3	13	79	1.6
37	Spinal cord injury	62,444	10 October 2004	1062	474	3.3	0	96	2.2
38	Stroke	115,479	16 April 2001	3425	1636	1.4	2	150	2.1
39	Taste	65,554	2 April 2002	2086	1112	2.1	10	114	1.9
40	Upper motor neuron lesion	3615	30 January 2005	81	55	40.7	0	4	1.5
41	Vertigo	28,227	04 September 2005	1258	685	2.5	23	99	1.8
42	Wernicke's area	11,390	21 March 2004	231	176	16	0	23	1.3

these images/illustrations were not at the standards expected of educational resources and the images used were not labelled to explain radiological, microbiological and pathological changes.

As indicated by the Wikipedia administrators, several articles were incomplete. These deficiencies may be summarized as follows: (1) articles in their early stages, for example, the articles on ‘peripheral neuropathy’, ‘brainstem’, ‘autonomic nervous system’, ‘Broca’s area’, ‘encephalopathy’, ‘motor neuron’, ‘lower motor neuron lesion’, ‘smell’, and ‘spinal cord’; (2) articles showing deficiencies in some content or needing tables, images, illustrations or media to make the message meaningful and enhance their educational value, for example, the articles on ‘brainstem glioma’, ‘dizziness’, ‘encephalopathy’, ‘myopathy’, ‘sensory neuron’, ‘smell’, ‘upper motor neuron lesion’; and (3) articles requiring the addition of proper citations for some statements, for example, the article on ‘sensory neuron’, and ‘encephalitis’. Although the number of references for the 42 articles was 1517, some articles had no references and a number of problems were identified in the list of references and the quality of references cited. Interestingly, none of the 1517 references was a Wikipedia citation. Recently, Bould et al. (2014) found that 1433 full text articles from 1008 journals indexed in Medline, PubMed or Embase with 2049 Wikipedia citations were accessed. They also found that the frequency of most citations occurred after December 2010. The Wikipedia citations were not limited to journals with a lower or no impact factor, but were in many journals with high impact factor. The authors warned journal editors and peer-reviewers to use caution when publishing articles that cite Wikipedia. The readability of Wikipedia articles was geared at college level indicating that the articles were not written for the public and the language used was suitable for the medical students.

It is obvious from recent research that Wikipedia has continuously worked to improve the quality of its medical/health content (Chiang et al., 2012; Rasberry, 2014). However, few articles meet the quality standards that medical schools would expect before recommending such resources to medical students. These findings have been reached when researchers evaluated Wikipedia ‘gastroenterology’ and ‘hepatology’ articles (Azer, 2014). A few researchers reported that Wikipedia articles are useful resources for patients with hand illness (Burgos, Bot, & Ring, 2012), and a reliable source for nephrology patients although written at a college reading level (Thomas, Eng, de Wolff, & Grover, 2013). It was also reported that Wikipedia was a prominent source of online health information compared to other online health information providers (Laurent & Vickers, 2009). Others reported that the quality of osteosarcoma related information in the English version of Wikipedia was inferior to the patient information provided by the US National Cancer Institute (Leithner et al., 2010).

The methods used in evaluating Wikipedia articles in this study aimed at providing a critique of accuracy, clarity, quality, and adequacy of content committed to nervous system articles. Three evaluators conducted the assessment of the Wikipedia articles and the methods were used in earlier publications (e.g., Azer, 2014). The agreement among evaluators had mean ± SD range of scores of 0.65 ± 0.10 to 0.79 ± 0.12.

Wikipedia articles need peer-review by experts and professionals. Harnad (1999) described peer-review as a quality control and certification process to ensure accuracy and validity of material produced in an academic environment. The results from this study show that most articles were updated regularly and the mean ± SD number of revisions of the 42 articles was 1298 ± 1418.00 and the average time between edits varied from 0.8 to 70.5 days; 10.15 ± 13.94 (mean ± SD). However, anonymous users of Wikipedia made approximately 30 % of edits. Generally, it is difficult to know the actual experience, level of education and skills of the Wikipedia articles.

Several suggestions have been made to improve the quality of editing of Wikipedia articles by doctors (Kint & Hart, 2012), experts and professionals who have specialized in the designated topic. Reavley et al. (2012) suggested that professional associations could create task forces for reviewing Wikipedia and even place an approval statement on acceptable articles. Wicks and Bell (2012) suggested that professional societies could nominate or suggest peer-reviewers that can take such responsibilities.

Recently, 'WikiProject Medicine' has been introduced where people interested in medical and health content on Wikipedia can discuss, collaborate or debate issues. Additionally, Wikipedia articles have also been categorised in regard to their status by administrators. For example, awarding of a golden star means 'Featured Article', or awarding of 'A' means Approved A-Class article etc. Details about Wikipedia categorisation are given on the following link (http://en.wikipedia.org/wiki/Category:FA-Class_medicine_articles). The aim of such categorisation is to help readers and editors/authors understand the relative status and possible veracity of the article.

The study reported in this chapter has several limitations; it evaluated only 42 Wikipedia articles and was limited to English-language topics on the nervous system. Therefore, generalization of these results to other medical or healthcare disciplines is not applicable. More work is needed in the future to evaluate Wikipedia articles on a wider range of medical and surgical diseases.

However, despite these limitations, this study raises important issues in the area of medical education and medical informatics particularly for problem-based learning programmes where self-directed learning is an important domain in the curriculum design (Artino, Cleary, Dong, Hemmer, & Durning, 2014). Expected directions in research in this area may include:

1. Expanding the evaluation of Wikipedia articles to other medical and surgical topics so that a conclusive evaluation of Wikipedia articles could be made.
2. Further assessment of the data provided by Wikipedia in regard to updating and revision of its articles in order to assess the quality of such revisions and understand why, despite recording higher numbers of revisions, articles were not at the standards required for an educational resource.
3. Assessing the impact of engaging medical students in reviewing Wikipedia articles and critically assessing them on their learning and understanding of topics evaluated and studied.

7.5 Conclusion

This is ongoing research; the findings from this study suggest that there were deficiencies and scientific errors in most Wikipedia articles evaluated. Considering the tendency of medical students to depend on Wikipedia in their learning, it may be necessary to educate students in critically engaging with online information by, for example, using guidelines such as the criteria used in this study in evaluating online resources. Given the expectation of medical teachers that students should take responsibilities of their self-regulated learning, Wikipedia articles could be a resource for critical evaluation and content improvement. These recommendations together with the need of medical schools to offer training to its students on how to select their learning resources is necessary.

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Part II

Educational Technologies in Clinical Contexts

Chapter 8
Learning Communication Skills for Dealing with Different Perspectives: Technologies for Health Sciences Education

Joachim Kimmerle, Martina Bientzle, and Ulrike Cress

8.1 Introduction

Knowledge in the fields of health and medicine is complex and sophisticated. A multitude of research endeavors worldwide contribute to its fast and sometimes confusing development (Sniderman & Furberg, 2009). Health knowledge originates from various sources and thus includes diverse perspectives on therapies and methods of treatment (Betancourt, Green, Carrillo, & Park, 2005; Glanz, Rimer, & Viswanath, 2008). Health care professionals continuously have to come to terms with these different perspectives when they deal with patients and laypeople (Fritzsche et al., 2014; Kenny et al., 2010), or when they communicate with colleagues in interdisciplinary contexts (Carty et al., 2012; O'Leary, Sehgal, Terrell, & Williams, 2012).

Different perspectives on therapy and health are typically expressed in people's *therapeutic health concepts* (Boorse, 1977). These health concepts represent a particular system of views, values, and norms and determine the perspective that people take on health and therapy. Two dominant paradigms that are prevalent among health care professionals are *biomedical* and *biopsychosocial* therapeutic health concepts (Bientzle, Cress, & Kimmerle, 2014a; Domenech, Sánchez-Zuriaga, Segura-Ortí, Espejo-Tort, & Lisón, 2011). Difficulties in communication can arise in the exchange of knowledge among health care professionals or between health

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care professionals and patients when they have conflicting health concepts. Dealing adequately with these communication problems is a competence that health care students should acquire as early as possible in their professional training (Bleakley, Bligh, & Browne, 2011; Kurtz, Silverman, & Draper, 2005). Such learning includes recognizing and understanding different health perspectives, as well as taking the health concepts of their communication partners into account when they want to express their own attitudes and knowledge. In this chapter, we identify and analyze approaches that make use of *information and communication technology* (ICT) to aid in the development of communication skills in health professionals' education. In particular, we argue that interactive technology can be used to support *heath care students* in dealing with these communication issues.

In the following section, we discuss the issue of differing perspectives in communication in health care settings that may result from the confrontation of the two dominant health concepts. For this purpose, we first explain the meaning of these health concepts in health communication and then present strategies that may be applied for dealing with communicative conflicts that result from differing health concepts. In the second section, we introduce two types of interactive technology that we applied for supporting communication in medical education. Then we report on two field studies in which students of physiotherapy and students of medicine were asked to deal with different perspectives on therapies and health. In one study, the participants were supplied with a *wiki* tool for writing texts in which they had to deal with different perspectives on the effectiveness of stretching as a physical exercise. For the second study, we developed a training *online forum* in which the participants responded to a variety of queries from fictitious patients who were seeking information about mammography screening. In the conclusion, we discuss our findings and their implications for practical application and for future research on educational technologies.

8.2 Differing Perspectives

8.2.1 Health Concepts

People have different beliefs regarding what they consider to be relevant in health, medicine, and therapy. These beliefs about health can be described as their personal therapeutic health concepts (Alonso, 2004; Boorse, 1977; Domenech et al., 2011). Two health concepts are dominant in the health care sector, that is, the biomedical and the biopsychosocial health concept (Bientzle et al., 2014a, 2014b, Bientzle, Cress, & Kimmerle, 2014b; Domenech et al., 2011). These health concepts find expression in two coexisting classification schemes that can be jointly used in everyday practice (Simeonsson, Scarborough, & Hebbeler, 2006): The *International Classification of Diseases* (ICD; World Health Organization, 1992) represents a biomedical therapeutic health concept, whereas the *International Classification of Functioning, Disability and Health* (ICF; World Health Organization, 2001) represents a biopsychosocial perspective. According to these classifications, a biomedical health concept comes along with a scientific mindset that can be characterized by keywords like "evidence-based," "scientific," or "standardized." This concept emphasizes a biological view of health and therapy. A biopsychosocial health concept, in contrast, also emphasizes a psychological and social view of health and therapy. This concept highlights the relevance of aspects such as "individualization," "social participation," or "subjective well-being."

Different perspectives on therapy and health are a challenge in the daily routine of health professionals, regardless of the discipline to which they belong. It is known from previous research that professionals and patients tend to have differing therapeutic health concepts (Patel, Arocha, & Kushniruk, 2002). This may result in differing beliefs and expectations about what medical course of action should be taken. Many patients place high priority on improving and maintaining psychological and physical well-being and performance (Blaxter, 1990). A result is that if patients with a biopsychosocial health concept feel good and are integrated in their social and professional life, they often do not recognize any necessity for medical treatment. Imagine in this situation a strongly biomedically oriented physician who tells a patient that her blood pressure is outside the standard physiological limits and that medical treatment is necessary to achieve the standard value. This patient would possibly be quite unwilling to comply, since she subjectively feels quite healthy at the time and is hardly impressed by some abstract, seemingly arbitrary, standard values. But if the physician takes the patient's perspective of health and therapy into account (patient-centered communication), for instance, by emphasizing that the measurement of this too high blood pressure is a good opportunity to take some preventive action which will make future crises less likely, the patient might be more encouraged to comply with the medical treatment recommendations (Krousel-Wood, Hyre, Muntner, & Morisky, 2005). The perspective in which health information is embedded even has an impact on considering and understanding factual information (Kreuter & Wray, 2003). Thus, differing perspectives can either impede or facilitate the process of informed medical decision-making and medical treatment compliance.

But health concepts may differ not only among patients and professionals. Different professionals may have diverse health concepts as well (Bensing, 2000; Domenech et al., 2011; Engel, 1977; Larson, 1999; Reuben & Tinetti, 2012; Roberts, 1994). These differing conceptions of health which determine a person's point of view may pose a great challenge to interdisciplinary and interprofessional communication and collaboration, as lack of clarity in an individual's or group's conceptual disposition may hinder effective communication and knowledge exchange. In view of this challenge, medical education should take the issue of differing perspectives in the health care system into consideration in order to find ways to foster smooth communication, interdisciplinary collaboration, and productive relationships between health professionals and patients.

8.2.2 *Handling Differing Perspectives*

When people interact with others who hold a contradictory health concept, they will experience socio-cognitive conflicts. In order to recognize a conflict that results from differing perspectives, people need to compare others' points of view to their own knowledge and attitudes. They can accomplish this by assessing and verifying external information or opinions which they have perceived as contradictory to their own in the interaction dialogue. This requires that people simultaneously activate and retrieve contradicting propositions from their working memory (see Kintsch, 1998; van den Broek & Kendeou, 2008). In addition to this *conflict detection*, there has to be some kind of *conflict regulation* (Stadtler & Bromme, 2014), a process in which people have to cognitively deal with differing perspectives. It is well known from the literature that people in such situations tend to follow the basic goal of restoring coherence (Chinn & Brewer, 1993) which can be achieved in various ways (Stadtler & Bromme, 2014). One strategy is to *ignore differing information*. In adopting this strategy, people will try not to consider contradictory evidence and stick to knowledge and opinions they already hold. Another strategy for restoring coherence is the attempt to *reconcile differing propositions*. This might be achieved with both scientifically valid and invalid inferences (see, e.g., Legare, Evans, Rosengren, & Harris, 2012). Finally, people may also try to restore coherence by *accepting differing information* and extending or modifying their own perspective (Festinger, 1957; Nussbaum & Schraw, 2007).

In addition to merely handling differing information cognitively, people may also aim to deal with conflicts actively (Leitao, 2000). On a communicative level, this implies providing arguments against contradictory positions and clarifying one's own point of view (Clark & Sampson, 2008). So people try to resolve conflicts by actively pointing out what they perceive to be true based on their own knowledge and their own opinions. They may also look for similarities and common ground in differing viewpoints and try to bring them together and integrate them (Leitao, 2000). Reasonable handling of socio-cognitive conflicts is particularly relevant for successful learning. A clash of differing perspectives may enhance the probability that people modify their knowledge structures (Doise & Mugny, 1984; Held, Kimmerle, & Cress, 2012). The studies presented in this chapter will examine to what extent health care students make use of these strategies of ignoring, accepting, and reconciling information when they have to deal with differing therapeutic health concepts.

From a perspective of educational technologies, the question is how interactive technology might contribute to the recognition and resolution of conflicts. To what extent do particular tools tolerate ignoring differing perspectives? How do they allow for clearly explaining one's own position? And in what way can technology support the combination and consolidation of differing viewpoints? These questions are highly relevant for health care educators who wish to train and support their students in communicating about differing perspectives in a reasonable way, and to foster the development of communication skills that students need in daily practice.

8.3 Interactive Technology

Communication is an increasingly important issue in health care (Ong, De Haes, Hoos, & Lammes, 1995; Rimal & Lapinski, 2009). For this reason efforts are being made to design curricula for communication skills training in health care (Bachmann et al., 2013; Street & De Haes, 2013). As communication skills are needed for various purposes, like *communication with patients* or *communication in professional teams* (Bachmann et al., 2013), there are in principal different ways to practice communication skills (Cegala & Lenzmeier Broz, 2002; Moore, Wilkinson, & Rivera Mercado, 2004). But what all forms of communication training seem to have in common is that some kind of interaction is required. Accordingly, technologies should be applied to education in the health professions that allow for (real or simulated) interaction among different people. One reason for fostering communication skills is to enable health professionals to communicate in a more sophisticated way in work situations. Another reason is to foster the learning that comes from communicating one's own knowledge and opinion to colleagues or patients in a collaborative situation (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Kaye, 1992). Collaborative learning can play a relevant role in dealing with socio-cognitive conflicts since socio-cognitive conflicts and their solutions are considered to be crucial for successful learning and higher-order thinking (Nastasi & Clements, 1992). Therefore it follows that technologies which facilitate collaborative learning should be applied to education in the health professions. In this section, we discuss to what extent wikis on the one hand and online forums on the other allow for interaction and collaboration.

8.3.1 Wikis

A wiki is a simplified content-management system that allows its users not only to read but also to modify content instantaneously (Cunningham & Leuf, 2001). In this way, wikis support groups of people in jointly working together on shared digital documents. A wiki user may directly take up what other people have contributed before, modify these contributions, and save the modifications in a way that makes them rapidly visible and usable for others again. This potential of wikis is already being used in health care education. For example, wikis are used to improve group projects (Ciesielka, 2008), to develop online courses (Harris & Zeng, 2008), or to support students in linking content of different subjects (Jalali, Mioduszewski, Gauthier, & Varpio, 2009). A wiki tool structures interaction in a clear-cut way. Thus, collaboration is the explicit purpose and goal of wiki usage (Cress & Kimmerle, 2008). The content that evolves in this process is therefore a collaborative product that also simultaneously reflects the current state of collaboration (Moskaliuk & Kimmerle, 2009).

So, on the one hand, a wiki supports collaboration. People have the opportunity to directly take up and adopt the preliminary work of other users. In the end, the users need to come to an agreement about which information to present and how to present it. The common product that results from this procedure might therefore support the integration and combination of differing perspectives. However, on the other hand, it is also possible that wikis might support the tendency to disregard contradictory information. On a technological level, *rejecting content* is very easy for wiki users because they can simply delete information that does not suit them. Thus, regarding the strategies of dealing with differing information as introduced above, wikis may be considered to be versatile and multifunctional: They may be applied both for a fruitful collaboration where different perspectives are integrated and for enforcing one's own position (see Kimmerle, Moskaliuk, Bientzle, Thiel, & Cress, 2012).

8.3.2 Online Forums

Online forums are virtual platforms for information exchange where people can ask questions, express opinions, share knowledge, and relate their own experiences (Holtz, Kronberger, & Wagner, 2012; Kimmerle, Gerbing, Cress, & Thiel, 2012). People can post messages in forums that other users can pick up and reply to. Health-related forums allow everyone to make contributions, that is, to ask or answer questions (Keeling, Khan, & Newholm, 2013; Kimmerle, Bientzle, & Cress, 2014).

Online forums support interaction among users through easy coordination of questions and answers. Here, one question can induce several replies—from one or from diverse other users. An inquirer may also post further queries, clarify the original question, or comment on the replies. In contrast to wikis, in online forums a respondent only writes her or his own text (an answer, a comment, a counter question) without directly changing the contribution of the predecessor. In this effect, interaction in online forums does not automatically imply collaboration: People do not necessarily have to arrive at an agreement, and integrating differing perspectives is not required. Instead, people can focus on presenting their own points but still need to consider other perspectives, at least to a certain degree. In doing so, they may develop their argumentative skills, which is considered an important goal in education (Christmann, Mischo, & Groeben, 2000; Leitao, 2000).

8.3.3 Implications

In sum, wiki technology supports the development of a consistent text as a collective product, whereas online forums rather support conversation: With wikis, the creation of a final product is the goal, where conversation between the people involved regarding the collaboration process is rather a means to an end. In online forums, in contrast, the conversation process itself is the centerpiece of collaboration; here, communication is a means in itself.

Correspondingly, in supporting health communication, wikis might be applied for advancing the presentation of a consistent text, for example, about a medical procedure. Online forums, on the other hand, appear to be more suitable for practicing direct communication, such as in doctor–patient conversations. Therefore, we applied these two types of tools accordingly in the following two studies with future health care professionals.

8.4 Study 1

Both scientific and anecdotal knowledge about effects and outcomes of medical treatments accumulates quickly. The evidence for the knowledge, however, is not always clear, so health professionals have to deal with tentative or inconsistent knowledge on a regular basis (Kienhues, Stadtler, & Bromme, 2011; Kravitz, Duan, & Braslow, 2004; Sniderman & Furberg, 2009). As described above, health knowledge often reflects diverse perceptions of medical issues and is embedded in the perspectives of different therapeutic health concepts.

The general idea of this study was to apply a wiki in order to support future health professionals in meeting this challenge of having to deal with inconsistent knowledge. The intention was to use a wiki to assist in elaborating upon and organizing knowledge about particular treatments and their effects. This study thus aimed to contribute to a better understanding of how health professionals would deal with differing perspectives when the collaboration process is structured by a wiki tool (Bientzle, Cress, & Kimmerle, 2013, 2014b).

8.4.1 Methods

We worked with future health care professionals who were supposed to deal with a topic that was relevant for their field of application. We aimed at choosing a subject that allowed presenting this topic from varying perspectives. Accordingly, we recruited 76 physiotherapy students as participants and chose *stretching* as a physical exercise—a controversially discussed topic in physiotherapy—as the subject they had to deal with in the wiki text.

To establish differing perspectives between the wiki text and the physiotherapy students' perspectives, we identified the participants' individual therapeutic health concepts in advance. For this purpose, we measured participants' agreement with seven pairs of statements that represented either biomedical or biopsychosocial concepts. Here, the students had to indicate their opinions on 6-point rating scales between bipolar statements. An example of a statement pair is “A deficit in mobility needs treatment, if a patient does not achieve the standard values of joint mobility” (biomedical account) vs. "A deficit in mobility needs treatment, if a patient cannot manage movements of everyday life optimally" (biopsychosocial account). This procedure enabled us to provide wiki texts that either differed from the therapeutic health concept of the participants or that were consistent with their concept.

The biopsychosocial therapeutic health concept is very prominent in and characteristic for the field of physiotherapy (Jorgensen, 2000; Stenmar & Nordholm, 1994). This was true for our participants as well ($M_{bps} = 5.51$, SD = 0.43; $M_{bm} = 3.99$, SD = 0.61; $t(75) = 18.41$, $p < 0.001$, $d = 2.79$). So, we embedded the information about stretching either in a biomedical (i.e., differing) or a biopsychosocial (i.e., congruent) health concept. An example of a statement with a differing health concept was: "*Since stretching has various effects*, *patients benefit most from standardized examination and the use of evidence-based treatments*." The biopsychosocial counterpart was formulated as follows: "*Since stretching has various effects*, *patients benefit most from individualized examination and the use of treatments suited to the individual's needs*." The students had to edit the wiki with the aim of improving the quality of the text (for more detailed information about the procedure of the study, see Bientzle et al., 2013).

We analyzed how physiotherapy students responded to socio-cognitive conflicts by examining the way they dealt with text sections in the wiki that represented a differing therapeutic health concept. Coding of the participants' contributions was accomplished by two independent raters (inter-rater reliability: Cohen's $\kappa = 0.75$). They coded whether a modified text section represented a biomedical, a biopsychosocial, or an integrated (biomedical and biopsychosocial) therapeutic health concept.

8.4.2 Results and Discussion

In the following examples of participants' text modifications, scratched out text indicates text that was deleted by the participants; underlined text indicates additions by the participants. As theorized above, the participants demonstrated various strategies to restore coherence (see Table 8.1).

Ignoring differing perspectives: In about half of the relevant text sections (54 %) differing perspectives were not modified at all by the participants. With the strategy of ignoring differing perspectives in the text, a student can easily remain with her or his own individual perspective without investing any notable cognitive effort. When learners ignore a differing therapeutic health concept, there will be no negotiation at all, and as a consequence, it is not likely that any significant development of their opinion or their knowledge will take place.

Accepting differing perspectives: Another strategy for restoring coherence was to accept a differing perspective. In some few cases (5 %) the participants revised parts of the relevant text sections without changing the differing perspectives in the text.

Table 8.1 Dealing with differing perspectives in a wiki (Study 1)

Number of participants	Number of text sections	Strategy	Frequency (percentage)
76	190	Ignoring differing perspectives	102 (54)
		Accepting differing perspectives	9 (5)
		Reconciling differing perspectives	30 (16)
		Rejecting differing perspectives	49 (26)

In the following example, a participant with a biopsychosocial health concept only modified a specific measurement regarding joint mobility, but, in doing so, apparently accepted that a standard measure (as a biomedical index) has relevance: "*A deficit in mobility which should be treated exists if a patient does not achieve the standard ROM* [e.g., *knee*: *ext/flex* (*0–5/0/120–150*)]." In another example a participant added an explanation for a mobility deficit: "*A deficit in mobility which should be treated exists if a patient does not achieve the standard ROM …, which, however, cannot be traced back only to the missing extensibility of the antagonist*." By accepting the information that is embedded in a conflicting perspective, it appears that this student may have adapted her or his individual mental model at least rudimentarily toward the biomedical model as expressed in the wiki. Thus, a change of perspective may have taken place on the individual level, whereas perspective development did not occur in the wiki, since the perspective expressed in the wiki text was not modified at all.

Reconciling differing perspectives: The physiotherapy students also tried to restore coherence by integrating their own individual perspective with the differing perspective (16 %). Using this strategy could have been one way to find common ground for successful collaboration in a wiki text with the other wiki authors. In a case such as this, both individual and shared collective perspective development may occur. For example, one participant amended the biomedical statement, "*A deficit in mobility which should be treated exists if a patient does not achieve the standard ROM* [e.g., *knee*: *ext/flex* (*0/0/180*)]" by supplementing it with a biopsychosocial view: "… *while the main focus should be on deficits that become apparent in the everyday life of the patient*."

Another student with a biopsychosocial perspective further modified the text by using both biopsychosocial ("*holistic*") and biomedical ("*specific diagnoses*") terms. So after her/his modification the text stated: "*In physiotherapy a holistic perception of the patient with his specific diagnoses is the most important thing*."

Rejecting differing perspectives: In many cases, students actively rejected the differing perspective in order to restore coherence. There were basically two ways of rejecting differing health concepts. First, some text sections that expressed a biomedical therapeutic health concept were completely deleted (11 %).

The second way was for participants to transform several of the differing statements to better align them with their own biopsychosocial perspective (15 %). For example, one participant replaced the biomedical terms "*standardized*" and "*evidence-based*" with the biopsychosocial terms "*individualized*" and "*individual*," respectively. So in the end the meaning of the statement was changed fundamentally as it read: "*Since stretching has various effects, patients benefit most from individualized examination and the use of individual treatments.*"

Another example of this transforming strategy is the following modification: "*A deficit in mobility which should be treated exists if this constraint limits a patient in his functionality*…." By using such strategies of rejection, an individual may restore coherence for the time being, but in the ongoing collaboration process of a wiki, the individual will probably be confronted with differing perspectives again and again. If this is the case, rejecting differing information is hardly a sustainable strategy for maintaining coherence.

To summarize, the wiki tool supported various strategies for coping with differing perspectives. In half of the cases a differing perspective was ignored, in several cases it was rejected, and in a few cases it was accepted. But sometimes the participants actually tried to purposefully and systematically reconcile different perspectives. It is important to note that the different strategies may have their own specific effects on the development of perspective—on individual development, on the development of the shared wiki text, or on both at the same time.

8.5 Study 2

Health-related information is accessible for everyone on the Internet. Both healthy people and patients use the Internet very often to search for health information (Baker, Wagner, Singer, & Bundorf, 2003; Robins, Holmes, & Stansbury, 2010; Siliquini et al., 2011). In addition to using search engines on the Internet, laypeople also frequently use expert online forums to obtain health-information and individual advice (Briet, Hageman, Blok, & Ring, 2014; Fujioka & Stewart, 2013; Umefjord, Petersson, & Hamberg, 2003). This is a new situation for doctors because they have to learn to use a different communication channel and communicate with previously unknown and anonymous patients.

In this study, 117 medical students used an online forum both to practice their communication skills and to learn how to respond adequately to patient inquiries about mammography screening. What is key in dealing with differing information is the fact that—even if patients remain anonymous during the communication—the patients' individual perspectives on therapy and health are often reflected in the wording of their requests. This study examined how medical students respond to online forum inquiries when their own perspectives on therapy and health differ from the perspective of the patient.

8.5.1 Methods

Medical students worked individually with an online forum in which they answered fictitious patient inquiries about mammography screening. We developed a PHP-based forum that was designed for educational and experimental purposes. To be able to identify interaction situations where differing perspectives clashed, we classified the participants' individual therapeutic health concepts in advance by using the *Therapeutic Health Concepts Scale* (Bientzle et al., 2014a; see Appendix D). In addition, we constructed various patient inquiries that expressed either a biomedical or a biopsychosocial health concept of a fictitious inquirer. An example of a patient inquiry embedded in a biomedical health concept was: "*Dear doctor X, I have read that it is scientifically proven that sonography devices have improved regarding their spatial resolution… Why is sonography not used instead of mammography for breast cancer screening*?…" An example of a patient request embedded in a biopsychosocial health concept was: "*Dear doctor X, I have a very personal request. I have read in Wikipedia that I am in a potentially risky situation … I am concerned about my health. Can you give me advice as to whether a breast cancer screening is useful for me personally*?"

The therapeutic health concept of most of the medical students was well balanced ($M_{bps}=4.84$, $SD=0.98$; $M_{bm}=4.83$, $SD=0.92$; $t(115)=0.18$, $p=0.861$). In order to identify students who had a very high biomedical orientation and, at the same time, only a moderate biopsychosocial orientation (and vice versa), we used a median-split procedure ($median_{bps}=5.00$; $median_{bm}=5.00$). For the following analysis, we only took those 39 interaction situations into account where students with a high biomedical orientation responded to a patient inquiry with a biopsychosocial orientation ($n=19$) and vice versa ($n=20$). The students were given the task of articulating adequate answers to the patient inquiries.

We analyzed how medical students dealt with patient queries that represented a differing perspective by using a coding-and-counting procedure. Coding of the participants' contributions was accomplished by one rater who used a predetermined list of biomedical and biopsychosocial keywords in order to code whether a reply post represented a biomedical, a biopsychosocial or an integrated (biomedical and biopsychosocial) therapeutic health concept, or whether no therapeutic health concept was explicitly mentioned.

8.5.2 Results and Discussion

We analyzed how medical students dealt with those patient inquiries that represented a differing perspective. Here again, the participants applied various strategies of conflict regulation in order to restore coherence (see Table 8.2).

Ignoring differing perspectives: In 20 cases (51 %) the participants did not take any differing perspectives into account. One strategy of ignoring an opposing

Table 8.2 Dealing with differing perspectives in an online forum (Study 2)

Number of participants	Number of postings	Strategy	Frequency (percentage)
39	39	Ignoring differing perspectives	20 (51)
		Accepting differing perspectives	6 (15)
		Reconciling differing perspectives	13 (33)
		Rejecting differing perspectives	0 (0)

perspective expressed in an inquiry was not to state any health concept at all in the reply (41 %). This was accomplished by solely presenting factual information about breast cancer and mammography screening. One student, for example, started his/her answer to a worried patient by writing: "*Thank you for your inquiry. I will gladly answer your question*." Then, however, this participant ignored the worries of the patient and provided only factual information about the illness and the procedure. With this strategy of not responding to the differing perspective, a student can conveniently adhere to his or her own perspective without investing additional communicative effort.

Another strategy of ignoring a differing perspective that was used by some students was to merely state one's own perspective in the answer (10 %). One student, for example, answered with emotionally charged wording to a scientifically oriented inquiry about the benefits of mammography screening compared to the benefits of sonography: "… *especially for a screening method it is very important … to be able to reassure a woman after the examination*." By using this strategy, the conversation in the online forum was enriched by a new perspective, while the student could remain within her or his own perspective.

Accepting differing perspectives: In some cases, the medical students tried to restore coherence by accepting a differing perspective (15 %). Here, they answered inquiries in which a differing health concept was embedded by trying to formulate their answer in accordance with the differing perspective. They adapted their answer completely to the differing perspective in the patient's question. For example, one student with a high biomedical orientation wrote the following answer to a biopsychosocially oriented patient: "*I understand that the discussion about mammography screening made you ponder. This is good, because prevention and screening are important things. But this should not unsettle you. I would like to briefly tell you why, and explain to you what we consider to be right*." In the explanation that followed, this participant used only biopsychosocial and no biomedical wording or keywords.

We observed the same type of response behavior for biopsychosocially oriented students who answered biomedical requests. In the following example, a biopsychosocially orientated student argued for the advantages of mammography screening in response to a post referring to the scientific evidence about the risk of X-rays: "*From a scientific perspective it is reasonable to accept the exposure to X-rays, because the cancer risk of X-rays is very much lower than the cancer risk caused by your familial predisposition*." This strategy indicates that these students were able to apply their individual mental models in quite a flexible way.

Reconciling differing perspectives: Several students tried to restore coherence by integrating the differing perspective of the inquirer with their own in their replies (33 %). Trying to reconcile differing perspectives within an online forum could support the communication partners in finding a basis for positive interaction. This strategy might facilitate both individual and collective development of a shared perspective. For example, a biomedically oriented student replied to a biopsychosocial patient request: "*I understand your concerns*," and then continued to explain from a biomedical perspective why the X-rays in mammography screening were not as dangerous as the patient had previously assumed. Finally, this participant concluded his/her contribution with an attempt to calm the patient down: "*So this concern is largely without cause*."

The same strategies were used by biopsychosocially oriented students who had to deal with biomedically oriented inquiries. One student, for example, started his/her answer to a biomedical inquiry with emotional statements: "*I think your anxiety is justified … and I like that you think about your health.*" This introduction was amended in the further course of the contribution by biomedical terms such as "*high probability*" or "*verified information.*"

What we did not find in the medical students' replies on the online forum was a strategy of directly *rejecting differing perspectives*. Rejection of a differing health concept would have been apparent if a participant had bluntly denied the appropriateness of the inquirer's point of view. While rejecting an opposing concept was quite common with a wiki with their peers (Study 1), apparently none of the participants considered this to be an adequate communication style in this online forum with patients.

To summarize, an online forum allows for various strategies in dealing with differing perspectives. In half of the cases a differing perspective was ignored. One strategy for ignoring a differing perspective was not to express any health concept at all. Another strategy was merely to state one's own perspective in the answer. In several cases, students tried to reconcile different perspectives, which supported the process of finding common ground as a basis for successful interaction. In a few doctor–patient cases, participants accepted the differing perspective by adapting their answer completely to the differing perspective of the patient inquiry. Interestingly, the strategy of directly rejecting a differing perspective of a patient was not used by medical students in this online forum.

8.6 Conclusions

ICTs, such as wikis or online forums, can be used as learning settings for supporting the development of communication skills in health sciences education. In two separate studies we analyzed how wikis and online forums may be applied in order to give students the opportunity to develop skills for communicating adequately with colleagues (Study 1) and patients (Study 2) who have perspectives different from their own. A direct comparison of results should be treated with caution since the data resulted from two different study designs with different tasks and samples of participants. Nonetheless, the comparison of the tools shows interesting trends in the usage of different strategies (see Fig. 8.1). These indications are relevant for the application of interactive technologies in health sciences education.

The analyses demonstrate that wikis and online forums support in their own particular ways the strategies of dealing with differing perspectives, but there were also some similarities. In both studies approximately half of the differing perspectives were ignored, or, at least, they were not actively addressed. However, the online forum setting seemed to support the strategy of manifestly accepting a differing perspective to a higher degree than the wiki tool. This might also be due to the fact that each tool required a different version of this strategy: In an online forum, accepting implied mirroring the perspective of the inquirer, whereas in a wiki, accepting as we defined it meant actively editing a text section that expressed a differing perspective, without modifying this perspective itself. We assume that mirroring another person's point of view is easier to carry out because people generally have a tendency to imitate the communication style of their conversational partners (Iacoboni, 2005; Seitz & Stewart, 1975). We observed a similar pattern with regard to the strategy of reconciling differing perspectives. This strategy was also used more frequently in the online forum than in the wiki setting. With a wiki, reconciling requires actual integration of the differing perspectives, whereas reconciling in an online forum only requires the coexistence of both perspectives in one post. These differences occur because the usual aim of a wiki is to provide a consistent text, while in an online forum this is not the goal. A wiki tool shows more clear benefits for fostering deep elaboration of an issue and the integration of perspectives than an online forum. To facilitate the awareness of differing perspectives about health and illness, however, it seems that an online forum might be more suitable than a wiki.

The strategy of rejecting differing perspectives did not occur in the online forum. A direct rejection of the perspective of a patient seemed to be very impolite and did not comply with the communication norms of patients and doctors. In wikis, in contrast, rejecting (i.e., deleting) differing perspectives is quite common and an established procedure (well known, e.g., from so-called edit wars in Wikipedia; see Kittur, Suh, Pendleton, & Chi, 2007).

A limitation of this comparison between the two studies is that we used different task types and different interaction situations in each study. In Study 1, physiotherapy students had the task of improving the quality of a wiki text. In Study 2, medical students answered simulated patient queries. Due to these different methods, we

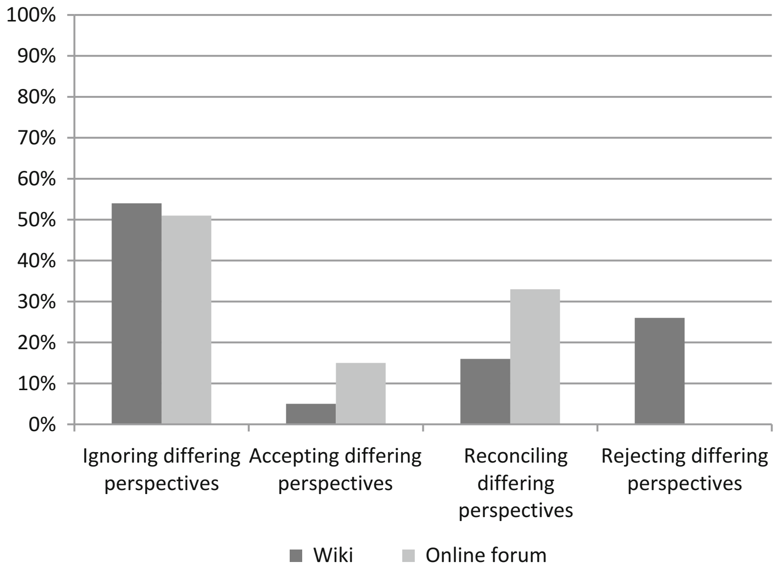

Fig. 8.1 Dealing with differing perspectives in a wiki compared to an online forum

cannot be sure at this point to what extent the obtained results can be considered effects purely of the technologies used. Indeed, it is likely that the interaction situation and the task type also influenced the editing and request behavior of the students. Another limitation is that we focused only on two different therapeutic health concepts. It is possible that socio-cognitive conflicts triggered by other therapeutic health concepts would result in other strategies of conflict regulation.

Nevertheless, our analysis provides some evidence for the particular usefulness and significance of wikis and online forums for training in health professions and for research. The two tools have different characteristics and may be applied for different tasks. It would probably not be appropriate to consult a patient in a wiki, or to elaborate on a conflicting medical issue only in an online forum. But it would still be very interesting to see which strategies would be used to deal with differing perspectives if diverse tools were available. This aspect should be addressed in future research.

Our analysis shows to what extent interactive technology has the potential to support the application of particular communication strategies among health care students. For the practical application of interactive tools, careful selection and strategic implementation of tools seem important to achieve particular goals. Wikis appear to be especially suitable for fostering deep elaboration of controversial issues. A wiki makes it possible for students to integrate differing perspectives but is probably not the ideal tool to aid students in learning communicative norms, like being polite or respecting differing perspectives. With wikis, there are not many hindrances for rejecting a differing perspective. In comparison, precisely because an online forum is based on direct communication, this tool appears to be more appropriate for fostering communication skills. It facilitates such activities as reflecting on the perspective of the conversational partner, which is an important element for positive interaction and a good relationship among health care professionals and patients. It provides more time for health care students to react to a patient reflectively, in contrast to face-to-face communication situations. An online forum can also be used to make future health professionals aware of the diversity in a health domain. So such tools could be helpful in increasing sensitivity and developing strategies for dealing with differing perspectives, information, opinions, and knowledge in a particular health domain, especially for future health care professionals.

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Chapter 9
Utilising Mobile Electronic Health Records in Clinical Education

Kristine Elliott, Terry Judd, and Geoff McColl

9.1 Introduction

Health information technologies (HIT) are increasingly being used in clinical environments to manage patient care (Graham-Jones, Jain, Friedman, Marcotte, & Blumenthal, 2012). The use of electronic health records (EHRs) in particular is now considered an integral part of primary care and hospital practice (Blumenthal & Glaser, 2007). The potential advantages of EHRs in health care are numerous, but importantly include greater efficiencies, and improved quality of care and patient safety.

Despite the increasing use of EHRs in clinical practice, explicit teaching of EHR-related skills to trainee clinicians is often lacking (Ellaway, Graves, & Greene, 2013). A recent review of the implementation and evaluation of e-Health education in entry level degrees that prepare students to enter clinical practice found little evidence of formal curriculum initiatives (Gray, Dattakumar, Maeder, Butler-Henderson, & Chenery, 2014). While the study took a broad approach to e-Health competencies, defining e-Health as “the combined use of electronic communication and information technology in the health sector” (Gray et al., 2014, p. 7), teaching efforts specifically aimed at EHR-related competencies are also scarce.

Medical schools would be hard-pressed to find formal recommendations for the teaching and assessment of EHR-related competencies. The American Accreditation Council for Graduate Medical Education (ACGME), for example, describes six

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core competencies that residents are required to master at key stages of their medical training, none of which are specifically related to EHR skills (Wald, George, Reis, & Scott Taylor, 2014). Within an Australian context, the Australian Medical Council (AMC) lists only one general EHR-related requirement in its graduate outcome statements—"Retrieve, interpret and record information effectively in clinical data systems (both paper and electronic)" (AMC, 2012, p. 3). While the Australian Curriculum Framework for Junior Doctors (CPMEC, 2012) provides more detail on the EHR-related competencies expected of a junior medical officer, it fails to provide an integrated view of EHR-related skills. Instead it makes a questionable distinction between electronic skills and health record skills and places them in different learning areas, for example:

Electronic

- Uses electronic resources in patient care e.g. to obtain results, populate discharge summaries, access medicines information.
- Complies with policies regarding information technology e.g. passwords, e-mail & internet, social media (CPMEC, 2012, 'Communication, Managing Information, Electronic,' para. 1).

Health Records

- Complies with legal/institutional requirements for health records.
- Uses the health record to ensure continuity of care.
- Provides accurate documentation for patient care (CPMEC, 2012, 'Communication, Managing Information, Health Records,' para. 1).

Despite the lack of recommendations from national standards and assessment bodies, the use of EHRs is viewed as "an exciting and welcome advance in patient care" (Peled, Sagher, Morrow, & Dobbie, 2009, p. 4) that, with appropriate implementation and training, can enhance medical education. Using EHRs for patient care involves numerous skills. Peled et al. (2009) recommend that students be taught the mechanics of documenting electronic patient cases, for example:

- Efficient management of data within electronic systems (e.g. using drop-down menus and free-text fields for data entry, ensuring records are saved, navigating through systems)
- Accurate recording of information (e.g. accurate typing/keyboarding) and in sufficient detail to ensure continuity of patient care
- Effective retrieval of specialist medical information (e.g. medicines information)

Increasingly, the literature points to the importance of EHR skills that are necessary to maintain patient- and relationship-centred care (Duke, Frankel, & Reis, 2013; Silverman et al., 2014; Wald et al., 2014), for example:

- Effective integration of the computer into the consultation (e.g. optimising the position of the device, introducing the computer while logging in, verbalising shifts to the computer, integrating data entry around patients' needs).
- Using EHRs in a manner that encourages patient engagement, particularly in viewing and reviewing information.
- Articulating the benefits of EHRs to patients.

Recent initiatives to incorporate EHR-related skills training into medical education include a communication skills checklist for first-year medical students

(Morrow et al., 2009) and an online self-directed module for second year medical students (Han, Lopp, & Walters, 2012). Wald et al. (2014) also describe the iterative, systematic development of a longitudinal EHR curriculum for undergraduate medical education. The curriculum includes: an initial training session on EHR use for third-year clinical skills clerkship students, which introduces the computer into the clinician–patient interaction; a second advanced EHR training module for fourth year internship preparation and an expanded behaviour grid for introductory and advanced EHR training. Our own efforts to incorporate EHR-related skills training into the curriculum of our university's new Doctor of Medicine (MD) programme, have focused on the implementation of a student-centred EHR system for clinical education. The rationale, design and development of the EHR system are described further in Sect. 9.2.4.

The novelty of incorporating EHR-related skills training into medical education means there is currently little evidence on its effectiveness. As Wald et al. (2014) point out in relation to implementation of their EHR curriculum,

> We have planned rigorous analyses of survey construction and validation practices, though at introductory stages of a much-needed curriculum, achieving the desired educational impact may take precedence over accessing validity and reliability data over the long term (p. 383).

Preliminary evaluation of a desktop application of our EHR system showed that students appreciated the learning benefits of the system and were positive about its functionality, yet they often found it impractical to use in the clinical environment because of inadequate access to hospital computers (Elliott, Judd, & McColl, 2011). These initial findings were encouraging in terms of the potential of the EHR system as a tool for learning EHR-related skills, yet at the same time they raised questions about the system's accessibility that warranted further investigation.

Clinicians are increasingly using mobile technology to access up-to-date information, communicate with colleagues around the world, and directly enter information into healthcare systems (Burdette, Herchline, & Oehler, 2008). Mobile devices have the potential to overcome issues of accessibility and to enhance point-of-care use of EHRs; they are portable, enable anytime/any place connectivity, offer flexible and timely access to resources, and provide immediacy of communication (JISC, 2005). Given the affordances of mobile technology, we proposed that by implementing our EHR system on mobile devices, students would be better supported to create and access health records either during or immediately after bedside interactions with patients.

Furthermore, there is growing evidence that mobile learning, or the use of mobile technologies to enhance students' learning experiences, can improve student performance of skills in the clinical environment. For example, the case presentation performance of fourth year medical students in the emergency department was significantly improved by the use of just-in-time mobile educational videos delivered via iPods (Tews, Brennan, Begaz, & Treat, 2011). Students also reported that they preferred this method of dissemination. Similarly, medical students who used iPods to view a video on chest tube insertion immediately prior to a simulated task, scored better on the skills checklist than the control group (Davis et al., 2012). Mobile technology has also been used successfully to deliver learning resources and support to students on hospital placement. The use of iPods to access lecture materials and video podcasts of clinical skills as well as mobile phones to access library resources and tutor and peer support "was perceived as a positive and exciting development by students, offering them access to information and support where previously unavailable or where access to IT was limited" (Lea & Callaghan, 2011, p. 140). Pimmer, Linxen, Grohbiel, Jha, and Burg (2013) also found students used mobile technology to enrich educational practices in a resource-constrained environment. Personal digital assistants (PDAs) loaded with high-quality educational resources and given to students for the duration of their clinical studies, tended to be used 'on the go'—between patients or scheduled teaching activities and on the wards for quick access to references (Davies et al., 2012).

The studies described above primarily examine the effectiveness of mobile learning in the clinical environment from the perspective of information retrieval for educational purposes. To our knowledge, no studies have investigated a mobile tool for the clinical environment, which incorporates data entry in support of EHR creation and management, and that has been designed for students to use while directly interacting with patients. When it comes to teaching EHR-related skills, it is unclear which methods or tools, particularly mobile tools, are effective. Nor is it clear at which stage of their clinical training students would gain the most benefit from EHR-related skills training.

For these reasons, we undertook a mixed methods study that aimed to build on the literature about recent initiatives to incorporate EHR-related skills training into medicine education. The study had two major aims; firstly, it sought to investigate the effectiveness of a student-centred EHR system as a tool for learning EHR-related skills, focusing on how medical students used the tool to scaffold their patient interviews. Secondly, the study sought to explore the perceptions and use of a mobile version of the EHR system as a learning tool in the clinical environment, with a particular focus on how students used it for data entry in support of record creation and management while directly interacting with patients.

9.2 Method

The study was conducted with approval from the host university's human research ethics committee.

9.2.1 Participants

A cohort of fourth year medical students on clinical placement ($n = 47$) were invited to participate in the study. These students were enrolled in a 6-year undergraduate medical programme and this was their first clinical placement. At this time, our university was running two medical programmes; an existing undergraduate programme that was scheduled to end in 2013 and a new 4-year masters level MD programme that commenced in 2011. Thirty-nine students initially agreed to participate: five participants withdrew during the study, giving a final participation rate of 72 %. Equal numbers of female and male students completed the study with an average age of 22.9 years ($min=20.9$; $max=28.0$).

9.2.2 Procedure

A longitudinal crossover study design was adopted to investigate student perceptions and clinical use of the EHR system implemented on mobile devices. The study took place in a metropolitan teaching hospital over one teaching semester from July to November 2011—19 weeks in total.

The EHR software was installed on two classes of mobile devices—iPads and Netbook computers—as well as being provided on USB memory stick. These memory sticks were 'mobile' in the sense that they could be carried around the clinical environment, but their use is better characterised as 'fixed' in that they needed to be plugged into a hospital or clinical school computer in order to access the EHR software, which could be run directly from the memory stick without any additional installation.

Students had access to a high performance wireless network in the clinical school, but prior testing across hospital locations showed varying levels of connectivity to the G3 mobile network and the hospital's wireless network. WiFi access was freely available in some areas of the hospital, but was restricted in others. To overcome this, the iPads and Netbooks used in the study were both WiFi and 3G enabled, so that if students had difficulty accessing one network they could swap to the other. Students were shown how to do this during the training session described below.

Participants were randomly allocated to three groups according to the design outlined in Table 9.1, which was dictated by the number of available iPads and Netbooks. Students allocated to these groups used each device for 5 weeks before crossing over to another, ensuring they had the opportunity to use and compare all three devices (i.e. iPad, Netbook and USB memory stick). The remaining nine students, who were not assigned to one of the three crossover groups, were assigned to an ancillary group and each provided with the EHR software on a USB stick to use during the course of the study.

At the beginning of week 1, students attended a training session facilitated by the researchers to introduce the EHR software, demonstrate its functionality and explain how each device operated. Students had the remainder of the week to test devices, trial the EHR software and create test records. At the end of week 1, all test records were cleared from the system. Timely technical support via e-mail was provided to students for the duration of the study. In a small number of cases, a technical person

Table 9.1 The study design

Week(s)	Group 1 ($n=8$)	Group 2 ($n=8$)	Group 3 ($n=9$)
1	Training session and testing		
2–6	iPad	Netbook	USB drive
7	Focus groups and device crossover		
8–12	USB drive	iPad	Netbook
13	Focus groups and device crossover		
14–18	Netbook	USB drive	iPad
19	Focus groups and device collection		

visited the study site to resolve individual issues that couldn't be resolved via e-mail. Students were encouraged to enter at least one patient record per week. At the time of the study, the use of the mobile EHR system and the creation of patient records was not formally integrated into the clinical curriculum. This meant that students' submissions were not formally monitored or assessed.

9.2.3 Data Collection and Analysis

Throughout the study, participants' movements and activities within the EHR system were electronically recorded. This dataset was analysed to determine frequency and location of use by students.

Students were interviewed in small groups (3–4 students) about their use and perceptions of the EHR system at the end of each 5-week period and at the end of the study. Interview questions focused on: general usability of the EHR system (e.g. system functionality, which components students used, did components operate as expected, potential improvements); general usability of the mobile device on which the EHR software was implemented (e.g. functionality, connectivity, ease of use, usage challenges, use in the hospital environment, use at home) and the usefulness of the EHR system for learning.

Focus group interviews were audio-taped, transcribed and the written transcripts manually analysed to identify emerging themes. One researcher (KE) undertook an initial coding of the data with constant comparison of the 19 datasets (one from each focus group session). The coding categories were then discussed amongst the research team and modified until agreement of the major themes was reached. Using this process, student comments related to the usefulness of the EHR system for learning were categorised into four major themes: record content and structuring; patient management; case presentations and electronic health record skills. Student comments related to the use of the mobile EHR system in the hospital setting were categorised into three major themes: portability; network connectivity; and patient encounters. Selected quotes have been used to illustrate the key themes identified.

9.2.4 The EHR System

The EHR system used in this study was developed to facilitate the learning and teaching of EHR-related skills to medical students on clinical placement. The rationale behind its development was that EHR use is better learned through direct hands-on practice than through classroom or lecture activities (Zelnick & Nelson, 2002). It was thought that through using the system, students would develop expertise in the practice of documenting high quality electronic patient records, and would develop an awareness of the potential benefits of EHR use in patient care.

The system was considered to be student-centred because it was explicitly designed for the purpose of clinical education: it did not play any role in authentic hospital administration or management. The initial design was based on commercially available clinical software products currently used for general practice and hospital pre-admission clinics, which was modified or simplified for student use. Further adaptation and refinement for educational purposes, such as the addition of prompts, functionality that allowed clinical supervisors to provide feedback on students' patient records, and a section for student reflection, were made using an iterative design process, informed by medical and clinical educators, educational designers and students.

The system was secure, requiring students to sign in using their university username and password and all patient information entered into records was de-identified. A message reminding students they were required to obtain patient consent before entering any patient information was presented each time a new record was created. By dismissing this message, students were formally agreeing that patient consent has been obtained. Students were then free to enter data about their patient in a section entitled 'Basic Details' via a series of drop-down menus and text fields (Figs. 9.1 and 9.2).

Further patient information was entered mostly via a series of free-text fields organised under the following sections: Presenting Problem, Past Medical History, Family History, Social History, Medications, Health Maintenance, Physical Examination, Investigations, Diagnosis, Management, and Notes (see Fig. 9.1). The Medications section allowed users to add new medications using a predictive entry field linked to a comprehensive list of available drugs and pharmaceutical preparations from the Australian Medicines Handbook (2014). Drugs could be entered using either their generic or trade names. Each new medication was automatically linked to the appropriate drug information sheet from the Australian Medicines Handbook (2014), which could be accessed and viewed within the EHR software. The Notes section was intended to be a space for reflection where students could enter personal reflections about a patient, their condition, treatment and management, as well as broader issues such as the healthcare system, or the students' own learning.

The EHR software also captured a record of the location where the patient record was entered (e.g. home; clinical school; hospital ward; other areas of the hospital including, emergency department, ambulatory care, library, computer room, public areas).

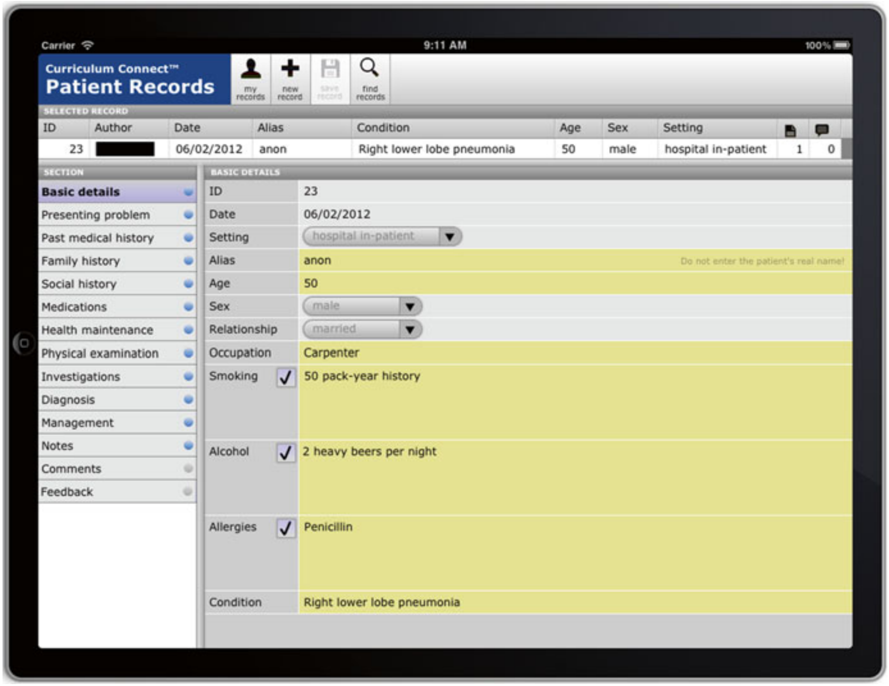

Fig. 9.1 The EHR software interface for entering patients' basic details (*Note*: Other sections of the patient record are listed in the left hand side menu)

9.3 Results

9.3.1 A Useful Learning Tool

Student perceptions of the EHR system as a learning tool were generally positive. For example:

> *It was useful for me because the first time I did my history … it was the first Monday that we got here. One doctor just said, 'Go take a history' and I was so lost. I went back and I put my thing* [*USB drive*] *into the system and I realised this is what I should have done. And after that… when I'm taking a history it's still messy… and I guess as I go along I'll get more organised. So I don't know how useful the system will be in the future, but it is definitely helping me organise my notes right now*. (Female student A, Group 3, Interview 1)

Thematic analysis of the student interview data revealed four major themes relating to the usefulness or helpfulness of the EHR system for learning: record content and structuring; patient management; case presentations; and electronic health record skills.

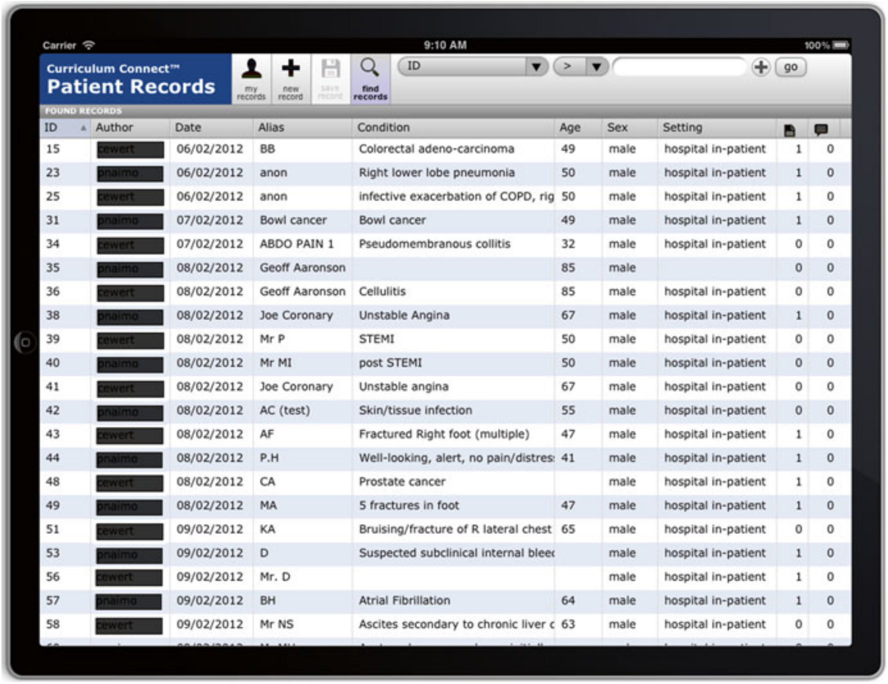

Fig. 9.2 The EHR software interface displaying a summary list of patient records

9.3.1.1 Record Content and Structuring

A number of students in the study reported using the EHR system as a template for patient interviews, describing how this helped them to determine what sort of patient information to record and how detailed this information needed to be:

It really helped with me thinking about the whole history taking framework. It had everything I needed to take down. I basically developed my history taking from the software (*Male student A*, *Group 2*, *Interview 1*)

… because this is the first time we've been interviewing patients I thought the programme was really helpful because when we started I did the history, but I didn't realise what segments were important and the programme had past history, medications, issues and so on and so forth. So when I was typing it in I realised that I didn't ask that … I didn't do that section and I should have. (Female student A, Group 3, Interview 1)

Students also reported that the software was useful for structuring patient information into a comprehensible record, and for identifying information gaps in their records that could be repaired by re-interviewing a patient:

I kind of found it a good exercise to sort of write patient notes in a coherent manner. Just typing it out I sort of wrote it as if I were writing admissions for emergency… so I found it quite useful. (Male student B, Group 2, Interview 1)

In terms [*of*] *being useful… it provides a template for us to put everything in there. If you've forgotten something you can … when you're typing into the software … you can see 'Oh I forgot the alcohol or the allergies.' You can go back to the patient and ask them again*. (Male student A, Group 1, Interview 2)

Features of the Medications, such as predictive typing, and the linking of drug entries to the Australian Medicines Handbook (2014), seemed particularly valued by students.

B: *But I do think there is a lot of potential with the drugs*. (Male student B, Group1, Interview 1)

C: *Yeah I loved that*. (Female student C, Group 1, Interview 1)

B: *Because sometimes you see in* [*hospital*] *progress notes that someone has scribbled something down. It's like, Sal … buta … something. Type it in* [*the programme*] *it comes out eh*!

I quite like the fact that the drugs, you click on them and they link you to the Australian Medicines Handbook and it teaches you about each drug. (Male student C, Group 3, Interview 1)

9.3.1.2 Patient Management

The EHR system helped students to organise and manage information from multiple patients they had seen during their hospital placement:

It's a good way of keeping track of the patients you see. Because usually I write it on notepaper and it gets lost, or I write it really messy and write it all over the page. So it's good to enter it all into a database. (Female student B, Group 1, Interview 1)

…and in some cases, it actually prompted students to interview more patients.

It helped me to remember to clerk patients and interview patients. That's one of the other things that it helped me do. I'd be doing things and I'd be like, oh yeah, I've forgotten to put in this week's, so I'd go and see a patient. (Female student A, Group 1, Interview 1)

9.3.1.3 Case Presentations

The act of entering and structuring patient information into a comprehensive record appears to have been beneficial for several reasons. Firstly, several participants identified that sitting down and entering information into the EHR after interviewing a patient had given them the opportunity to reflect on the patient and rethink the patient's condition. Secondly, students commented that the process had assisted with case presentations because as they entered information they thought about how best to present it. For example:

It helps you with your presentation. Because when you write it, you say, I should say this first … (Female student D, Group1, Interview 1)

However, one participant felt that the process was helpful only during the early stage of case development because later it required input from a medical expert:

One of the hardest things right now is my long case[*s*] *and trying to organise it and this programme has helped me refine it along the way. I think I'm at the point where the aspects of my long case that need refining can't be refined by the programme. It needs input from other doctors. We have to present it as a summary, which requires more thinking than just typing something up. So the typing helps you at the beginning*. (Female students A, Group 3, Interview 1)

9.3.1.4 EHR Skills

Students were aware that the EHR system was allowing them to practice EHR skills:

I met a registrar. He showed me a very thick history [*paper-based*]—'*This is my patient. I haven't finished. I have to take six months to finish it.*' *I think that using this software maybe will train you to directly type* [*in*] *your work*. (Female student B, Group 3, Interview 1)

It was good because electronic health records are happening already and they're going to happen. It's good to get used to putting things in online. (Female student B, Ancillary group, Interview 1)

I just kind of viewed it as another administrative task… it was useful, but really only because it's good to learn another system and to wrap your head around putting records in electronically. (Female student A, Ancillary group, Interview 1)

Finally, several noteworthy observations were made by students, which did not fall into the major themes. The first of these was that the EHR system enabled reflection on learning progress:

It was kind of cool that I could see how my history taking had improved over time. (Female student A, Group 3, Interview 1)

The second was the excitement created by the potential benefits of an EHR system:

[*I was*] *a bit excited that this would work, in the sense that you don't have to struggle reading the ugly handwriting of the medical records of the random consultants. Like you could really see what letters they wrote instead of trying to interpret …* (Male student B, Group 2, Interview 1)

Although not all participants reported that the EHR system was helpful at this stage of their clinical training:

How useful it is for me personally. I don't know. I guess it's good to have a record of all of the patients I have seen. But having said that I haven't really gone back to look over them and I don't know if come closer to exam time, it would be something that I would do. (Male student B, Group 3, Interview 1)

…not something which I found that I felt like I really needed to use to supplement my learning. Maybe not at this stage. It's only been the first block at hospital. It's all been sort of getting used to everything. (Male student D, Group 3, Interview 1)

Table 9.2 Timing of patient records created by students in the three rotating groups

Group	1 ($n=8$)	2 ($n=8$)	3 ($n=9$)	Total ($n=25$)
End of first block	40	40	56	136
End of second block	77	84	97	258
End of third block	125	120	148	393
Average per student	15.6	15.0	16.4	15.7

9.3.2 Record Creation

By the completion of the study, students had created a total of 480 electronic records of patient encounters during their first clinical teaching semester. Those students in the three crossover groups created a combined total of 393 records, an average of 15.7 records per student (mean 15.7; *min* = 6; *max* = 22) (Table 9.2).

The cumulative frequencies of records created by students in each group are presented in Fig. 9.3. Each group followed a similar pattern of record creation over time, although there was a time lag in record creation by group 2 during the second and third block with most records being created in the last/latter week(s) of the block.

The number of records created by each device type and group are presented in Table 9.3. Overall, similar numbers of records were created by students in groups 1 and 2 regardless of device type: students in group 3 created slightly more records, particularly when they were using the iPad or the USB stick.

The number of records entered by students did not vary significantly between devices (iPad, 34 %; USB, 33 %; Netbook, 33 %), despite clear individual preferences being reported by students, for example:

The iPad itself, I didn't have any problems. I actually loved it … I took it to clinicals. I took it to the hospital. I took it to the ward (Female student A, Group 1, Interview 1)

I found myself carrying the iPad around much more than the Netbook (Male student B, Group 2, Interview 2)

After I got the iPad I went to the wards to try to use it [*to*] *record patients. It was difficult* (Male student A, Group 2, Interview 2)

If I [*was*] *given a choice between the Netbook and the iPad to enter data at the patient's bedside, I would prefer the Netbook because it's more feasible* (Male student C, Group 2, Interview 2)

… the easiest, quickest way to put in data was to hook up the USB and to type on a keyboard that we're used to. Rather than on the iPad which was slower and the Netbook, which was, you know, not too bad, but still it was half-way in-between (Male student A, Group 3, Interview 3)

I didn't mind using the USB … I mean I didn't find it an inconvenience to plug it in, type it up (Male student B, Group 3, Interview 1)

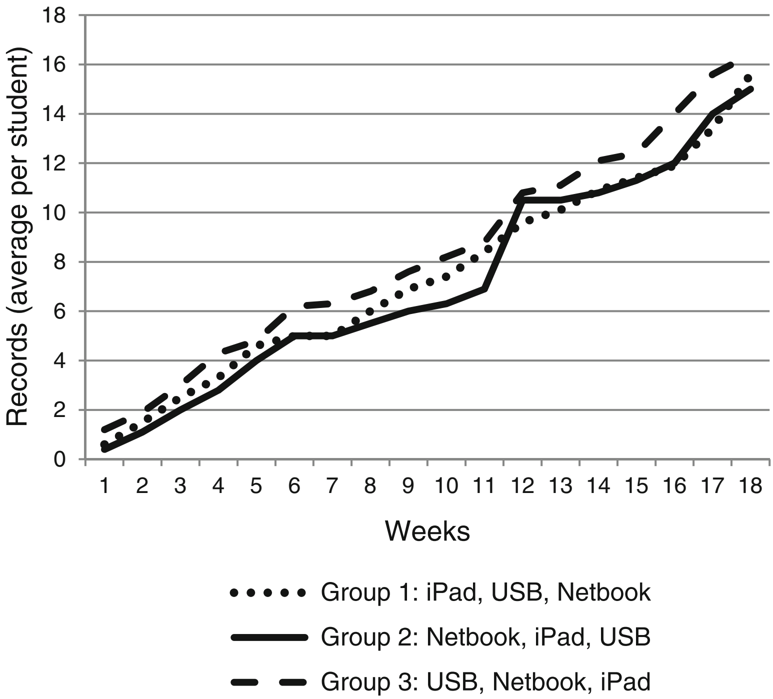

Fig. 9.3 Cumulative frequencies of records created by students in each rotating group

Table 9.3 Frequencies of records created using each device type in the three rotating groups

	Number of records (average per student)				
	Group 1 (n=8)	Group 2 (n=8)	Group 3 (n=9)	Total (n=25)	Total (%)
iPad	40 (5.0)	44 (5.5)	51 (5.7)	135 (5.4)	34
Netbook	48 (6.0)	40 (5.0)	41 (4.5)	129 (5.2)	33
USB	37 (4.6)	36 (4.5)	56 (6.2)	129 (5.2)	33
Total	125 (15.6)	120 (15.0)	148 (16.4)	393 (15.7)	

The main locations where students entered records are shown in Fig. 9.4. Unexpectedly, and somewhat disappointingly, the majority of records were entered at home (68 %), rather than in the clinical school (22 %) or hospital (6 %). Of the hospital locations, only 2 % of records were created on the wards: The remaining 'other' 4 % were created in either the Emergency Department, Ambulatory Care, library, computer rooms, or public areas such as the cafe. A few students reported entering records while on public transport.

The devices that were used to create records at each location are shown in Fig. 9.5. Of the three devices, iPads were most likely to be used to create records in locations outside the home or clinical school.

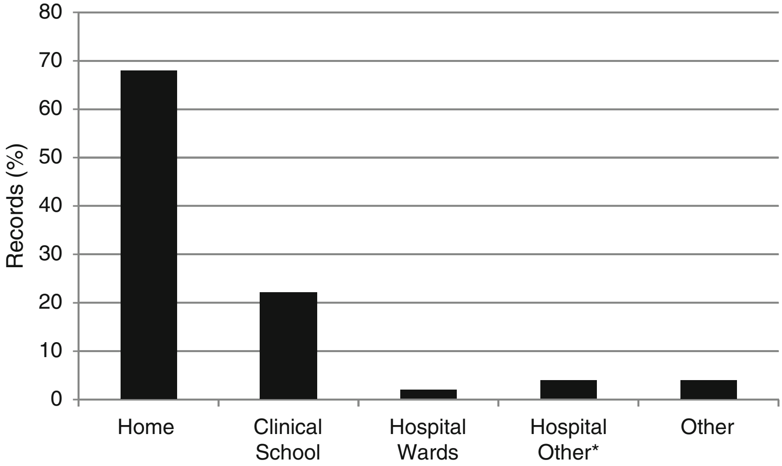

Fig. 9.4 Main locations where students entered patient health records. **Hospital Other* combines data for emergency department, ambulatory care, library, computer rooms and other public areas of the hospital

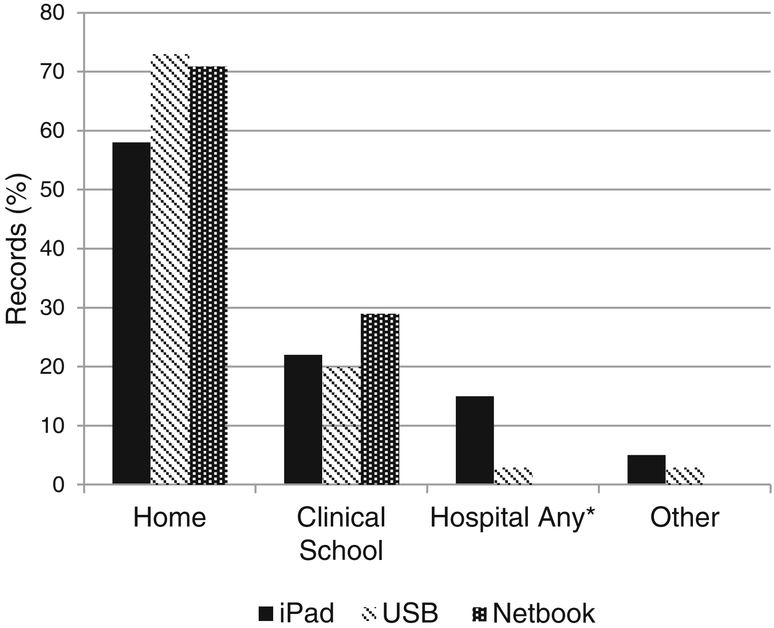

Fig. 9.5 Frequencies of records entered by location and device. **Hospital Any* refers to any location in the hospital, including wards

9.3.3 Use in the Clinical Environment

Students reported a number of concerns about the use of the mobile EHR system in the hospital setting, which were related to portability, network connectivity and their interactions with patients at the bedside.

9.3.3.1 Portability of Mobile devices

Students often felt that the iPads and Netbooks were not easy to carry around on the hospital wards. They reported having nowhere to put them while doing a physical examination and were concerned that they might be damaged or lost:

I found the iPad a lot easier to carry around… but I didn't actually use it at the bedside with a patient. I just felt it was too awkward (Female student B, Group 2, Interview 2)

But the Netbook itself is quite large… I just left it in my locker or at home. I didn't often bring it around. I would never bring it to the wards (Female student C, Group 3, Interview 2)

[*The USB drive*] *can be quite small and it was on my mind that I didn't want to lose it and I nearly did. That was annoying*. (Male student B, Group 3, Interview 1)

9.3.3.2 Network Connectivity

Students reported experiencing problems with network connectivity in the hospital. They encountered varying levels of connectivity to both the G3 mobile network and the wireless network at different times, which resulted in a slower or unreliable connection to the Internet.

I had the same internet problem… I found the signal too weak sometimes. There were times when it worked well and there were times when it didn't work. (Female student A, Group 1, Interview 3)

9.3.3.3 Mobile Device Use During Patient Encounters

When attempting to use the mobile EHR system during a patient interview at the bedside, students reported that the mobile devices created a barrier between themselves and the patient that impacted on their interactions with the patient.

… if you have a Netbook or an iPad that always acts as a barrier between you and the patient (Male student B, Group 1, Interview 1)

… the first time I tried entering a record while I was trying to talk to a patient—it made the interaction with the patient less personal… (Male student D, Group 3, Interview 3)

When you are there [*in the wards*] *you have to try and make eye contact with the patient … and there's nowhere to put the iPad when you are going through the examination* (Male student A, group 2, Interview 2)

Several students also raised concerns about bringing the iPad, which they perceived as a luxury item, to the wards and using it in front of patients from low socio-economic backgrounds.

I don't feel comfortable bringing the iPad to the ward… A lot of the patients are lower socio-economic status and I wouldn't want to bring an iPad and type on it in front of them. (Female student C, Group 3, Interview 2)

9.4 Discussion

Medical students have always learnt how to interview and manage patient encounters at the bedside; however, the use of a mobile EHR system that has the potential for direct entry and retrieval of patient information at the point-of-care presents new learning opportunities as well as challenges for students working within a framework of patient-centred care. The findings from this study of situated learning in a hospital setting provide valuable insights into how a student-centred EHR system functioned as a learning tool for EHR-related skills, but showed that its implementation on mobile devices did not result in students creating patient records at the bedside.

The findings from our interviews with students showed that the EHR system supported the learning of EHR-related skills by: scaffolding patient interviews; providing a means of managing information gathered from multiple patients seen on hospital placement; providing opportunities to practice EHR-specific skills; and raising awareness of the potential benefits of EHRs for patient care. The ways in which the system provided educational support for patient interviews, included:

- As a template for conducting the interview
- To clarify what information to seek from patients to record
- How to structure patient information into a comprehensible record
- To identify missing information in patient records

The ways that the EHR system supported the learning of EHR-related skills suggests that it went some way towards helping students develop the ability to manage data within an electronic system, and to record patient information in sufficient detail to ensure continuity of care.

The effectiveness of the system for learning, however, went beyond EHR-related skills. We identified that it also supported students in preparing key cases for presentation, prompted students to seek out more patient interviews, and allowed students to reflect on learning gains made throughout their hospital placement.

The diversity of ways that the mobile EHR system assisted students in the clinical environment, reflects the multifaceted nature of clinical learning when EHR-related skills training, mobile learning and bedside pedagogy converge. Our findings provide a starting point for medical educators to understand these interactions and to leverage them for education opportunities. While the primary purpose of the mobile EHR system was for EHR-related skills training, we identified other education opportunities that it provided in the study. For example, key features of the system when combined with the mobile capabilities of portable devices, meant that students were able to access valuable diagnostic and treatment information (such as comprehensive drug listings and information sheets) 'on the go', in a similar manner to students using PDAs in the clinical environment (Davies et al., 2012). Some students in our study also reported accessing apps and web sites via the iPad for just-in-time learning, a brief educational experience targeting a specific need or clinical question (Kahn, Ehlers, & Wood, 2006). Although the majority of students used the mobile EHR system at home for record creation, some students did take the mobile devices to the clinical school and hospital to access information for educational purposes. Learning in the clinical environment, however, is not always immediate. One participant noted that sitting down and entering information after interviewing a patient at the bedside gave them an opportunity to reflect on the patient and their condition. In this case, the EHR system created an opportunity for learning that was not related to its mobility.

While many students in the study perceived the mobile EHR system to be a useful learning tool for the clinical environment, electronic monitoring data showed that the majority of patient records were not created in hospital locations. Moreover, this lack of in-situ use occurred irrespective of which type of mobile device students had access to. Our findings point to a number of reasons for this unexpected pattern of use. Firstly, network connectivity issues meant that WiFi or 3G connectivity was not always available across all hospital locations. Despite connectivity and internet speed previously being identified by students as barriers to the successful implementation of mobile technology (Vafa & Chico, 2013), a supportive technological infrastructure for educational purposes is often difficult for large work organisations, such as hospitals to achieve. Secondly, concerns about the size of the mobile devices, the ease of carrying them, or that they might be lost, meant they were often not taken to the wards. Similar concerns around theft and loss emerged as a barrier to the use of PDAs for accessing learning resources in the clinical environment by a cohort of undergraduate medical students (Davies et al., 2012). Of greater concern for students, however, appears to be their unfamiliarity with patient encounters. For example, a number of students commented that the system was not particularly helpful at that stage of their clinical training—their first clinical placement—when they were not accustomed to the hospital setting and not experienced with patient interactions. Some of these students were also worried that the mobile devices would negatively impact their bedside interactions with patients, or that they might appear disrespectful. These findings resonate with previous findings reported in the literature about mobile device use in clinical environments, which can cause concerns for both students and practice staff around professionalism, distraction, patient confidentiality, consent, data security and infection control (Lea & Callaghan, 2011; Phelps et al., 2013). Students feel that patients will think they are 'playing video games or listening to music', rather than accessing learning resources (Tews et al., 2011). Davies et al. (2012) note that '… the etiquette of using a PDA whilst with patients was of concern, and the students had to learn how to incorporate it into their consultations without harming their relationship with the patient' (p. 7). Medical students express similar concerns about their ability to effectively integrate EHR use in clinical encounters (Rouf, Chumley, & Dobbie, 2008).

A substantial limitation of this study is that the use of the mobile EHR system and a requirement for patient records to be created were not yet, at the time of the study, formally integrated into the clinical curriculum. This meant that there was no explicit connection between EHR-related activities and other clinical learning resources or activities such as case presentations. Nevertheless, it is interesting to note how some students in the study independently integrated their preparation for case presentations with their EHR-related activities. A lack of integration with the formal curriculum also meant that students' submissions were not formally monitored or assessed. Clinical supervisors were informed of the study (with one attending the training session), however, despite our best efforts to persuade otherwise, time pressures prevented them from monitoring student progress with the system and providing feedback on their patient records. Considering this, the overall level of student engagement was very encouraging with over 400 unique patient records created over the course of the study.

Subsequent to the study described here, an online version of the EHR system was implemented for the second year cohort of our masters level MD programme ($n=328$). In this later implementation, use of the EHR system was explicitly integrated into the formal curriculum as a hurdle assessment requirement, with students required to enter 24 records of their patient encounters over the year. Also, clinical supervisors began using the system as an avenue for feedback to students on their records. We identified six different levels of feedback that clinical supervisors provided: positive encouragement of performance; factual knowledge about conditions; identification of gaps in record; writing style; case reflection and learning progress. (Elliott, Judd, & Tse, 2013). Further research efforts are required to determine if feedback provided to students via the EHR system encouraged more reflective learning and practice. As of this year, use of the system has also been extended to final year MD students ($n=326$) in their preparation for practice subject, during which students also complete an online, self-study module on incorporating EHRs and mobile devices into the medical consultation. The module emphasises how this can be achieved with minimal impact on patient- and relationship-centred care.

The EHR software continues to be refined and we recently released a smartphone version of the system to students. Ownership of smartphones among out students is extremely high (well over 90 % according to our most recent 2012 survey) and it is hoped that the smartphone app will provide students with greater flexibility when using the EHR system, as well as helping to reduce some of the portability and connectivity issues identified by students using the iPads and Netbooks in this study. Connectivity, is 'solved' in this case by allowing the user to create records offline and then sync them later when the device has access to a reliable network connection.

Based on the results of this and other studies, we believe that EHR-related activities have an important role to play in contemporary medical curricula. For maximum benefit, it is critical that their use is strongly embedded in the curriculum and is linked to established learning activities and objectives. Wherever possible, student contributions should be regularly assessed and students provided with effective feedback on their progress. We recommend a spiral curriculum for the teaching of EHR-related skills where there is an iterative revisiting of topics at different stages of the programme, with deepening layers of complexity at each visit (see Bruner, 1960). While calls have been made to introduce and instruct students on the use of EHRs from their earliest patient encounters so that it becomes a natural part of the training environment (Peled et al., 2009), at the same time students need to have in place the skills to effectively manage a patient-centred interview at the bedside while integrating EHR use. A spiral curriculum for the teaching of EHR-related skills would address the four objectives of a EHR training curriculum proposed by Wald et al. (2014): (1) introducing students to the presence of a computer within a clinical encounter, (2) training students in EHR-related skills, (3) empowering patient- and relationship-centred interviewing skills while incorporating EHR skills, and (4) fostering student' appreciation for added value of integrated computer use within the clinical encounter. Our findings build on published EHR curriculum innovation by underscoring the importance of sequencing in EHR-related skills training, especially when the EHR learning tool is mobile. In this context, consideration must be given to the order in which students receive instruction on (1) patient-centred interviewing skills, (2) incorporating mobile devices into the consultation so as not to harm patient relationships, and (3) incorporating EHR-related activities into the consultation so as not to harm patient relationships. For example, performing mobile EHR-supported patient encounters before students are sufficiently proficient at patient-centred interviewing while incorporating mobile devices and EHR-related activities, means students are less likely to benefit from the potential efficiencies afforded by mobile EHRs (e.g. direct capture of patient information at point-of-care).

9.5 Conclusion

This study has shown that a student-centred EHR system can support medical student learning of EHR-related skills in the clinical environment. Students reported that the EHR system helped them to scaffold patient interviews, provided a means of managing information gathered from multiple patients, allowed them to practice EHR-related skills, and allowed them to consider the potential benefits of EHRs for health care. The study also identified learning benefits that students derived from the system, which extended beyond EHR-related skills, such as preparation for case presentations, increased patient encounters, and general reflection on learning progress made throughout the hospital placement. The findings from this study provide medical educators with valuable insights into understanding the multifaceted nature of clinical learning when EHR-related skills training, mobile learning and bedside pedagogy converge. In this context, we found that a mobile version of the EHR system did not encourage students to create and access health records either during or immediately after bedside interactions with patients. Network connectivity issues and student concerns about the portability of the mobile devices were identified as potential barriers to its adoption and use in the clinical environment. Further, concerns that the mobile devices would negatively impact their bedside interactions with patients, or that they might appear disrespectful, suggest that some students in this study were focused on the quality of the medical interview at the bedside, rather than potential efficiencies afforded by mobile devices.

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Chapter 10
Measuring Emotions in Medical Education: Methodological and Technological Advances Within Authentic Medical Learning Environments

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10.1 Introduction

Theories of achievement emotions (e.g., Pekrun, Elliot, & Maier, 2006) and self-regulated learning (e.g., Boekaerts, 2011; Pintrich, 2000, 2004; Zimmerman, 2000, 2011) suggest that emotions can either enhance or hinder learning, motivation, and performance (Pekrun & Linnenbrink-Garcia, 2014). For instance, positive emotions (e.g., enjoyment) have been linked to more creative and flexible modes of thinking, such as elaboration, critical thinking, and metacognitive monitoring, whereas negative emotions (e.g., anxiety) have been related to more rigid thinking, such as the use of rehearsal strategies (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011; Pekrun, Goetz, Titz, & Perry, 2002). Within medicine and health sciences, however, researchers have largely overlooked the functional role of emotions for learning and performance (McNaughton, 2013). Recently, calls have been made to address this gap (e.g., Artino, 2013; Artino, Holmboe, & Durning, 2012; McConnell & Eva, 2012; O'Callaghan, 2013; Shapiro, 2011). As Croskerry, Abbass, and Wu (2008) argue, there is a need for medical educators to better understand the role of emotions and apply this knowledge to clinical training given the potential impact on decision-making and affect-based errors.

In order to effectively address these calls and empirically examine the role of emotions within medical education, there is a need to critically examine how tools and methods can be used to measure emotions within medical education. With this in mind, we will review a diverse range of measures and methods from fields such as psychology, education, and affective sciences. We will also provide examples from our current research, which examines emotions among medical trainees and experts within authentic learning environments. This includes our empirical work

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on surgical skills training within operating rooms (e.g., Duffy, Lajoie, Jarrell et al., 2015; Duffy, Lajoie, Azevedo, Pekrun, & Lachapelle, 2014; Duffy, Lajoie, Pekrun, Ibrahim, & Lachapelle, 2015), emergency care training within simulation settings (e.g., Duffy et al., 2013, Duffy, Azevedo, Sun et al., 2015), and diagnostic reasoning training within BioWorld, a computer-based learning environment (e.g., Lajoie, 2009; Lajoie et al., 2013). Although this chapter focuses on medical education, it also has broader implications for research and instruction within other domains of health science education, particularly those professions that involve patient care, team dynamics, complex tasks, and high-stakes situations where a range of emotions are likely to be more strongly elicited and influential for learning and performance. As Leblanc, McConnell, and Monteiro (2015) note: "… health professions education could be enriched by greater understanding of how these emotions can shape cognitive processes in increasingly predictable ways" (p. 265).

In the sections that follow, we discuss issues related to validity and reliability, challenges of collecting and analyzing data, as well as theoretical and conceptual considerations. In order to design advanced learning technologies that are sensitive to the role of emotions for learning and performance, we argue that it is critical to understand the advantages and limitations of various methodological approaches. As such, rather than provide an exhaustive review, the goal of this chapter is to provide a better understanding of considerations when measuring emotions within medical education. We start by providing a theoretical background of emotions as the assumptions and issues therein have important methodological implications.

10.2 Theoretical and Empirical Background

10.2.1 The Nature and Structure of Emotions

Emotions are assumed to serve important functions for survival by allowing individuals to react quickly, intensely, and in an adaptive fashion (Plutchik, 1980). Emotions are also important for psychological health and well-being and can impact the surrounding social climate (Izard, 2010). But what is meant by the term *emotion*? How are emotions generated? And what is their role in learning and performance? Emotions are considered by theorists and researchers to fall within the broader concept of affect, but are distinct from other affective phenomena, such as moods, in that they are more intense, have a clearer object-focus, a more salient cause (linked to an event and situation), and are experienced for a shorter duration (Scherer, 2005; Shuman & Scherer, 2014). A rich history of scholarly interest in emotions (e.g., Darwin, 1872; James, 1890) has produced a number of theories of emotion (for review see Gendron & Barrett, 2009; Gross & Barrett, 2011) including theories of basic emotions (e.g., Ekman, 1992; Ekman & Cordar, 2011; Izard, 1993), psychological construction (e.g., Barrett, 2009; Russell, 2003), and appraisal theories (e.g., Frijda, 1986; Lazarus, 1991; Scherer, 1984). For the purposes of this review we focus on componential and appraisal approaches to studying emotions as these frameworks have gained greater traction within educational psychology.

According to the componential model, emotions are widely considered to be multifaceted in that each emotion is composed of coordinated sets of psychological states that include subjective feeling, as well as cognitive, motivational, expressive, and physiological components (Gross & Barrett, 2011; Pekrun, 2006; Scherer, 2005, 2009). As such, this framework considers emotions to be dynamic and recursive episodes[1] that reflect a continuous change in each of the multiple components over time (Scherer, 2009). According to appraisal models of emotions (for review see Moors, Ellsworth, Scherer, & Frijda, 2013) and related frameworks such as control-value theory (Pekrun, 2006; Pekrun, Frenzel, Goetz, & Perry, 2007; Pekrun & Perry, 2014), subjective cognitive appraisals lie at the heart of emotion generation. Within the control-value framework (Pekrun, 2006), for example, individuals will experience specific emotions depending on whether or not they feel personally in control of activities or outcomes that they perceive to be important to them. For instance, if an activity is perceived to be controllable and is positively valued, then an individual is expected to experience enjoyment (Pekrun, 2006; Pekrun et al., 2007), whereas, if an activity is perceived to be controllable but is negatively valued, then anger is likely to occur (Pekrun, 2006; Pekrun et al., 2007). Within this framework, subjective appraisals of value and control (high versus low) play a key role in predicting the specific emotions experienced at a given point in time. The antecedents for these subjective appraisals are influenced by a host of features in the social environment, such as information related to controllability, autonomy support, quality of instruction, achievement-related expectancies of peers/instructors (i.e., how definitions of success and failure are influenced by social expectations), consequences of achievement, and cultural values related to achievement (Pekrun et al., 2006). Theoretically, once emotions are activated, they can in turn influence performance through the mediated role of cognition (e.g., working memory, information processing), motivation (e.g., persistence, effort), and self-regulated learning (e.g., monitoring understanding, evaluating progress; Pekrun et al., 2007; Pekrun & Perry, 2014). In the following section we describe empirical work that has examined these relations within the context of learning and achievement.

[1]Although the componential approach uses the term *emotional episodes* to capture the dynamic nature of emotions (see Scherer, 2009; Shuman & Scherer, 2014), we have opted to use the term *emotional states* as it aligns more closely with the terminology used more commonly in questionnaires (e.g., AEQ Pekrun et al., 2011) and self-regulated learning models (e.g., Azevedo et al., 2013).

10.2.2 Linking Emotions to Learning and Achievement

Research has demonstrated that positive emotions are generally related to more creative and flexible modes of thinking such as elaboration, critical thinking, and metacognitive monitoring, whereas negative emotions (e.g., anger, anxiety) have been linked with more rigid thinking, such as rehearsal strategies (Pekrun et al., 2002). It has also been found that certain negative emotions (e.g., boredom) may hamper self-regulation, whereas positive emotions are related to facets of self-regulation including goal setting, strategy use, monitoring, and evaluation (Pekrun et al., 2002, 2011). In addition, negative emotions are generally negatively related to achievement whereas positive emotions are positively related to achievement (Pekrun et al., 2002, 2011). Within medical education, for example, there is some evidence to suggest that within classroom settings, positive emotions, such as enjoyment, may be beneficial for achievement (Artino, La Rochelle, & Durning, 2010). However, both positive and negative emotions can focus attention away from the task and lead to task-irrelevant thinking by redirecting attention toward the object of the emotion (Meinhardt & Pekrun, 2003; Pekrun et al., 2006). For example, anxiety can be useful if it leads to increases in effort or studying but ineffective if it interferes with attention (Pekrun et al., 2006). This is consistent with research in medical and health science education that has demonstrated complex relationships between anxiety and performance; in some cases anxiety is positively related to performance (e.g., LeBlanc & Bandiera, 2007; LeBlanc, Woodrow, Sidhu, & Dubrowski, 2008), whereas in others it has a negative relationship (e.g., Harvey, Bandiera, Nathens, & LeBlanc, 2012; Hunziker et al., 2011; LeBlanc et al., 2012; Leblanc, MacDonald, McArthur, King, & Lepine, 2005). As Harvey et al. (2012) suggest, these differential effects may be related to the complexity of the task: during less complex tasks (e.g., suturing) anxiety may serve to enhance attention, whereas during more complex tasks (e.g., trauma resuscitation) anxiety may place excessive demands on limited cognitive resources and impede performance. As such, whether or not a particular emotion is considered *adaptive* is context-dependent (Pekrun et al., 2006). For example, as McConnell and Eva (2012) suggest based on their review, positive emotions may enhance more global big-picture thinking among health professionals, whereas negative emotions may lead an individual to become detail-oriented, which can be beneficial for tasks demanding such attention. On the other hand, negative emotions may also promote reliance on well-rehearsed and formulaic problem-solving strategies, whereas positive emotions may lead to more cognitively flexibility and adaptation of strategies, which can be more useful when a strategy is ineffective. More broadly, emotions can influence health professionals' decision-making and performance through its impact on various cognitive processes, such as attention, perception, reasoning, and memory (Leblanc et al., 2015).

Within medicine and health sciences, emotions have typically been assessed in terms of psychological health, burn-out, and well-being (e.g., Chew, Zain, & Hassan, 2013; Dyrbye et al., 2014; Satterfield & Hughes, 2007) rather than their functional role in learning and performance. Research that has examined links between affect-related variables and clinical performance have focused primarily on the role of stress (e.g., Harvey et al., 2012; Leblanc, 2009; LeBlanc et al., 2011; Piquette, Tarshis, Sinuff, Pinto, & Leblanc, 2014), which is typically considered to be a negative state that aligns closely with anxiety (Sharma & Gedeon, 2012). Table 10.1 includes representative examples of studies and measures resulting from a literature search of research examining the role of emotions within medical and health sciences education. These studies range from emergency medicine and technical skills training to clinical reasoning and communication skills training.

As demonstrated in Table 10.1, previous research has typically employed a combination of self-report and physiological measures to identify stress patterns in particular. The few studies within medical education that have examined a broader range of emotions from a learning and achievement perspective have typically relied on self-report measures (e.g., Artino et al., 2010; Fraser et al., 2012; 2014; Hunziker et al., 2011; Kasman, Fryer-Edwards, & Braddock, 2003). As such, there is a need to consider a more diverse array of emotional states and measures.

10.3 Measuring Emotions

As the emotion literature grows, there remain several unresolved questions and discussions regarding the nature and structure of emotions, which have methodological and analytical implications. For example: should emotions be characterized as discrete or dimensional? Are they precipitated by cognitive appraisals or are they largely automated responses? Are they universal or context-specific? Are they distinct from other psychological states? Despite these unresolved conceptual issues, emotion research continues to move forward, as do methodological and analytic developments. Perhaps, as Picard (2010) and other affective computing researchers (Calvo & D'Mello, 2012) and neuroscience researchers (Immordino-Yang & Christodoulou, 2014) have suggested, data collected from advanced emotion-detection technologies and methodologies may provide insights that allow researchers to overcome conceptual hurdles and enrich theoretical models. To assess the utility of these methods for medical education, however, it is important to first consider approaches to organizing the array of emotion measures.

10.3.1 Organizing and Classifying Emotion Measures

Emotion measures and their corresponding analytic techniques can be organized based on conceptual features and methodological approaches. For example, from a conceptual standpoint, emotions can be grouped according to valence: positive emotions (pleasant valence) versus negative emotions (unpleasant valence); physiological arousal: activating versus deactivating (Pekrun et al., 2002, 2006); and action tendency: whether the emotion is associated with a tendency to approach

Table 10.1 Examples of studies measuring emotions in medical and health sciences education

Authors	Title	Emotions	Measures
Arora et al. (2010)	Stress impairs psychomotor performance in novice laparoscopic surgeon	Stress/anxiety	Self-report (questionnaire)
			Physiological (cortisol level, heart rate)
Artino et al. (2010)	Second-year medical students' motivational beliefs, emotions, and achievement	Positive and negative emotions	Self-report (questionnaire)
Cheung and Au (2011)	Nursing students' anxiety and clinical performance	Stress/anxiety	Self-report (questionnaire)
Clarke et al. (2014)	Heart rate, anxiety, and performance during a simulated critical clinical encounter: a pilot study	Stress/anxiety	Self-report (questionnaire)
			Physiological (heart rate)
Duffy, Azevedo, Sun et al. (2015)	Team regulation in a simulated medical emergency: an in-depth of analysis of cognitive, metacognitive, and affective processes	Positive and negative emotions	Self-report (interview)
			Behavioral (body language, speech, facial expression)
van Dulmen et al. (2007)	The impact of assessing simulated bad news on medical students' stress response and communication performance	Stress/anxiety	Self-report (questionnaire)
			Physiological (cortisol level, heart rate, blood pressure)
Fraser et al. (2012)	Emotion, cognitive load, learning outcomes during simulation training	Positive and negative emotions	Self-report (questionnaire)
Fraser et al. (2014)	The emotional and cognitive impact of unexpected simulated patient death	Positive and negative emotions	Self-report (questionnaire)
Harvey et al. (2012)	Impact of stress of resident performance in simulated trauma scenarios	Stress/anxiety	Self-report (questionnaire)
			Physiological (cortisol level, heart rate)
Hunziker et al. (2011)	Perceived stress and team performance during a simulated resuscitation	Positive and negative emotions	Self-report (questionnaire)
Keitel et al. (2011)	Endocrine and psychological stress responses in a simulated emergency situation	Stress/anxiety	Self-report (questionnaire)
			Physiological (cortisol level)
Leblanc et al. (2005)	Paramedic performance in calculating drug dosages following stressful scenarios in a human patient simulator	Stress/anxiety	Self-report (questionnaire)

Table 10.1 (continued)

Authors	Title	Emotions	Measures
LeBlanc et al. (2008)	Examination stress leads to improvements on fundamental technical skills for surgery	Stress/anxiety	Self-report (questionnaire)
LeBlanc et al. (2012)	The impact of stress on paramedic performance during simulated critical events	Stress/anxiety	Self-report (questionnaire)
			Physiological (cortisol level)
Meunier et al. (2013)	The effect of communication skills training on residents' physiological arousal in a breaking bad news simulated task	Stress/anxiety	Self-report (questionnaire)
			Physiological (cortisol level, heart rate)
Müller et al. (2009)	Excellence in performance and stress reduction during two different full-scale simulator training courses: a pilot study	Stress/anxiety	Physiological (cortisol level)
Piquette, Reeves, and LeBlanc (2009)	Stressful intensive care unit medical crises: how individual responses impact on team performance	Stress/anxiety	Self-report (interview)
Piquette et al. (2014)	Impact of acute stress on resident performance during simulated resuscitation episodes: a prospective randomized crossover study	Stress/anxiety	Self-report (questionnaire)
			Physiological (cortisol level)
Wetzel et al. (2006)	The effects of stress on surgical performance	Stress/anxiety	Self-report (interview)
Wetzel et al. (2010)	The effects of stress and coping on surgical performance during simulations	Stress/anxiety	Self-report (questionnaire)
			Behavioral (not specified)
			Physiological (cortisol levels, heart rate)

Note: Studies were included in this review if they: (1) measured state emotions/short-term affective states (e.g., acute stress) rather than trait emotions/long-term affective states (e.g., burn-out) and (2) examined emotions in relation to learning and/or performance variables stimuli (e.g., anger, excitement) or avoid stimuli (e.g., anxiety; Frijda, 1986, 1987; Mulligan & Scherer, 2012). Emotions can also be classified according to the object or event focus, which refers to the focus of the attention (Pekrun & Linnenbrink-Garcia, 2014; Shuman & Scherer, 2014). For example, *outcome emotions* relate to the outcome of an event (e.g., anticipating success on an exam), whereas a*ctivity emotions* relate to the task at hand (e.g., frustration during problem-solving; Pekrun, 1992; Pekrun et al., 2002). A distinction can also be made based on temporal generality of an emotion: *state emotions* (occur for a specific activity at a specific point of time) or *trait emotions* (recurring emotions that relate to a specific activity or outcome; Pekrun et al., 2011). Emotions can also be organized based on taxonomies, which consist of discrete emotions (e.g., frustration) that are likely to be activated during specific activities or within specific contexts (e.g., academic emotions).

In addition to these conceptual groupings, emotion measures can also be organized based on the methodological approaches employed. For example, emotion measures can be distinguished according to the type of data channel used (e.g., self-report, behavioral physiological), the frequency of data points (e.g., one point in time versus continuous process measures), and the time of administration in relation to the event of interest (e.g., concurrent versus retrospective). Overall, these systems of organizing emotions can be used to identify underlying assumptions, as well as the benefits and limitations of each measure. These conceptual and methodological features will be taken into consideration in the following review of emotion measures, which we organize according to the type of data channel (self-report, behavioral, physiological). Table 10.2 contains a summary of each data channel, including example measures, advantages, limitations, and applications for medical education.

10.3.2 Self-Report Measures

Self-report measures of emotions include data channels that rely on individuals' perceptions and communication of emotional states, typically collected through questionnaires and interviews. Given that emotions are considered to be subjective experiences (Shuman & Scherer, 2014) that can be verbally communicated (Pekrun & Linnenbrink-Garcia, 2014), self-reports will likely continue to be widely used (Shuman & Scherer, 2014). Questionnaires are typically designed to measure frequency and intensity of emotions, whereas interviews can be used to further explore participants' perceptions, experiences, and antecedents related to the onset of emotional states. These types of measures vary greatly in terms of breadth and structure, such as single versus multi-item scales, open-ended questions versus structured ratings, state versus trait perspectives, and retrospective versus concurrent reporting (Pekrun & Bühner, 2014). On the surface, self-reports seem to solely assess the subjective feeling component of emotions yet questionnaires and interviews can also be designed to measure other emotion components by designing questions or

Table 10.2 Summary of review of emotion measures and applications for medical education settings

Data channel	Sample measures	Technology advances	Advantages	Disadvantages	Med Ed settings
Self-report	• Questionnaires	• Wi-Fi-enabled and tablet accessible for increased mobility, efficiency, and storing	• Economical	• Difficult to capture continuous or dynamic nature of emotions	• Classrooms
	• Interviews		• Efficient	• Susceptible to cognitive and memory biases	• Simulations (difficult to collect during performance tasks)
	• Experience sampling		• Scalable		• Naturalistic (difficult to collect during performance tasks)
	• Emote-aloud		• Captures subjective experience		• CBLEs
Behavioral	• Facial expression	• Automatic detection software for coding (facial recognition software; speech analyses software)	• Not susceptible to cognitive and memory biases	• Human coding is time-intensive	• Classrooms (ideal with individual or small group learning)
	• Speech and paralinguistics		• Provides continuous stream of process data	• Software is reliant on databases of posed emotions; not well-equipped to detect subtle, spontaneous emotions	• Simulations (ideal for body language)
	• Body language			• Quality of video and audio data dependent on recording	• Naturalistic (recording equipment can be intrusive in some settings)
				• Multimodal interference	• CBLEs (ideal for facial)
				• Susceptible to impression management	

(continued)

Table 10.2 (continued)

Data channel	Sample measures	Technology advances	Advantages	Disadvantages	Med Ed settings
Physiological	• Central nervous system (regional brain activation)	• Brain imaging studies	• Provides continuous stream of process data	• Only assess physiological component rather than valence or specific discrete emotions	• Classroom
	• Autonomic nervous system (electrodermal activity, heart rate, salivary cortisol test)	• Mobile physiological measures	• Not susceptible to attempts to conceal emotion or cognitive and memory bias	• Brain imaging studies are expensive, low ecological validity	• Simulations
			• Fine-grained data	• Susceptible to interference by non-affective factors	• Naturalistic
			• Some measures are more mobile and discrete		• CBLEs

scale items that include physiological, cognitive, motivational, and expressive responses corresponding to each unique emotion (Pekrun & Bühner, 2014).

Questionnaires can be administered in several manners, including traditional paper-based formats, as well as electronic and web-based questionnaires accessible through computers and Wi-Fi-enabled handheld mobile devices, such as tablets and smartphones (see Fig. 10.1). These electronic questionnaires afford the flexibility to unobtrusively measure emotions in diverse environments. They also allow responses to be reviewed in real-time, which can be useful for identifying key emotional events to examine further during follow-up interviews or adaptive learning systems.

However, there are several unresolved questions regarding the ideal frequency and timing of administration. For instance: how often should a questionnaire be administered to provide a representative picture of concurrent emotions during learning? Should the deployment of questionnaires be aligned to key events or set time intervals? Whereas time-based sampling captures the trajectory of emotions across different phases of learning, event-based sampling can reveal sources of emotions (Turner & Trucano, 2014). Decisions regarding administration will largely depend on the nature of the learning environment and research questions. For instance, researchers may aim to capture salient emotions experienced during learning or they may be interested in linking emotions to specific events, such as the deployment of self-regulated learning processes (e.g., cognitive, metacognitive, motivational) or instructor prompts and feedback. Furthermore, some naturalistic learning environments may require that the questionnaire be administered less frequently to reduce interruptions to the learning activity or performance task at hand.

Experience sampling methods (ESM; Csikszentmihalyi & Larson, 1987; Hektner, Schmidt, & Csikszentmihalyi, 2007) have been used to provide an unobtrusive and representative sample of individuals' emotions in naturalistic settings (e.g., Becker, Goetz, Morger, & Ranellucci, 2014; Goetz et al., 2014; Nett, Goetz, & Hall, 2011) by prompting participants to respond to questions at random time points over a specific interval (e.g., over the course of a day, week, or month). This technique has also been used within medical settings to measure trainees' emotional experiences (e.g., Kasman et al., 2003). Although this method is intended to capture a representative selection of emotional experiences, it falls short of providing a continuous measure of emotional states at a fine-grained (second-minute) level of temporality. More recently, emote-aloud methods have been used to prompt participants to communicate their emotional states during learning in a manner similar to think-aloud protocols (Craig, D'Mello, Witherspoon, & Graesser, 2008); thus, capturing an online trace of emotions and potentially state-transitions as they occur in real-time. However, further work is needed to determine whether this approach is cognitively taxing for participants, whether it is susceptible to social desirability biases or individual variability in verbosity, and how it differs from other speech and paralinguistic channels used to assess emotions (described below).

In terms of the range of emotions detected using self-report measures, the education literature has been largely dominated by a focus on anxiety (Zeidner, 2014). This is also the case for medical and health sciences education as evidenced by the use of the State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) across of number of studies (e.g., Arora et al., 2010; van Dulmen et al., 2007; Harvey et al., 2012; Leblanc et al., 2005; Meunier et al., 2013; Piquette et al., 2014). Although these scales have provided important insights into the role of stress in learning, they are complicated by issues with discriminant validity—namely, they appear to assess multiple negative emotions, such as shame and hopelessness rather than providing a pure measure of anxiety (Pekrun & Bühner, 2014). More recently, the Achievement Emotion Questionnaire (AEQ; Pekrun et al., 2002; 2011) has been used to capture a broader range of emotions expected to be elicited within achievement contexts, which according to Pekrun and Linnenbrink-Garcia (2014, p. 260) can be defined as: "activities or outcomes that are judged according to competence-related standards of quality." Several studies (e.g., Goetz, Pekrun, Hall, & Haag, 2006; Pekrun et al., 2006, 2009, 2011; Pekrun, Elliot, & Maier, 2009; Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010) have used the AEQ to assess trait and state emotions (e.g., hope, pride, enjoyment, relief) across various facets of academic achievement settings (e.g., learning and test-taking) at various points in time (e.g., before, during, after the activity). This measure has also been used to assess course-related emotions for medical students (e.g., Artino et al., 2010).

In our research within medical education (e.g., Duffy et al., 2014; Duffy, Lajoie, Jarrell et al., 2015; Duffy, Lajoie, Pekrun et al., 2015), we have used likert-scale questionnaires and semi-structured interviews to assess state emotions before, dur-

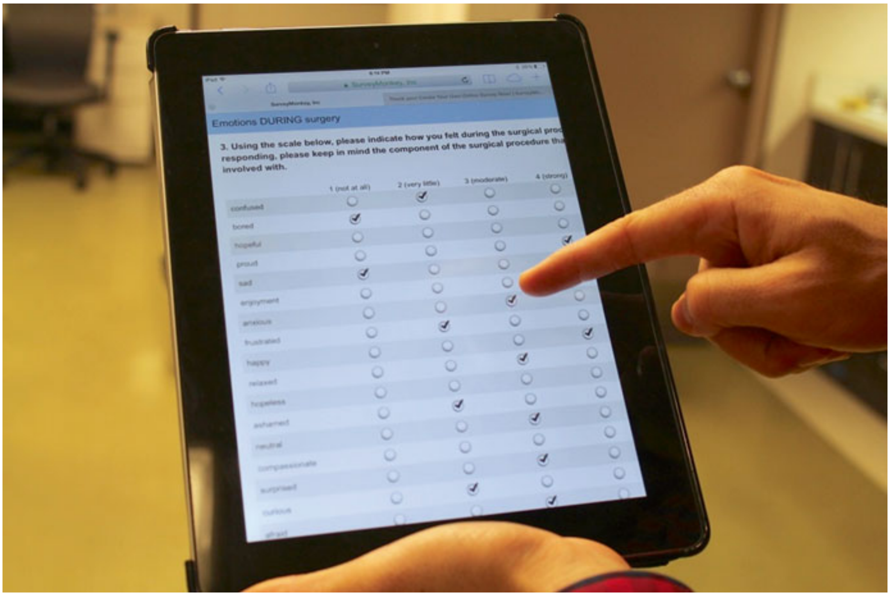

Fig. 10.1 Self-reported concurrent emotional states using Wi-Fi enabled tablet to complete the Medical Emotions Questionnaire (Duffy, Lajoie, Jarrell et al., 2015; Duffy, Lajoie, Pekrun et al., 2015)

ing, and after learning and performance activities across authentic learning environments (simulation training, surgical settings, and computer-based learning environments). We have found questionnaires to be relatively efficient to administer and analyze across a range of learning environments, whereas interviews can be conducted retrospectively to provide rich contextual information regarding the antecedents, object-focus, and role of emotions. Collectively, these self-report measures allow us to examine participants' perceptions and subjective experience of emotions.

Within computer-based medical learning environments (e.g., Duffy, Lajoie, Jarrell et al., 2015; Lajoie et al., 2013), we have embedded time-triggered questionnaires to measure activity emotions as they occur at multiple points during the session. These concurrent measures are considered to be more valid (Mauss & Robinson, 2009) as they are less susceptible to memory biases and do not appear to interfere with learning within this environment. In contrast, within team-based simulation and surgical settings (Duffy et al., 2013; Duffy, Lajoie, Pekrun et al., 2015; Duffy, Azevedo, Sun et al., 2015), we have opted to measure self-reported activity emotions retrospectively (via questionnaires and interviews) given that administering questionnaires during the activity could significantly interfere with performance and group dynamics within these achievement-oriented environments.

To conduct follow-up interviews, we have integrated both retrospective (Ericsson & Simon, 1993) and cognitive interviewing techniques (Muis, Duffy, Trevors, Ranellucci, & Foy, 2014). In addition to gaining information about the nature of emotional experiences, these methods allow us to assess convergent validity (i.e., whether there is alignment between interview and questionnaire responses), construct validity (i.e., whether interpretations and responses to questionnaire items align with theoretical assumptions), and face validity (i.e., whether the questionnaire presents a representative range of emotions experienced and is presented in a way that is clear). Eye-tracking and video replay can also be integrated into retrospective interviewing protocols to align participants' recall of emotional states with cued learning events (see Van Gog & Jarodzka, 2013).

From analyses of questionnaire data collected from medical trainees within surgical settings (i.e., conducting a vein harvest procedure within the operating room) and computer-based learning environments (i.e., conducting a diagnostic reasoning task within BioWorld to solve a virtual case) we have found that the more intensely experienced emotions across these environments include: curiosity, compassion, happiness, relaxation, confusion, pride, and relief. The salience of these emotions varies according to prior experience (e.g., high versus low) type of task/environment (e.g., technical skills within the operating room versus diagnostic reasoning skills within computer-based learning environments), and time of response relative to learning or performance (e.g., before, during, after task; Duffy, Lajoie, Jarrell et al., 2015). From analyses of interview responses, we have discovered that the emotion "disgust" is perceived as less relevant than other emotions. These interviews also illuminated the reoccurring theme of group dynamics in emotion generation within team environments.

To collect this data, we have developed a scale (Medical Emotion Questionnaire), which consists of emotion taxonomies specifically selected for their relevance to medicine education. For example, within most medical education environments, it is likely that achievement emotions (e.g., anxiety, enjoyment; Pekrun et al., 2011), social emotions (e.g., compassion, gratitude; Fisher & van Kleef, 2010; Weiner, 2007), and epistemic or knowledge emotions (e.g., confusion, curiosity; Muis et al., 2015; Pekrun & Stephens, 2011) are activated given the inherent performance expectations, social dynamics, and knowledge-based nature of medicine. Basic emotions (e.g., fear, anger, sadness; Ekman, 1972, 1992) may also play a role within high-stakes medical education environments, such as simulations and naturalistic settings (e.g., surgical and emergency rooms) given that crisis responses might generate what are considered to be more automated and psychologically primitive or elemental emotions (Tracy & Randles, 2011). Our approach is consistent with Shuman and Scherer's (2014) recommendation to include multi-emotion measures, as well as previous work that has adapted self-report measures to include taxonomies of emotions that are more context-sensitive (e.g., Zentner, Grandjean, & Scherer, 2008) given that emotions are considered to be domain-specific and may vary according to the educational environment (D'Mello, 2013; Goetz, Frenzel, Pekrun, Hall, & Lüdtke, 2007; Goetz et al., 2006) and sociocultural context (Turner & Trucano, 2014). These developments prompt new questions, such as whether the emotions included are strictly orthogonal (represent independent and unique emotions) or whether they represent several clusters or families of related emotions that share similar components (e.g., sadness and disappointment; Mauss & Robinson, 2009; Shuman & Scherer, 2014).

A key drawback to using self-report measures is that they are susceptible to several validity threats including cognitive and memory biases. Participants may forget the emotional state they are asked to recall or construct a false memory of an emotion to explain their performance. It is also not clear whether participants' interpretation of self-report questions aligns with researchers' assumptions or whether they possess adequate emotional awareness to monitor and effectively describe their emotions. This latter concern may be particularly relevant within medical domains, as it has been suggested that the culture of medicine encourages students to disconnect from their emotions to the extent that they may have difficulty recognizing and processing emotional states (Shapiro, 2011). As previously mentioned, another limitation is that self-reports are not always feasible to administer concurrently during performance tasks within high-stakes environments as the nature of these measures interrupts the task itself. As such, it is worth complementing questionnaire data using less intrusive methods; in the following section, we discuss behavioral measures of emotion.

10.3.3 Behavioral Measures

There is a wide array of behavioral measures, which rely on overt actions, movements, and mannerisms to detect emotional states. Although these measures directly measure the expressive component of emotions, it is argued that these expressions correspond to specific emotional states. Typically behavioral measures are used to identify the frequency of emotions although intensity can also be assessed depending on the coding methods used (Reisenzein, Junge, Studtmann, & Huber, 2014).

Facial expressions are one of the more commonly used behavioral channels for emotion detection and typically rely on video recordings of facial expressions as they occur and change over time. Coding systems developed to detect these emotional states typically rely on facial movements. While some coding methods (e.g., Kring & Sloan, 2007) focus exclusively on sets of muscle movements that are postulated to represent theoretically meaningful emotions, the Facial Action Coding System (Ekman & Friesen, 1978; Ekman, Friesen, & Hager, 2002) includes a broad range of action units (micro motor muscle movements), and as such, is designed to provide a more objective approach to coding. The FACS approach may also be well suited to natural, subtle expressions given that the facial action unit combinations can result in thousands of possible facial expressions (Zeng, Pantic, Roisman, & Huang, 2009). Automated systems for emotion detection can help to reduce human resources needed to manually code emotions (Azevedo et al., 2013; Zeng et al., 2009). For example, automatic facial recognition software, such as Noldus FaceReader™ is designed to classify basic emotions automatically (typically post-hoc) and has been used within a host of studies to detect and trace emotion (e.g., Craig et al., 2008; Pantic & Rothkrantz, 2000).

Speech provides another behavioral channel commonly used to detect emotions through discourse patterns and paralinguistics/vocal features (e.g., intonation, pitch, speech rate, amplitude/loudness) (e.g., D'Mello & Graesser, 2010, 2012). Previous research has found that combinations of multiple speech features can help to detect specific emotional states (Mauss & Robinson, 2009). Software programmes also exist for linguistic and paralinguistic content (Zeng et al., 2009). These programmes share similar limitations to facial recognition software in that they are often restricted to detecting basic emotions (e.g., happiness, sadness, disgust, fear, anger, surprise), which may not capture the full range or types of emotions activated within educational settings (Zeng et al., 2009). These programmes are also based on databases of deliberately displayed (i.e., posed) expressions and, as such, are better equipped to detect extreme or prototypical expressions rather the natural spontaneous expressions we would expect to see in most learning environments (Zeng et al., 2009).

Recent trends have also included analysis of other behavioral features, such as body language and posture (e.g., D'Mello, Dale, & Graesser, 2012; D'Mello & Graesser, 2009). Compared to facial expression and speech features, which appear to be better equipped to predict valence and arousal dimensions of emotions respectively, specific body postures appear to provide markers for distinct emotional states that cannot be detected as reliably with other behavioral data channels (Mauss &

Robinson, 2009). For example, research has shown that there is a link between pride and increased posture, and embarrassment and reduced posture (Keltner & Buswell, 1997; Tracy & Robins, 2004, 2007). An upright posture has also been observed during states of confusion (D'Mello & Graesser, 2010).

In our research within medical education, we have collected facial expression data, as well as body language, and speech/vocal features during computer-based learning and simulation training using video and audio recordings (Duffy et al., 2013; Duffy, Lajoie, Jarrell et al., 2015; Duffy, Azevedo, Sun et al., 2015). Although we have not collected this data to the same extent within naturalistic settings (e.g., operating rooms, clinical settings) given the practical challenges of installing equipment, we have conducted field observations that rely on similar behavioral indices. Overall, we have found that these data channels are relatively inconspicuous and allow participants to complete learning and performance tasks without interruption. They also allow us to detect emotions without reliance on participants' knowledge and unbiased communication of their emotional states. Collectively, these behavioral measures provide a concurrent trace that allows us to measure the onset and transition of emotional expressions as they occur in real-time. However, the analyses of this data can be time and labor intensive, particularly when human coding methods are employed.

We have found that computer-based learning environments are ideal for facial expression detection; high-quality video recordings can be captured using a mounted camera given that these sessions are typically conducted with one participant at a time and involve relatively stationary behavior. However, this may pose challenges when using a multimodal approach. For instance, if we instruct participants to sit upright and restrain from covering their face with their hands (to maintain a consistent view of the face), this interferes with the ability to collect recordings of natural body movements, such as leaning towards the computer when curious. Similarly, using think-alouds or emote-alouds for speech and paralinguistic analysis can interfere with the accuracy of facial expression detection as the coding process is reliant on facial muscle movements, including the mouth, which may change as an artifact of speech rather than facial expression. Segmenting videos for reliable expressions can be time-consuming; fortunately, facial recognition software provides probabilities of classified emotional states that can be verified if the threshold is too low. Figure 10.2 illustrates automated classification of emotion (in this case happiness) using facial expression recognition software during learning within a computer-based learning environment. Moment-to-moment fluctuations in emotion intensity and valence can be displayed over time, as well as a summary of proportions of expressed emotions during the entire learning session. Detailed log files are produced to analyze variations in emotional states and emotion recognition accuracy.

Simulation environments allow for more natural body movements and speech behaviors but the issue of multimodal interference still exists. The increased mobility and dynamic nature of this environment also introduces new challenges, particularly within team-based simulations. For instance, movement can interfere with the ability to consistently capture facial expressions and the distance between the camera(s) and individual team members do not provide ideal conditions to use facial recognition software due to lack of precision and inconsistent facial views. Within these settings we have opted to code facial expressions, body language, and speech by coding each team member individually and collapsing across the group for analyses and comparative purposes (e.g., team leader versus team members Duffy, Azevedo, Sun et al., 2015). Emotion events can be segmented according to the onset and endpoint of an emotional cue (as opposed to pre-determined time segments), which is linked to a behavioral channel (e.g., facial expression, body language). Neutral can be included to provide a baseline or resting state (no positive or negative valence) and allow for a continuous stream of emotion codes. To establish validity and reliability, we have used multiple coders, subject-matter experts' analysis, and theoretically driven coding schemes. This process brings to light several considerations, including: the number of data channels needed to make grounded inference, whether certain data channels are more reliable than others, segmentation of emotional events (time-based versus event-based), the degree of intensity needed to classify an emotion as present versus absent, the co-occurrence of multiple emotions, conflicting evidence from different data channels, and as Järvenoja, Volet, and Järvelä (2013) have discussed, the occurrence of socially shared emotional events that appear at the group rather than individual level.

One advantage of human coding within these environments is that coders can be trained to detect subtle and natural changes in emotion by analyzing microexpressions (Matsumoto & Hwang, 2011) or including contextual cues (e.g., baseline behavior, events preceding emotional event, peer responses, changes over time). This in situ idiographic approach can boost ecological validity by detecting variations that are unique to an individual, group, or task. Another benefit of human coders is that they can employ adapted coding schemes that include a range of emotion taxonomies and corresponding behavioral indices that are context- and domain-sensitive. As previously mentioned, most of the automated computer-based coding systems classify basic emotions exclusively. Recent advances in machine learning techniques (e.g., use of log files and eye-tracking for contextual cues) and facial recognition software (e.g., including databases composed of naturalistic facial expressions and learner-centered emotions) may help to address these limitations (Zeng et al., 2009).

Although behavioral measures obviate several limitations of self-report data, they are still influenced by the broader culture of a given domain. As Mauss and Robinson (2009) note, various factors such as social dynamics, feedback, and success/failure perceptions may affect the type and nature of facial expressions displayed, which suggests that expressions may be highly context-sensitive, rather than a one-to-one indicator of specific emotional states (Zeng et al., 2009). For example, in certain situations a smile may be indicative of embarrassment rather than happiness (Mauss & Robinson, 2009). Within medicine, it may be the case that expressions are masked or displayed in a different manner than in other educational environments. In particular, social desirability may reduce emotion expression within medical cultures as participants may consciously or unconsciously conceal observable displays of emotions that they are currently experiencing. Medical students may learn through training and socialization that communicating and displaying one's

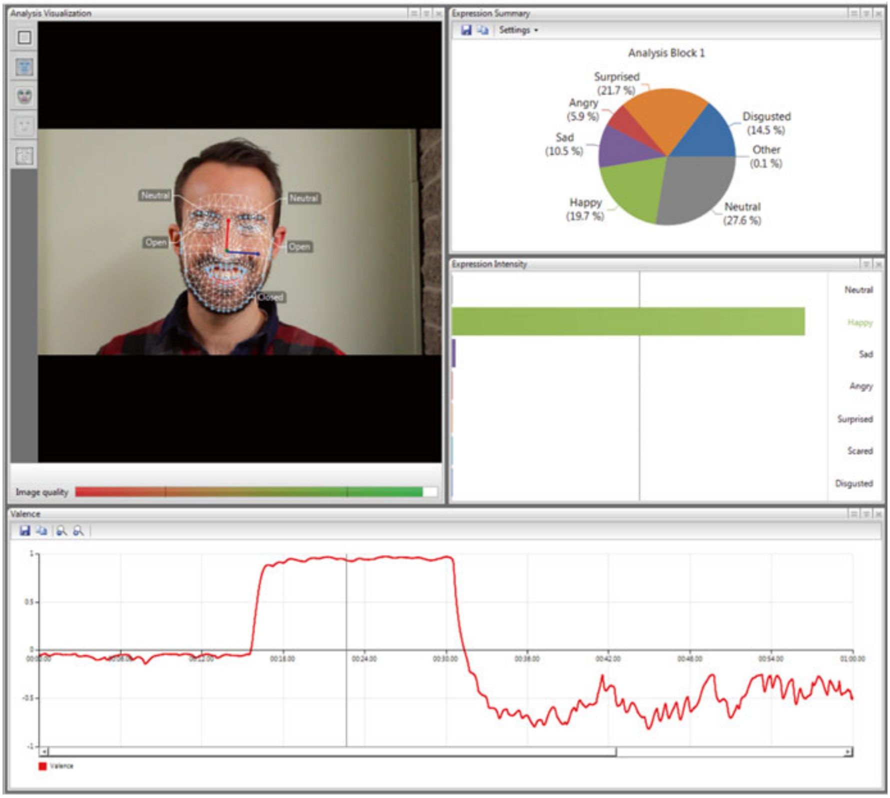

Fig. 10.2 Automated emotion classification of facial expression within computer-based learning environment using video and FaceReader™ software

emotions (whether explicitly or implicitly) is inappropriate (O'Callaghan, 2013; Shapiro, 2011). This may be the reason why behavioral measures of emotions have been less commonly used within medical and health sciences education research, compared to self-report and physiological measures. In the following section, we discuss physiological measures that are less vulnerable to these potential validity threats.

10.3.4 Physiological Measures

Physiological measures of emotion rely on responses of the central and autonomic nervous systems. Central nervous system (CNS) measures attempt to link brain regions to emotions and commonly employ electroencephalogram (EEG) or neuro-imaging methods. EEGs record electrical activity to identify which hemispheres (left versus right) and brain regions (e.g., frontal region) are activated during emotional states, whereas neuroimaging technologies (e.g., functional magnetic resonance imaging, positron emission tomography) can identify activation of more precise brain regions (e.g., amygdala) by measuring changes in blood flow and metabolic activity (Mauss & Robinson, 2009). There are several advantages to these types of devices. Similar to behavioral measures, they do not require accurate self-reports or interruption from activities. They also are less susceptible to impression management. These channels provide a fine-grained continuous trace that capture the dynamic nature of physiological arousal as it occurs in real time (Calvo & D'Mello, 2012).

In general, while these measures of the CNS show promise, it is likely that emotional states involve complex networks or systems of brain activity rather than isolated regions; as such, further work is needed to identify circuits of activation (Mauss & Robinson, 2009). At this stage, correlates between brain states and emotions are largely limited to discriminating between positive/negative valence and approach/avoidance action tendency dimensions of emotion rather than discrete emotional states (Mauss & Robinson, 2009) although progress is being made towards linking brain regions to specific emotions, as demonstrated in research linking fear to the amygdala (Murphy, Nimmo-Smith, & Lawrence, 2003). Furthermore, the methods employed to date typically involve provoking a prototypical or extreme emotional state by presenting sensational stimuli in highly controlled experimental settings rather than capturing the more subtle range of naturally occurring emotions likely to be experienced within academic and achievement settings.

In contrast to the brain regions, peripheral physiological measures of emotions rely on indices of the autonomic nervous system, which is responsible for managing activation and relaxation functions of the human body (Öhman, Hamm, & Hugdahl, 2000). Various peripheral physiological measures and affective devices have been used to track emotion-related patterns, including salivary cortisol tests, electrodermal activity (EDA)/galvanic skin conductance, and heart rate/cardiovascular responses (e.g., Azenberg & Picard, 2014; Matejka et al., 2013; Poh, Swenson, & Picard, 2010; Sharma & Gedeon, 2012). These types of measures, particularly salivary cortisol levels and heart rate, have also been used within medicine and health sciences research to measure stress-related states similar to anxiety during learning and performance (e.g., Arora et al., 2010; Clarke, Horeczko, Cotton, & Bair, 2014; van Dulmen et al., 2007; Harvey et al., 2012; Hunziker et al., 2012; Meunier et al., 2013; Piquette et al., 2014). However, given the diverse functions of the autonomic nervous system, it can be difficult to isolate fluctuations that are solely related to emotions rather than other activities of the autonomic nervous systems acting in parallel (e.g., digestion, homeostasis; Hunziker et al., 2012; Kreibig & Gendolla, 2014; Mauss & Robinson, 2009). Moreover, across measures, these channels appear to exclusively measure the physiological component of emotions (high versus low arousal) rather than differentiate between specific emotions (e.g., anger versus fear; Mauss & Robinson, 2009). Practically speaking, this also makes it difficult to determine whether an increase in physiological activity represents a state of a negative or positive emotion (e.g., anxiety or excitement).

In our research within medical education, we have used EDA sensors to measure emotion-related physiological arousal before, during, and after learning and performance activities within simulation training, surgical settings, and computer-based learning environments (Duffy et al., 2013, 2014; Duffy, Lajoie, Pekrun et al., 2015). We have opted to use Affectiva Q™ sensor bracelet (see Fig. 10.3)[2] within surgical settings as it is portable, noninvasive, and inconspicuous (Poh et al., 2010).

Within computer-based learning environments, we have used the Biopac™ sensor, which requires attachment of electrodes to the skin and a stationary transmitter. In both cases, these devices are arguably better able to isolate emotion-related arousal compared to other physiological measures (e.g., heart rate), which are influenced by non-affective factors to a greater extent (Kreibig & Gendolla, 2014). These devices can also be used across a range of environments; thus capturing more spontaneous and natural fluctuations compared to brain imaging techniques (Picard, 2010; Poh et al., 2010).

In our research, we have linked physiological traces to key events and other data channels (e.g., self-report) by recording time-stamped log files within computer-based learning environments and time-stamped field notes with naturalistic settings (see Fig. 10.4). Using this approach, we have observed fluctuations in arousal in response to key events during and after surgical procedures.

For example, Fig. 10.4 illustrates a medical trainee's arousal level heightening at the beginning of a more complex technical procedure (vein harvest), reducing during a less complex procedure (suturing), and increasing again during a follow-up interview as they recall emotions experienced during the procedure. One challenge we have encountered is that certain EDA devices require a baseline before engaging in the learning activity. Although this is feasible to obtain within lab-based settings, it is more challenging to obtain within naturalistic settings. Furthermore, individuals often possess different baseline measures of arousal/sweat conductance, so exercise or cognitively taxing tasks may be needed to reach a sufficient threshold for activation (Poh et al., 2010). In addition, researchers commonly administer the EDA bracelet on the palmar or forearm, which is not always feasible in clinical settings where hand-washing practices may interfere with device functionality. However, recent research suggests other sites on the body may provide viable options for measurement (Fedor & Picard, 2014).

Another significant challenge is that at this stage discrete emotions are not clearly or consistently differentiated through physiological patterns (Mauss & Robinson, 2009). One approach for analysis is to focus exclusively on reporting levels of arousal rather than emotions. Another approach is to examine how physiological signatures correspond to changes in emotional states using a multimodal approach (Immordino-Yang & Christodoulou, 2014). For instance, if an individual reports or displays expressions of enjoyment, we can examine their physiological data at that precise moment to identify patterns of arousal that may differentiate this emotion from other emotional states using intra- and inter-individual analyses. It is also pos-

[2] Image for illustrative purposes only. Manufacturer user manual suggests placing device on inside of wrist.

sible that a particular emotion (e.g., boredom) could produce different types of physiological signatures depending on whether an individual is experiencing mixed emotions (e.g., boredom and anger; Larsen & McGraw, 2011) or different subtypes of a particular emotion (e.g., indifferent boredom versus reactant boredom; Goetz et al., 2014). This type of work may help us to re-examine assumptions about the underlying physiological components of emotions.

At an analytical level, all emotion measures described may involve comparisons across a host of factors, including the following: (1) types of tasks (e.g., diagnostic reasoning, surgical procedures, emergency resuscitation); (2) key events during an activity or task (e.g., novel versus routine procedures); (3) learning environments (e.g., computer-based learning environments, simulation centers, real-world clinical environments, operating rooms); (4) time of response (e.g., before, during, after task); and (5) experience level (e.g., novice versus expert). Comparing across these factors may help to illuminate which emotions in particular are more frequently or intensely experienced, which can be used as a index for identifying the most relevant or influential emotions within medical education.

10.4 Discussion

In this section we return to the role of emotion measures in learning. Specifically, we discuss how the emotion measures and detection technologies reviewed can be used to improve learning and instruction through the development of affect-sensitive instruction and learning technologies. These new-generation advanced learning

Fig. 10.3 Affectiva Q™ sensor is used to track electrodermal activity in dynamic environments

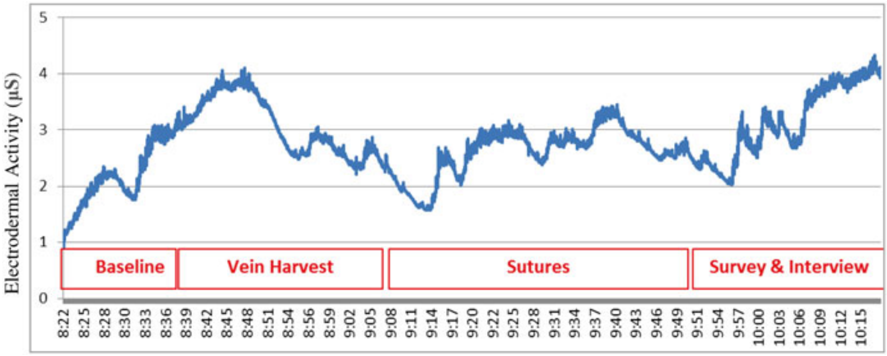

Fig 10.4 Electrodermal activity data over time within surgical environment (Duffy, Lajoie, Pekrun et al., 2015)

technologies embody the importance of employing reliable emotion measurement techniques.

Data collected from emotion measures can help to promote effective instruction in several ways. One way is to examine self-report responses and behavioral expressions at the individual or group level to gauge whether specific pedagogical approaches and learning activities prompt a positive emotional reaction (e.g., curiosity, enjoyment). For example, after an emergency care simulation, asking learners to report how they feel can help instructors to determine whether the complexity, novelty, and high-stakes features of a scenario were overwhelming or engaging. At the individual level, detecting negative emotions (e.g., anxiety, boredom) through more subtle channels (e.g., facial expression) can be useful to determine if scaffolding or remediation is needed depending on the intensity and persistence of the emotional state. For example, confusion may be beneficial for the deeper-levels of learning involved in complex medical tasks or concepts given that it may serve as a catalyst for conceptual change (D'Mello, Lehman, Pekrun, & Graesser, 2012; Graesser, D'Mello, & Strain, 2014). However, unproductive persistent confusion that is coupled with low motivation or underachievement may require intervention to address misconceptions or disparities in prior knowledge and skill level. To determine whether a particular emotion serves to hinder or enhance learning and performance, emotion data can also be measured and analyzed in relation to other self-regulated learning processes (e.g., cognitive, metacognitive, motivational) and performance measures (Boekaerts, 2011; Efklides, 2011; Zimmerman, 2011). Identifying the sources or antecedents precipitating a particular emotional state can also help to inform instructional practices and the design of learning activities. In line with control-value theory (Pekrun, 2006), instructors can help to reduce unproductive emotional states (e.g., fear, anger) by increasing the fidelity and relevance of learning tasks (value) and providing learners with greater autonomy and opportunity to seek help when needed (control). Emotion measures can also help learners to effectively monitor and regulate their own emotions by tracking their emotional states. This self-reflective process can provide an opportunity for learners to develop their meta-level awareness of their own emotions and reactions (Chambers, Gullone, & Allen, 2009; Webb, Miles, & Sheeran, 2012). This is particularly important within medical and health sciences education (Shapiro, 2011), as trainees must learn to regulate their emotions during learning and performance tasks, as well as effectively recognize and respond to the emotional states of patients and team members (e.g., recognize sadness; convey empathy) while avoiding burn-out. Several studies, for instance, have highlighted the importance of effective stress-coping strategies to manage negative emotional states within surgical and emergency medicine settings (e.g., Arora et al., 2009; Hassan et al., 2006; Hunziker et al., 2013; Wetzel et al., 2010). One way that emotion regulation can be integrated into medical and health sciences training is through the use of video-based patient cases, which can be used to display, track, and monitor emotional expressions during mock patient–clinician discussions (Lajoie et al., 2012, 2014).

Although emotion can be detected using the measures previously described, scalable, mobile, and unobtrusive advanced technologies in particular (e.g., facial and speech recognition software, mobile and Wi-Fi-enabled self-reports, EDA devices) can help educators to view the temporal and dynamic nature of emotions and emotion regulation as they occur in real time. This allows for a greater degree of sensitivity and precision in adapting learning environments according to emotional states. Moreover, these measures can be embedded within technology-rich learning environments, such as simulations, serious games, and intelligent tutoring systems to create affect-aware learning technologies (Calvo & D'Mello, 2012; D'Mello & Graesser, 2010) that detect and trace each individual learner's emotional states in real time. For example, Fig. 10.5 provides an annotated illustration of the technologies used in our research to detect emotional states during learning within BioWorld, a computer-based learning environment designed to scaffold medical students' diagnostic reasoning skills as they solve virtual cases.

Several of these types of affect-aware learning technologies (e.g., AutoTutor; Craig et al., 2008; D'Mello & Graesser, 2012) combine multiple emotion data channels through machine learning techniques to detect learners' emotional states and respond accordingly by adapting the tutor's affective expression, the nature of scaffolding (e.g., frequency of prompts/feedback), or the learning environment to promote more adaptive emotional states (Zeng et al., 2009). It may be the case, for example, that if the learner is experiencing certain negative emotions (e.g., frustration, anxiety) the agent may scaffold regulation to help the learner monitor and manage their emotions. They might also use information about emotional states to strategically induce specific emotions (e.g., confusion, curiosity, surprise) by increasing content complexity or introducing conflicting perspectives when learners are unengaged or bored (Calvo & D'Mello, 2012; D'Mello et al., 2012; Markey & Loewenstein, 2014). Within these environments, multimodal approaches can help to improve the probability of accurately detecting emotional states (Mauss & Robinson, 2009) by providing complementary traces of emotion components (e.g., physiological, expressive, subjective) and reducing limitations unique to each data channel (e.g., lighting for facial, auditory noise for speech). This approach has been implemented in several studies but the relative importance or weight that should be given to each channel is unclear (Zeng et al., 2009).

Of course, these affect-aware learning technologies are still vulnerable to the same limitations of emotion measures as previously described. New challenges also arise. In some cases, researchers include blends of emotional-cognitive-motivational states (e.g., flow, engagement) in their work (e.g., Calvo & D'Mello, 2012; D'Mello, 2013). This can be challenging from a conceptual standpoint as it is not always clear that what is being detected, traced, and managed is truly emotion. This may explain why the accuracy of emotion detection within affect-aware learning technologies ranges widely and in some cases is only slightly better than chance (Graesser et al., 2014). With this is mind, both researchers and educators should consider the strengths and weaknesses of measures before integrating them into advanced learning technologies as there is currently no consensus as to the most valid and reliable measure of emotions (D'Mello, 2013; Gross & Barrett, 2011; Mauss & Robinson, 2009). Despite such challenges, these recent developments, which call on diverse interdisciplinary traditions from psychology, education, linguistics, and computer science, (Picard, 2010; Zeng et al., 2009) show great potential for the use of emotion measures in advanced learning technologies, including those designed for medical education.

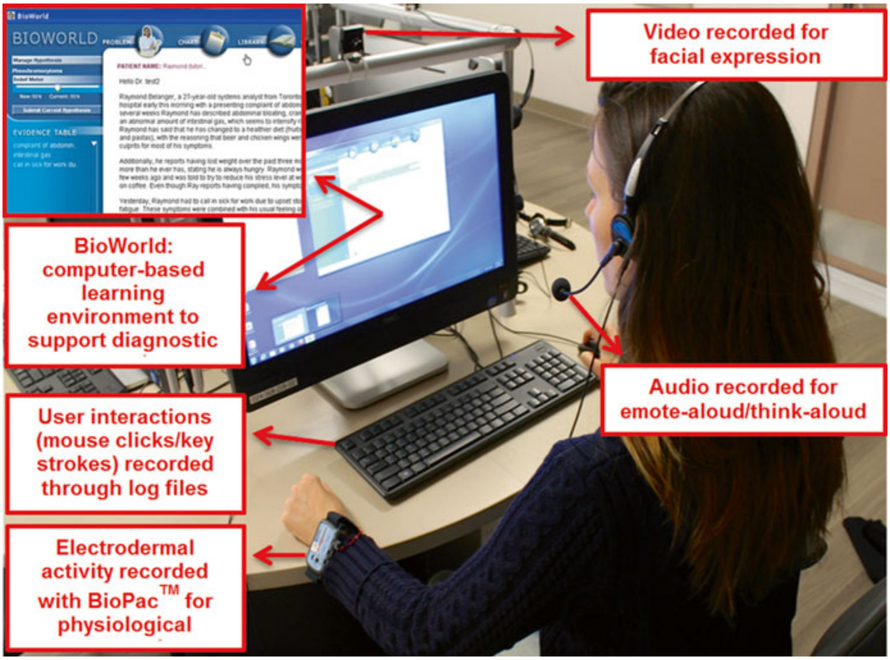

Fig. 10.5 Emotional states are measured in real-time during learning within BioWorld, a computer-based learning environment designed to scaffold diagnostic reasoning skills

> … Affect detection and affect generation techniques are progressing to a point where it is feasible for these systems to be integrated in next-generation advanced learning technologies. These systems aim to improve learning outcomes by detecting and responding to affective states which are harmful to learning and/or inducing affect states that might be beneficial to learning.
>
> (Calvo & D'Mello, 2012, p. 89)

10.5 Conclusion

Emotions play an important role in learning and performance, yet this construct has been largely overlooked in medical education. A critical review of emotion measures and their relevance for medical education may help to propel this research forward. In this chapter, we have discussed a variety of approaches to measuring emotions in the affective sciences, which includes technologies developed from computer science and methods used in educational psychology. This includes advanced technologies used to collect data (e.g., Wi-Fi-enabled tablets for more efficient self-report measures, mobile emotion-detection devices for physiological measures), analyze data (e.g., software for analyzing facial expression and speech), and provide contextual information (e.g., log files, eye-tracking). We have also identified advantages and disadvantages for commonly used data channels, including self-report, behavioral, and physiological measures, based on our research and a review of the literature. For example, self-report measures are efficient and well suited for group comparisons across a variety of settings but may be susceptible to cognitive and memory biases. On the other hand, behavioral channels can provide an objective and nonintrusive measure of emotion expressions but may be time-intensive to analyze if conducted manually and may not be feasible in naturalistic clinical settings if high-quality videos or consistent views of subjects are required, as is the case for automated facial expression analyses. Physiological data channels are not susceptible to attempts to conceal emotions (e.g., social desirability, impression management tactics) and provide a continuous stream of data to allow for analyses of temporal fluctuations; however, at this stage they are less capable of differentiating discrete emotional states (e.g., anxiety versus excitement) and better suited for identifying intensity of arousal levels (high versus low arousal).

Medical culture, and the corresponding socialization processes it promotes throughout training, is likely to influence the types of emotions experienced and the way in which they are expressed across these unique learning environments. As such, in our review, we have given special consideration to medical education when discussing emotion measures and have provided examples of our own deliberations, challenges, and decisions from this burgeoning area of research. However, these findings also have implications for other health science professions involved in patient care, such as nursing, ambulatory services, physical therapy, and social work. For example, we have discussed the future of emotion detection and how these measures are being used to improve instruction through their integration into affect-aware learning technologies, which can be broadly applied to training and education programmes across health science fields. By detecting, tracing, and scaffolding emotional processes throughout the learning trajectory, instructors may be better equipped to prepare trainees for professional practice. Ultimately, decisions about which measures to select will depend on a host of factors, including: research and educational goals, access to emotion-detection technologies, and practical challenges of the context (e.g., classroom versus real-world training); however, we hope these discussions help to illuminate methodological considerations and provide a blueprint for future work in this area.

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Chapter 11
The Deteriorating Patient Smartphone App: Towards Serious Game Design

Jeffrey Wiseman, Emmanuel G. Blanchard, and Susanne Lajoie

11.1 Introduction

Hospitals are dangerous and scary places for both patients and health professions learners: Only 18 % of hospitalized patients suffering an unmonitored cardiac arrest survive (Morrison, 2013). Of these patients 60 % show deteriorating vital signs (blood pressure, pulse, respiratory rate, oxygen saturation, level of consciousness, and temperature) for hours to days before the final cardiac arrest (Hillman, 2001; Kause, 2004). Medical students entering their first year of postgraduate training feel unprepared to care for these patients when on call (Labelle, 2012; Smith, 2007). ACLS (Advanced Cardiac Life Support) courses (Morrison, 2013) teach how to resuscitate a patient in cardiac arrest; however, there are few published teaching interventions that focus on the recognition of and response to an acutely deteriorating hospital ward patient *before* a cardiac arrest occurs (Featherstone, 2005).

In this chapter we will summarize current expert frameworks aimed at guiding a clinician's approach to a deteriorating patient situation. We will then describe teaching approaches based on these frameworks. Then we will show how one of these teaching approaches, the Deteriorating Patient Activity (DPA), led to the iterative design of a family of educational technologies. We will describe the latest member of this family, the Deteriorating Patient smartphone app (DPApp), a serious game

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(SG) designed to support learners' deliberate practice with feedback using smartphone-based deteriorating patient virtual cases. We will present a model of medical SG design that incorporates current literature as well as the new concepts we used in designing the DPApp. Finally, we will illustrate this medical SG design model by presenting some preliminary user feedback on the design of the DPApp graphic user interface.

11.2 Conceptual Frameworks and Educational Methods

Current teaching emphasizes a two-step general approach to a deteriorating (aka unstable or critically ill) patient, known as the primary and secondary surveys (Fisher, 2003; Frost, 2012; Mackenzie & Sutcliffe, 2002; Mohammad, 2014; Neumar, 2010) (Fig. 11.1), which describe a series of actions doctors must take in response to a given patient health state.

During the primary survey, healthcare workers use algorithms as organizing frameworks to prioritize information-gathering and treatment manoeuvres to rapidly detect and treat conditions that can kill a patient in 5–15 min. During the secondary survey, healthcare workers use a slower analytic approach to clinical problem solving (Eva, 2005; Sklar, 2014) that features information-gathering (history-taking, physical examination, choice of additional laboratory and radiology tests) and treatment decisions focused on resolving acute issues. Undergraduate medical students learn and practice even slower complete patient evaluations on patients admitted to wards in stable condition after more experienced physicians have performed primary and secondary surveys when the patient was sicker in the emergency room. The two-way arrows in Fig. 11.1 emphasize that patient states can suddenly and unpredictably change from "stable" to "deteriorating": A stable ward patient can develop a complication or new illness. As a result, undergraduates unfamiliar with primary and secondary surveys mistakenly use a complete data collection approach to critically ill deteriorating ward patients who need a primary survey to quickly recognize and address immediate life threats.

Patients who are critically ill (either already in cardiac arrest or in the process of deteriorating towards an eventual cardiac arrest) present in one of two ways: the patient who is unarousable (no response to voice, touch or pain) and the patient who is arousable (responds to voice, touch, or pain). The unarousable patient is easy to recognize as critically ill and the priority for this situation is to rapidly diagnose and manage the patient who is unarousable because of a cardiac arrest. The arousable patient situation carries different dangers; such patients may not appear to be critically ill to inexperienced healthcare learners who may skip the primary assessment and attempt the more familiar but slow analytic approach of history-taking, thorough physical examination and laboratory/radiology testing that they learned in the first few years of undergraduate medical education on stable patients.

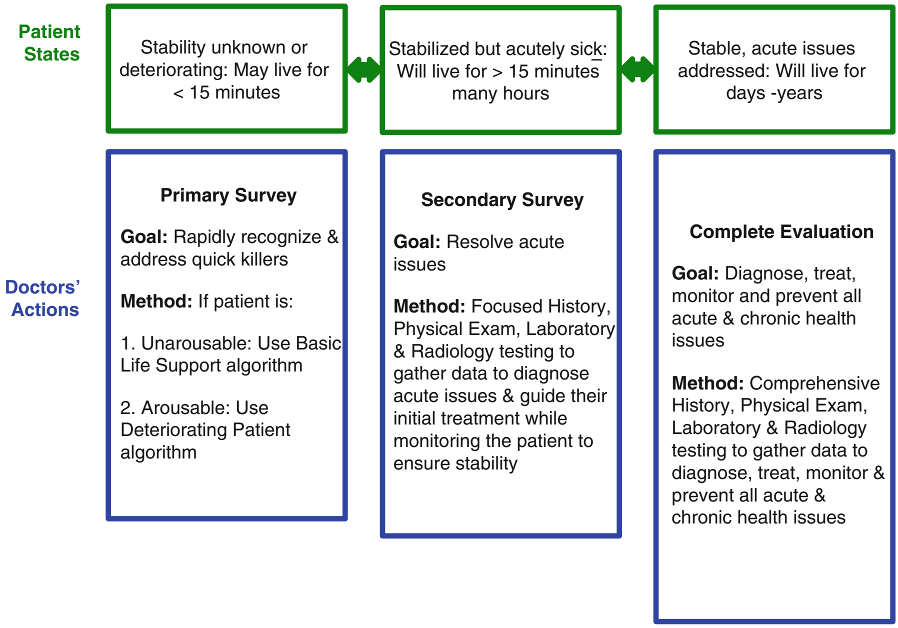

Fig. 11.1 General approach to emergencies: the primary and secondary surveys

There are two overlapping primary survey algorithms used for unarousable adult patients in current teaching:

1. The Basic Life Support (BLS) algorithm (Berg, 2010) described in the top half of Table 11.1 is taught to all undergraduate health learners. It emphasizes rapid recognition of the unarousable patient *in* cardiac arrest and rapid delivery of an electric shock to the heart via electrodes placed on a patient's chest as an emergency treatment to correct the commonest reversible mechanism of a cardiac arrest (also referred to as cardio version).

The ACLS algorithm (Neumar, 2010) is taught to postgraduate medical learners (junior doctors or residents) and emphasizes advanced drug therapy and cardiac procedures for a patient *in* cardiac arrest who is concomitantly receiving proper BLS. This algorithm is not illustrated here, as it is irrelevant to undergraduate students who cannot yet prescribe advanced drug therapy and cardiac procedures but who can and do provide BLS.

Thus none of the commonly taught Primary Survey algorithms refer to deteriorating ward patient situations *before* a cardiac arrest occurs and only the BLS algorithm is taught at the undergraduate medical student level.

Table 11.1 Algorithms used to guide the primary survey for critically ill patients

If patient is unarousable:	
Basic life support algorithm	Sample data to collect and act on
A: Arousability	Tap patient and shout: "Are you all right"?
B: Breathing	Check to see if the patient is breathing by observing the chest for 5–10 s
C: Carotid pulse CPR Call for help Cardio version ASAP	Carotid pulse: Check for 5–10 s. If no carotid pulse, start CPR: Chest compressions to 2″ depth allowing full recoil at 100/min. Give two breaths by bag and mask for every 30 chest compressions Call for help/activate the emergency response team Use an automatic external defibrillator if one is available or as soon as the emergency response team arrives with one.
If patient is arousable	
Deteriorating patient algorithm	Sample data to collect and act on
A: Airway	Level of consciousness, able to talk, inspiratory wheezing, facial swelling
B: Breathing	Oxygen saturation, respiratory rate, chest movements, tracheal position, lung sounds
C: Circulation Central nervous system Cervical spine	Carotid pulse, blood pressure, heart rate, jugular venous pressure, ECG, bleeding Level of consciousness, pupils, best motor response If trauma context protect until scanned
D: Drugs	Drug bracelets, prescription records, friends, family, and witnesses
E: Electrolytes and endocrine	Serum potassium, calcium, phosphorus, magnesium, bicarbonate, blood gases
F: Fever	Core temperature
G: Glucose	Blood or capillary glucose

11.3 The Deteriorating Patient Activity Simulations

High-fidelity simulations can effectively teach students how to use a primary survey to recognize and stabilize a critically ill patient. However, they are expensive, complicated to set up, often demand that learners take the time to leave the clinical setting to go to a simulation laboratory, can only teach a few learners at a time, and afford limited opportunities for the deliberate practice with feedback which is so important to the development of expertise (Ericsson, 2008).

The DPA is an inexpensive, logistically simple and rapidly deployable family of low-fidelity simulations whose objective is to help students learn how to gain control of unstable clinical scenarios by using a primary survey algorithm developed to specifically address the deteriorating patient before a cardiac arrest occurs. This "ABCDEFG" algorithm, described in the lower half of Table 11.1, consists of a series of rapid high-priority data gathering actions that are appropriate to undergraduate medical student level and urgent patient management options that are appropriate to postgraduate level but which undergraduate medical students need to understand.

In the original live small group variant of the DPA, the DPAlive (Wiseman & Snell, 2008), the learner takes on the role of "doctor on call" summoned at night to manage a deteriorating ward patient. Students must use the ABCDEFG algorithm to decide what steps to take in treating or stabilizing the situation. Students must know when and who to call for help and how to do an effective "hand-over" (World Health Organization Collaborating Center for Patient Safety Solutions, 2007) defined as communication of essential patient information to more senior colleagues when they arrive at the scene. The tutor takes on and moves between the roles of "patient" with deteriorating clinical signs, "vital sign and event recorder" and "nurse." The DPAlive learning objectives are shown in Table 11.2.

Clinical teachers from various healthcare professions can readily learn how to teach using a DPAlive (McGillion, 2011; Wiseman, 2007) using a simple teaching script (Fig. 11.2). The tutor controls how the situation evolves over time in response to the student's actions or inactions by changing the "patient's" "vital signs," "symptoms" or "physical findings." For example, the clinical teacher can choose to portray the role of a patient screaming in delirium or moaning in pain to further develop learners' skills at following the ABCDEFG's under duress. Alternatively, faced with a floundering or emotionally overwrought student the tutor can choose to provide hints or positive emotional stimuli in the form of encouragement or slowing down the "patient deterioration" or prompt the student to ask for help and consult a supervisor. In the debrief phase, the tutor uses recorded vital signs and events on a

Table 11.2 Deteriorating patient activity learning objectives

Learners completing these learning activities will, with appropriate supervision, be able to:
1. Apply an approach to recognize and stabilize common issues in acutely ill hospitalized patients. This approach includes using the ABCDEFG algorithm to
(a) Screen for and prioritize rapidly fatal but treatable medical conditions when caring for or called to see any hospitalized patient
(b) Recognize the vital sign and clinical patterns that are early harbingers of avoidable cardiac arrest and/or intensive care unit transfer
(c) Simultaneously diagnose, treat, and monitor an acutely ill patient
(d) Use observed changes (deterioration and improvement) in a patient's status as information to modify emergency diagnostic hypotheses and management strategies
(e) Recheck priorities when uncertain what is going on with a sick patient
2. Provide orders for the basic initial management of emergencies commonly encountered in hospitalized patients
3. Call for appropriate help in a timely fashion and apply the above approach while waiting for help to arrive
4. Communicate an appropriate hand-over of an acutely ill patient to another care team member
5. Describe and address the common patient safety events that lead to avoidable intensive care unit admission and death

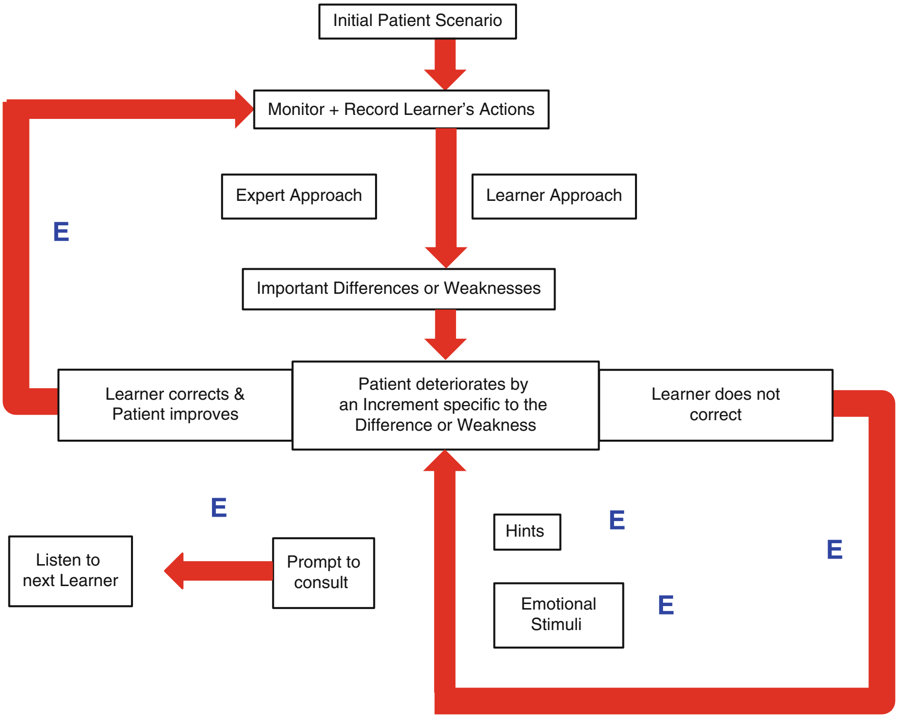

Fig. 11.2 DPAlive teaching script

whiteboard to support students' recall and reflections on their thoughts, decisions, and emotions during the scenario.

Steps marked by an E for "Emotions" in Fig. 11.2 represent points in the case where teachers can greatly increase or decrease learners' stress for optimal realism and learning. This manipulation of student stress levels is supported by studies of the variable effects of amount and types of stress on learning in rodents (Salehi, 2010) and in humans in nonmedical (Smeets, 2009) and medical domains (Leblanc, 2009). A major advantage of the DPAlive is the speed with which medical educators can use their "mental database of cases" (Eva, 2004) to rapidly generate additional DPAlive cases that can focus on learners' weaknesses and provide a range of cases over different contexts. Drawbacks of the DPAlive are that teachers must be physically present to provide students with deliberate practice with feedback and it is difficult for one tutor to manage a group of more than a few learners at a time.

Learners attempting to solve DPAlive cases who were given electronic prompts to refer to the ABCDEFG algorithm and collaboratively discuss their DPAlive case solutions using networked electronic whiteboards performed better on the DPAlive than those that did not (Lu, 2010). This study and extensive (unpublished) tutor experience with the DPAlive showed that learners commonly found the ABCDEFG algorithm simple to memorize but not simple to apply during DPAlive scenarios because:

1. Learners had difficulty understanding that a patient's vital signs as they evolve over time provide not only diagnostic hints for quick killers but also feedback on a doctor's or a healthcare team's performance.
2. The ABCDEFG algorithm must be used stepwise in only one direction—always starting with "A" then proceeding in order to F because initial disease presentations can be misleading. One must repeat the ABCDEFG algorithm recursively until the patient's vital signs have stabilized or normalized. Many learners do not recycle the ABCDEFG algorithm if vital signs deteriorate again and instead attempt the much slower processes of analytic reasoning.
3. Learners' emotional responses to the stress of emergencies when immediate help and resources are unavailable add to their extrinsic and germane cognitive loads (Fraser, 2012; Young, 2014) and interfere with their ability to apply a Primary Survey recursively.
4. Many learners do not use changes in vital signs over time as feedback that the patient will soon die and delay calling for help. Where they do seek assistance, as more healthcare workers arrive to help, the learner must then change from working individually to integrating staff into a growing and changing interprofessional team. Learners need to be able to integrate information from the ABCDEFG process into their communication of essential information or handoffs to other team members (Cohen, 2012).
5. Learners confound the BLS algorithm with the DPA ABCDEFG algorithm.

These observations led to the development of a more explicit DPA expert mental model aimed at guiding learners to use the ABCDEFG algorithm recursively and showing how the ABCDEFG approach relates to the cardiac arrest BLS algorithm (Fig. 11.3). The vital signs are an important part of the high-priority data to collect and act on in the BLS and ABCDEFG algorithms. For instance, both the BLS and ABCDEFG algorithms mandate determination and monitoring of the patient's level of alertness and consciousness. As can be seen in Table 11.1 both the BLS and ABCDEFG algorithms prioritize respiratory rate and carotid pulse or heart rate.

A *web-based DPA* (Blanchard, 2012a, 2012b) (DPAweb) was created as an online deteriorating patient that learners could repeat as often as needed. One of the authors, a senior medical educator, acted out the patient role in a sequence of short videos that formed the online patient representation. Interestingly, learners in informal conversations with the case designers even years later have spontaneously described feeling "scared" at having to treat a "patient" whom they personally knew. These emotional reactions to technology have been predicted by the media equation theory which hypothesizes that users respond socially and emotionally to technology it as if it were "real life" (Reeves & Nass, 1996) especially when prompt reactions are stimulated (Lee, 2008). Other learners commented on how much the DPAweb resembled a video game and wanted to know how well they performed compared to others and when more cases were coming out. This is not surprising

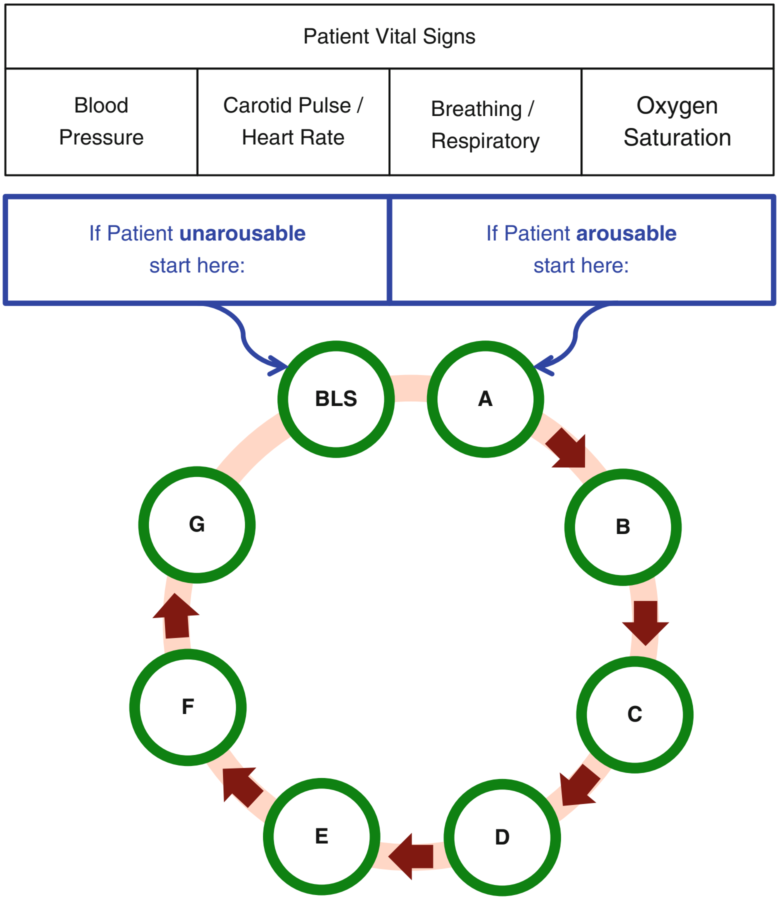

Fig. 11.3 Actions in the BLS + ABCDEFG algorithms must be applied recursively until patient vital signs are normal

considering the current generation of medical students, most of whom are fluent in the use of social media and many of whom play or are open to playing digital games (Kron, Gjerde, Sen, & Fetters, 2010). The DPAweb pilot demonstrated that it is possible to create a technology-based delivery mechanism for the DPA that is as engaging and challenging to learners as the DPAlive and could support deliberate practice without a live tutor present. Neither the DPAlive nor the DPAweb versions of the DPA resolved the problems of providing large groups of learners with:

1. Many different DPA cases of varying level of difficulty.
2. Feedback during the run phase and the debriefing phase of the simulation to that is sensitive to learners' emotions and cognitive levels and that is not dependent upon the synchronous presence of a live tutor.

11.4 What Is a Serious Game?

Games are activities with rules

> in which a player works, through interaction with an environment towards a goal. In the process, a player conquers challenges in an attempt to achieve the specified goal without any certainty that it will be attained (de Ribaupierre, 2014, p. 18).

The game environment, also referred to as the "game space," can take on varying representations such as decks of cards, boards, a playing field and computer-based videos (Blanchard, 2012a, 2012b). *Simulations* are "simplified, dynamic and accurate models of reality" (Sauve, 2011). When a game incorporates models of reality into its design, it becomes a *Simulation Game* (Sauve, 2011), with some authors reserving the use of the word "game" for activities that feature competition, rewards and rules (Akl, 2010). *Gamification* is a careful and considered application of game-based mechanics, aesthetics and game thinking to promote learning, engage people and motivate action through problem solving using all the elements of games that are appropriate (Kapp, 2012).

A *Serious Game* (*SG*) is a "gamified experience" (Kapp, 2012) using some type of interactive technology or tool that was designed with education as its primary goal and with engagement and entertainment as secondary goals (Gee et al., 2014).

The *attributes of a good game* are seen as analogous to the *attributes of good instruction* (Gee, 2007; McLuhan, Fiore, & Agel, 1967) and include:

- Compelling and relevant stories or problems
- Clear rules and goals
- Feedback
- An interactive learning environment
- Challenge such that "each level dances around the outer limits of a player's abilities, seeking at every point to be just doable" (Shute, Rieber, & Van Eck, 2011)
- Support or scaffolding adapted to players' zones of proximal development (Vygotsky, 1978)
- Player control over the game experience
- Uncertainty as to the eventual outcome
- Use of multiple sensory modalities

Similarly the steps involved in designing good games and good instruction are highly analogous: *Game design* consists of iterative cycles of planning, prototyping, play testing, evaluation and refinement "because the play of a game will always surprise its creators" (Salen Tekinbas & Zimmerman, 2003). *Instructional design* commonly follows the iterative (Hirumi & Stapleton, 2008) phases of the "ADDIE" generic instructional design model (Branch, 2014) consisting of analysis, design, development, implementation and evaluation. Both instructional and game design worlds use simple, incomplete but rapidly deployable and testable versions of an educational intervention (or game) offered to learners (or game players) with the express purpose of garnering their feedback to inform subsequent improved versions of the educational intervention or game.

A review of SGs in largely nonmedical educational contexts (Romero, 2014) identified good SG attributes that overlap with the above list but emphasized support of learner debrief and collaboration as the most important SG attributes and fidelity and fantasy as the least important SG attributes. The scenario or case-based subtype of SGs (Westera, Nadolski, Hummel, & Wopereis, 2008) are particularly well aligned with the case-based tradition of medical practice and education. Desirable attributes of a case-based SG include:

- A game environment that mimics the ambiguity and conflicting information of real-world environments.
- Learning activities demanding complex problem solving and adoption of professional roles and social relationships.
- Use of expert strategies as a reference to control complexity and to generate relevant feedback during the game (Westera et al., 2008).

From a medical instructional design perspective (Amundsen, 2004; Kern, 1998), one would add to Westera's attributes the degree to which a case-based SG:

- Is aligned (Biggs, 1996) with elements of the educational and professional practice systems it is intended to serve
- Serves an educational function that cannot be met by simpler, cheaper and more readily available educational approaches
- Can be adjusted to learner level and in response to learner and teacher feedback
- Supports formative and summative assessment of learners
- Supports the development of teaching expertise
- Supports the development of learners' and teachers' educational communities of practice (Wenger, 1998)

Systematic reviews of the literature on the effectiveness of SG's in medical education for knowledge outcomes are inconclusive. Few studies included any kind of outcome evaluation or controls for the gaming intervention for either medical student's knowledge (Akl, 2010) or for postgraduate health professionals' patient outcomes or care processes (Akl, 2013).

11.5 Medical Serious Game Design

Djaouti's (2011a, 2011b) extensive review of multiple game design approaches found no dominant framework to guide the design of a SG. Like many other authors, he emphasized the importance of alignment of educational theory, instructional design and game design to the effectiveness of a SG but offered no practical guidance on exactly how to go about doing this.

Westera et al.'s (2008) case-based SG design framework simplifies gaming design language by recommending that educators consider three game technology elements:

1. Game space: This contains components like game locations, ways of navigating between different locations as well as game objects, which could be tools, knowledge resources or other live or virtual subjects. All of these elements would

create an initial case representation whose narrative would then emerge or be further elaborated in response to the actions of the learner or other subjects.

2. Game dynamics: This consists of game states, a description of the game space at a given point in time during the game and the game logic or "If: Then" rules that govern whether and how game states evolve either in response to players' different actions or autonomously.
3. Game complexity. There are three ways of managing the complexity of the SG design that are highly relevant to educational designers:

    (a) Structure design: Because of the sequential nature of case-based SGs, one can simplify SG structures yet maintain the complex realism of gameplay by providing players with a wider number of simultaneous options (trees with more leaves relative to branches) rather than a deeper chain of sequential options (trees with more branches relative to leaves).
    (b) Feedback design: It is simpler and more effective to give players an overall sense of how they are doing and how they can improve rather than giving microfeedback on every step or action they take during the SG.
    (c) Representation design: Authentic content is far more important to an SG than beautiful graphics. In SGs it is the educational case itself that should stimulate tension and engagement.

Arnab et al.'s (2014) Learning Mechanics-Game Mechanics (LM-GM) SG model proposes analyzing the pedagogical potential of a SG by mapping its general learning mechanisms (LMs) onto its general game mechanisms (GMs) in an attempt to identify Serious Game Mechanisms (SGMs). According to Arnab et al. an SGM is defined as:

> the design decision that concretely realizes the transition of a learning practice/goal into a mechanical element of gameplay for the sole purpose of play and fun. SGM's act as the game elements /aspects linking pedagogical practices (represented through learning mechanics) to concrete game mechanics directly linked to a player's actions (p. 3).

The LM-GM model has the advantage of explicitly identifying the points in an SG where gameplay and pedagogy "intertwine" as SGM's but the disadvantage of not being able to describe how to prospectively design a SG using SGM's.

Lim et al. (2014) further developed the notion of SGMs for SG design by arguing that the narratives SG players encounter, create and share should have a central role in SG game design. Again, this fits well with medical education's tradition of case-based learning (Thistlethwaite, 2012) and practice. However, these authors did not define what they mean by "pedagogical outcomes." Such an unelaborated term might suggest that a SGM's only educational effect would be on learning outcomes to the exclusion of effects on evaluation, feedback, contexts or other elements of an educational system.

There are even fewer frameworks to guide the design of smartphone-based SGs. The "M-COPE" framework for mobile learning (Dennen, 2014) prompts designers to consider issues such as the added value of using mobile technology (M); the environmental conditions (C) that may affect learners' use of mobile technology; the intended and unintended learning outcomes (O) from mobile technology use; the pedagogical theory (P) justifying and matched to the use of mobile technology and the ethics (E) of mobile technology use.

In summary, an effective narrative SG (NSG) is the result of a judicious combination of design approaches from diverse disciplines. However, from a medical education perspective, we next argue that there is one final design component to consider before settling on a final model of NSG design, emotion.

11.6 The Role of Emotions in Narrative Medical SG Design

The role of emotions in healthcare professionals' education is relatively unexplored (McConnell, 2012). The emotional detachment and objectivity of the rational biomedical model of illness remains a dominant part of medical practice (Nettleton, 2008) especially during emergency situations (Powell, 2014) where emotionally distraught team members can negatively affect the performance of an entire team during medical crises (Piquette, 2009).

Learners' stress during simulated medical crisis scenarios variably affects their learning depending on scenario emotional content, debriefing timing and technique (DeMaria, 2013). Some but not all medical students prefer the challenge of additional emotional elements in standardized patient scenarios for communication skills (Lefroy, 2011). Residents are much more likely to cognitively appraise resuscitation scenarios as a threat rather than as a challenge when they contain scripted emotional stimuli (Harvey, 2010).

Control-value theory (Pekrun & Perry, 2014) predicts how emotions influence learning and can inform NSG design: Medical students experience achievement emotions that depend on their perceptions of the degree of control of scenario outcomes and value to their future practice. Previously experienced achievement emotions can also change learners' perceptions of control and value of future scenarios. NSGs can be designed to positively influence medical learners' perceptions of control and value and their subsequent achievement emotions (Artino, 2012; Graesser & D'Mello, 2014) by ensuring that features include:

1. Task demands appropriate to learners' capabilities

   Flow is a feeling many describe when they are engaged in and totally concentrated on a pleasantly challenging activity that is just within reach of their skills and/or knowledge (Csikszentmihalyi, 1991). The sensation of flow, which is associated with optimal learning, requires a balance between learners' skills and task challenge in order to avoid emotions like boredom (high skill, low challenge) and frustration (low skill, high challenge). This balance can be maintained for learners attempting very difficult challenges by scaffolding them in their zones of proximal development—that is by providing help in the form of hints, feedback and support by live or online tutors or peers (Kiili, Lainemab, de Freitasc, & Arnabc, 2014; Vygotsky, 1978).
2. Authentic cases and thinking activities that are highly relevant to learners' future careers.
3. Case narratives that change in response to users' actions.
4. Timely and explicit feedback.

5. Choice of cases of different levels of difficulty.
6. A learning environment where errors are explicitly seen and treated as learning opportunities.
7. Debriefing that welcomes, normalizes and responds to learners' expressions of emotion and difficulty.

This section has summarized work that would inform the emotional component of NSG design. In the following sections we will describe a model of narrative medical SG (NMSG) design that includes planning for learners' achievement emotions and then show how this model informs the development of the DPApp.

11.7 Model of Narrative Medical SG Design

Based upon the above concepts, an effective approach to NSGM creation would align design elements of instruction, emotions, games and technology around a central core of narrative design over time (Fig. 11.4). Areas where design elements converge either as a "node" at a particular point in the time of the patient narrative or along a period of narrative time as a "weave" will be demonstrated in the following paragraphs. Nodes and weaves represent points where all aspects of SG design work together synergistically.

11.8 The Deteriorating Patient App "Nodes and Weaves"

Table 11.3 shows a "walk through" of one deliberate practice session with the DPApp in relation to the different screen shots (Fig. 11.5) learners would encounter in each phase. In the following paragraphs we will describe how, for each

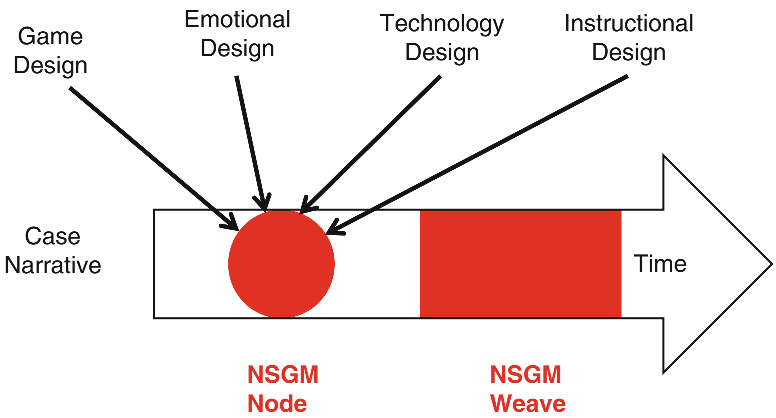

Fig. 11.4 Narrative medical serious game design model showing convergence of multiple design decisions for a given point in time of the case narrative

Table 11.3 Deteriorating patient app (DPApp) walkthrough

Instructional and emotional design elements	Narrative design elements	Game and technology design elements: DPApp smartphone screen views			
Node 1	Orientation	A			
Node 2	Beginning	A	B	C (ABCDEFG prioritized cyclic menu)	C (HxPxLabRadTreatment unprioritized dropdown menu)
Weave 1	Middle	A	B	C	D
Node 3	End/debrief	A	F		

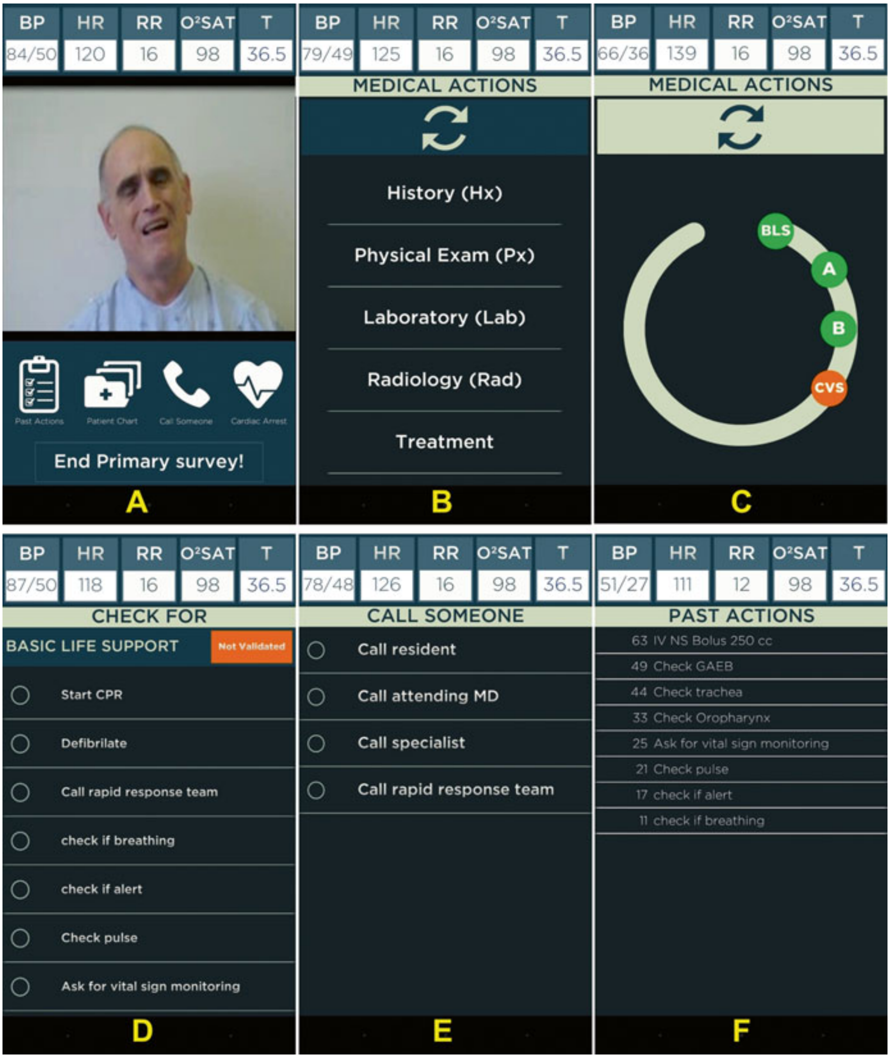

Fig. 11.5 DPApp smartphone screen views

narrative design element, game and technology design elements were created to fit that narrative element as well as work with the instructional and emotional design elements as three nodes and one weave that are embedded within the DPApp case narrative.

11.8.1 Node 1: Orientation

Game/Technology Design Elements: In this phase a live tutor ensures that learners understand the game space, how to toggle between and use different app screen views and input buttons and that each smartphone functions properly.

Instructional and Emotional Design Elements: The orientation minimizes extraneous cognitive load and negative achievement emotions imposed by the DPApp itself. The learning objectives, rules and goals of the DPApp case are identical and thus aligned with those of prior DPAlive sessions.

11.8.2 Node 2: Narrative Beginning

Game/Technology Design Elements: After signing in learners select the case they want to practice on and encounter the initial scenario in the "Patient Chart" section:

> You are called at 2 AM to see Mr. W. a 68 year old male who feels terrible, is confused and is covered with sweat. His initial vital signs are normal. He was admitted 4 days ago for treatment of a community-acquired pneumonia. His past medical history includes atrial fibrillation, hypertension, and diabetes. His current medications include intravenous Ceftriaxone and Doxycycline, oral Diltiazem, Metformin, and Coumadin and subcutaneous Insulin. He has no known allergies.

Learners can then toggle between three different screen views (See screen views A, B, and C in Fig. 11.5).

Screen view A shows the patient's initial vital signs, a looped video of the patient in the initial state and buttons at the bottom of the screen that permit learners to see a record of their Past Actions and Collected Data (taking the learner to screen F), a button to Call Someone for help (taking the learner to screen E) and a button to call a Cardiac Arrest team. As time goes by, the vital signs and patient video change for better or for worse, depending on learners' actions.

Screen view B shows the vital signs and a choice of any of six actions learners can choose: The cyclic ABCDEFG algorithm symbol button (two arrows forming a cycle) and History, Physical examination, Laboratory tests, Radiology tests, and Treatment option buttons respectively from top to bottom. Learners who choose the cyclic ABCDEFG algorithm symbol button are taken to screen view C. Learners who choose the History, Physical Examination, laboratory, or Radiology symbol buttons are taken to drop-down menus (not displayed here) that permit them to choose whatever additional unprioritized data they think is needed.

Screen view C shows the cyclic ABCDEFG algorithm. When learners select a button within screen view C the learner is then taken to another screen view that prompts the learner to choose high-priority data and actions corresponding to that part of the cyclic algorithm. For instance, selecting the “BLS” button takes learners to screen view D. Learners must complete the entire cycle in order—the software will not allow a learner to skip B and go from A to C for instance. Once the algorithm has been completed, learners can go through it again as needed by the patient’s status as indicated by the video and/or patient vital signs.

Instructional and Emotional Design Elements: Learners assume a highly desirable future professional “on call” role. This authentic scenario is complex, ambiguous and challenging, as it is initially unclear why this patient with multiple health issues feels terrible and (in the video) looks and acts unwell. Learners are confronted with a realistic situation in which there is a lot of data to gather and decisions to make for a patient who may very well die in the time it takes for more experienced help to arrive.

11.8.3 Weave 1: Narrative Middle

Game/Technology Design Elements: As long as learners search for irrelevant information and prescribe irrelevant treatments, the “if-then” game dynamic makes the patient vital signs progressively worsen over 10 min with simultaneous successive 2 min long patient video loops showing a moaning confused patient who becomes more somnolent and eventually comatose and then suffers a cardiac arrest. Learners who choose relevant treatments will see the vital signs improve and the patient video loop portray a successively more alert and less sick patient. Learners who use the ABCDEFG algorithm will collect relevant information and prescribe relevant treatments much more efficiently than those who do not as the search space for all of the patient data one could collect is huge. Designing a wide choice of options rather than deep chains of sequential options makes the game complex for learners but easier to programme.

Instructional and Emotional Design Elements: The narrative, displayed using multiple sensory modalities and interactively constructed by learners, becomes more compelling and challenging as the patient deteriorates or improves in response to learners’ actions, supporting learners’ perceptions of control and value and demanding that learners use an expert (ABCDEFG) strategy to manage case complexity or encounter realistic consequences of not using the ABCDEFG strategy. Scaffolding from a live tutor (and from future versions of the DPApp) will keep learners in their zones of proximal development and a state of flow.

11.8.4 Node 3: Narrative End/Debrief

Game/Technology Design Elements: The session ends when the patient “dies” or if learners press the End Primary survey! Button (meaning they think that they have successfully stabilized the patient) in screen view A. At the end of the case the learner is taken to screen view F which displays a learner's past actions or a plot of time on the vertical axis with patient vital signs and corresponding learner past actions taken on the horizontal axis. This personalized leaderboard helps learners and tutors visualize what was done well or not well and when.

Instructional and Emotional Design Elements: Screen view F presents the data needed to support a live debrief of both learner actions in relation to the ABCDEFG expert framework and learner emotions experienced during the case. Learners discover how easily one can forget to stick to the expert ABCDEFG framework and get lost in minor details when faced with the emotional heat of deteriorating vital signs and an ill-appearing patient.

11.9 Conclusions

The node and weave model of NMSG design portrays the most difficult and time consuming part of SG design, that of making decisions on instructional, emotional, technology and game designs coordinate in explicit subservience to educational goals.

Once the current version of the DPApp performs as designed based on additional user testing we will then be in a position to create additional cases with differing levels of difficulty, a scoring system, adaptive feedback based on learners' commonest errors and difficulties, a case builder for learners and educators to create and try out each others' cases, and an online environment where learners and teachers can debrief their case solutions synchronously or asynchronously.

McLuhan wrote, "Anyone who tries to make a distinction between education and entertainment doesn't know the first thing about either" (McLuhan et al., 1967). If so, then those who know about education—learners and teachers—already know a few things about both. The most effective "playing field" for conceiving and testing an SG is the live teaching environment where it is intended to function.

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Chapter 12
Mobile Just-in-Time Situated Learning Resources for Surgical Clerkships

Robert B. Trelease

12.1 Introduction: Curriculum and Context

With the continuing evolution of global Undergraduate Medical Education (UME) curricula over the last few decades, there has been a widespread integration, compression, and distillation of instructional time for early, traditional basic science courses and anatomy (Drake, McBride, Lachman, & Pawlina, 2009; Heylings, 2002) preceding the onset of on-service clinical training (e.g., clerkships/clarkships, externships, and pre-internships). Anatomy learning is an integral part of and crucial to clinical understanding, diagnosis, and treatment of diseases and disorders as encountered in surgery (Cottam, 1999; Older, 2004), radiology and imaging (Orsbon, Kaiser, & Ross, 2014), and obstetrics and gynecology (Heisler, 2011; Jurjus et al., 2014). Thus, reduction in basic sciences learning time has placed increasing emphasis on the acquisition, review (revision), and reinforcement of clinically relevant basic anatomical concepts in clinical training contexts (Lazarus, Chinchilli, Leong, & Kauffman, 2012; Yammine, 2014).

The task of facilitating structured learning during medical student clinical clerkships faces the challenges of eking out significant dedicated time for basic for science learning amidst the compelling ad-hoc service demands of daily hospital and clinic activities. This is a particular concern for surgical clerkships, wherein students must acquire and reinforce a clinically relevant diversity of detailed structural knowledge for specific diagnoses, diseases, and procedures many months after

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experiencing their streamlined introductory anatomy course (Jurjus et al., 2014). Although some medical schools (like author's) have taken a "longitudinal" or "vertically integrated" curriculum approach by instituting anatomy reviews for individual clerkship rotations and free-standing third- or fourth-year electives (Lazarus et al., 2014), demands still remain for students to learn those additional structural and functional details most relevant to the specific clinical problems and surgical procedures that they individually encounter on-service.

To help address this need for in-situ learning in a self-guided mode complementary with an updated, constructivist UME curriculum, we set out to develop a Web-deployable surgical anatomy information resource. The comprehensive content coverage was to be based on diagnosis/problem/procedure data obtained from medical student patient contact logs. The specific implementation objective was to provide general surgery clerkship students with a concise, in-pocket, clinical anatomy information reference scaled to small-screen mobile devices, to be consulted as needed on-site during their clinical patient encounters and prior to surgical procedures.

At the outset in 2007, this project was primarily focused on developing a learning resource for early generation handheld computers, personal digital assistants (PDAs). However, the overall effort evolved further in its scope and implementation during the early period of rapid widespread popular adoption of a new class of mobile devices, smartphones, and of associated new media, e-books. A brief semi-historical view will thus be taken, in order to inform readers about some of the most important challenges for flexible learning resources development and platform migration as a new educational technology is introduced and rapidly evolves. Furthermore, since the growing, pervasive use of smartphones and tablets has been associated with increasing demands for mobile learning (m-learning) technologies in medical education (Smith et al., 2013; Wallace, Clark, & White, 2012), we consider evidence for growing student usage of newer electronic media integrating with the existing information sources available to students with differing learning styles.

12.2 What Was Tried: Materials and Methods

In 2000, the David Geffen School of Medicine at UCLA initiated a PDA requirement for third- and fourth-year medical students aimed at equipping them with mobile, handheld clinical information resources that could be carried in-hospital for patient encounters (Trelease, 2006, 2008). In addition to a comprehensive pharmacopoeia application, an evidence-based decision support application was part of the core software suite initially required for contemporary student PDAs, which were Palm or Pocket PCs. Soon after the PDA requirement started, a patient data log was developed for tracking data on student–patient encounters, including general patient demographics, disease/problems/complaints, and patient encounters by clinical site. These privacy-compliant data were collected by students via PDA forms synchronized with a secured, web-accessible database or via direct data entry on a PC webpage.

Table 12.1 Compiled patient encounter data for three surgical clerkship rotations in 2007, partial list ordered by most common diagnoses

Diagnosis name	Number of times problem reported	Number of students have seen	Percentage of students reporting from total of 79	Avg. cases seen per student
Hernias	348	74	93.7	5
Fractures	323	77	97.5	4
Biliary disease	319	76	96.2	4
Prostate disease	267	75	94.9	4
Bowel obstruction	258	69	87.3	4
Blunt trauma	251	58	73.4	4
Anorectal disease	251	67	84.8	4
Thyroid and parathyroid disease	227	70	88.6	3
Neck mass	211	70	88.6	3
Appendicitis	191	63	79.7	3
Surgical infections	185	65	82.3	3
Venous disease	142	50	63.3	3
Kidney stones	142	68	86.1	2
Penetrating abdominal trauma	142	58	73.4	2
Pancreatic disease	140	57	72.2	2
Gastric disease	139	58	73.4	2
Diverticular disease	126	60	75.9	2
Breast disease	112	45	57	2
Vascular access	108	37	46.8	3
Aneurysmal disease	99	42	53.2	2
Intestinal stoma management	92	43	54.4	2
Colon cancer	90	42	53.2	2
Carotid artery disease	84	42	53.2	2
Esophageal disease	82	45	57	2
Pelvic mass	72	39	49.4	2

Analysis of student patient log data (Table 12.1) identified the diagnoses, diseases, and surgical procedures most commonly encountered by all students on their general surgery clerkship rotations. For example, on the average, each student encountered four different patient/cases of biliary tract diseases on their clinical rotation.

These data were then grouped by organ/systems in order to establish a list of discrete disease/diagnosis-related chapters for resource development, such as biliary system, large bowel, and gastroduodenal diseases. Twenty six chapters were developed for the first production version of this surgical anatomy review resource, covering clinically relevant anatomy from the head and neck, thorax, abdomen, and limbs regions.

Each chapter of the resource was subdivided into three major sections, each reviewing in bullet/outline format the most clinically relevant information needed for understanding surgical treatment of the specific organ system. The first section reviewed the surgically essential gross anatomy and structural landmarks of the specific organ/region affected, including innervation related to symptoms and analgesia. The second, vascular section reviewed arterial supply and venous drainage of the organ/system, vital to surgical resections and hemostasis. The vascular section also covered lymph nodes and drainage, important for assessing and treating cancers. The third section, entitled "Clinical Correlates," included a range of structurally relevant clinical presentation, diagnostic, and procedural information, including essential facts about the most common diseases and pathologies.

Surgical residents are intimately involved in medical student supervision and clerkship teaching, and longitudinal or vertically integrated curricular approaches increasingly view medical education as a continuum incrementing student learning through residency levels of knowledge (Andrew, Oswald, & Stobart, 2014; O'Brien & Irby, 2013). For these reasons, clinically relevant review chapter content was made consistent with the subject mastery of organ systems knowledge appropriate to the American Board of Surgery In-Training Examination (ABSITE) for qualifying surgical residents. The resulting surgical anatomy review resource thus became capable of encompassing self-guided learning needs for medical student clerkships through surgical residencies.

At the outset of the project in early 2007, it was initially decided to programme the resource as a web application in hypertext markup language (HTML), specifically XHTML, the version encoded in Extensible Markup Language (XML). This was done for two primary reasons: (1) to allow the entire resource to be hosted on web servers for use on conventional personal computers and laptops (PCs); and (2) to allow the resource to be individually downloaded to PDAs via existing web-based delivery.

Early prototypes of a PDA version of the surgical anatomy review demonstrated some major constraints for text and image displays due to limited system memory and font and image size limitations for the Palm OS operating system. As shown in Fig. 12.1, screen size was limited to 320×480 pixels, with a single, relatively primitive font size and fixed formatting restricting the amount of text that could be displayed on a single display page. Additionally, a built-in limit on the size of loadable image files necessitated the partitioning of desired anatomical figures into a mosaic of four to six individual files. Displayed pages could not be "zoomed" for magnification of image detail. Finally, calculations were made of the cumulative text and image files memory requirements for the desired chapters and figures of the comprehensive surgical anatomy review, and these exceeded the available PDA memory size.

Furthermore, despite the early institutional commitment to the use of PDAs, it had become apparent that use of those devices was declining in the general commercial market, with decreasing sales and difficulties with manufacturers staying in business. Over the years that PDA popularity was decreasing, cellular telephone capabilities were added to high-end models, and a new class of "smartphones" was developed, delivering PC-class computational capabilities in a pocket-sized device. In the spring of 2007, Apple Inc. released the touch-screen iPhone, which rapidly

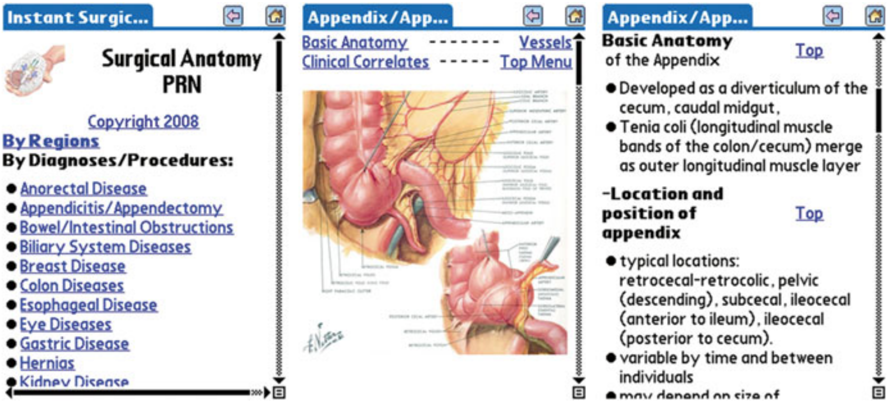


Fig. 12.1 Early prototype surgical anatomy review content shown in three screen capture images from a Handspring Prism (Palm OS) PDA

became a mass-selling device that combined cellular telephony with more advanced imaging, multimedia, and computational capabilities than the most powerful PDAs. Because this "smartphone" evolution was perceived early in the process, development attention was directed toward shifting development of the surgical anatomy review resource to adaptive XHTML code that was compatible with this new class of smartphones, as well as with large-format PCs. Responsive design principles were thus followed in creating pages that scale appropriately for screen size, using cascading style sheets code (CSS) for mobile devices and PCs.

In 2007, the author also received an invitation from a major medical publisher to develop a learning resource for the Apple iPod, a PDA-like mobile multimedia player. Because the surgical anatomy review project was ongoing and the publisher owned a comprehensive collection of historical anatomical and clinical illustrations, it was negotiated that selected images would be incorporated. Chapters and sections were subsequently organized around selectively labeled, clinically relevant anatomical figures, with the most structurally representative images beginning each chapter and major subsections (e.g., views of specific organs' arteries and veins in Vascular sections).

As negotiations with the publisher progressed, interest grew in adopting the surgical anatomy review for publication, initially as a print book, with consideration of an electronic version as the new smartphone e-books market developed. E-books were originally conceived for the PC market, and during the 1990s, compact e-books became available and modestly popular on PDAs. With the rise of smartphones, it became possible to create e-books with better graphics for figures and more fonts and typography than had been available on PDAs. Over the course of a few years of development, e-books sales began to increase greatly, enhanced by the introduction of dedicated mobile readers (e.g., Kindle) and mobile tablet computers (e.g., the iPad).

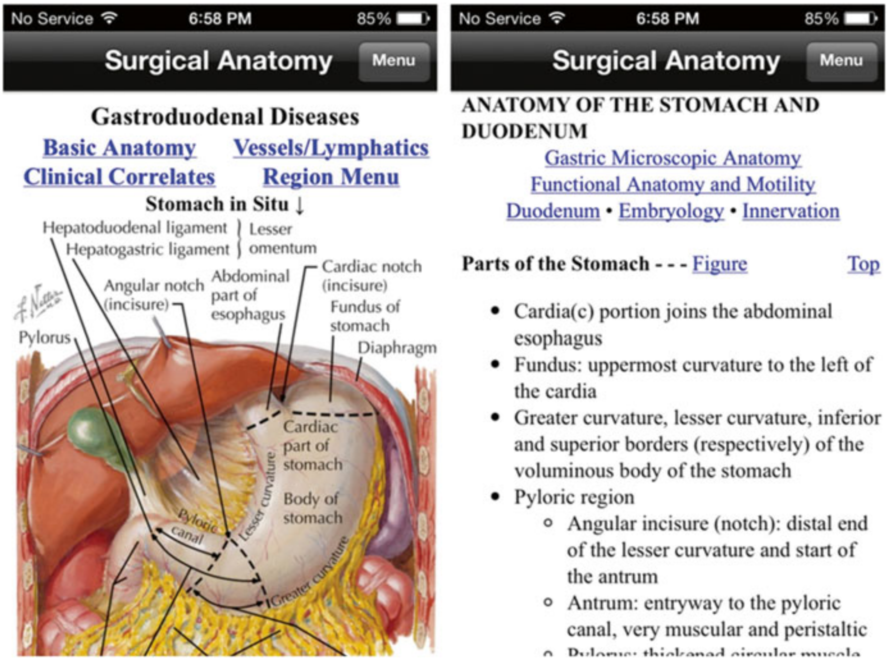


Fig. 12.2 Final version of surgical anatomy review content shown in two screen capture images from an Apple iPhone 4

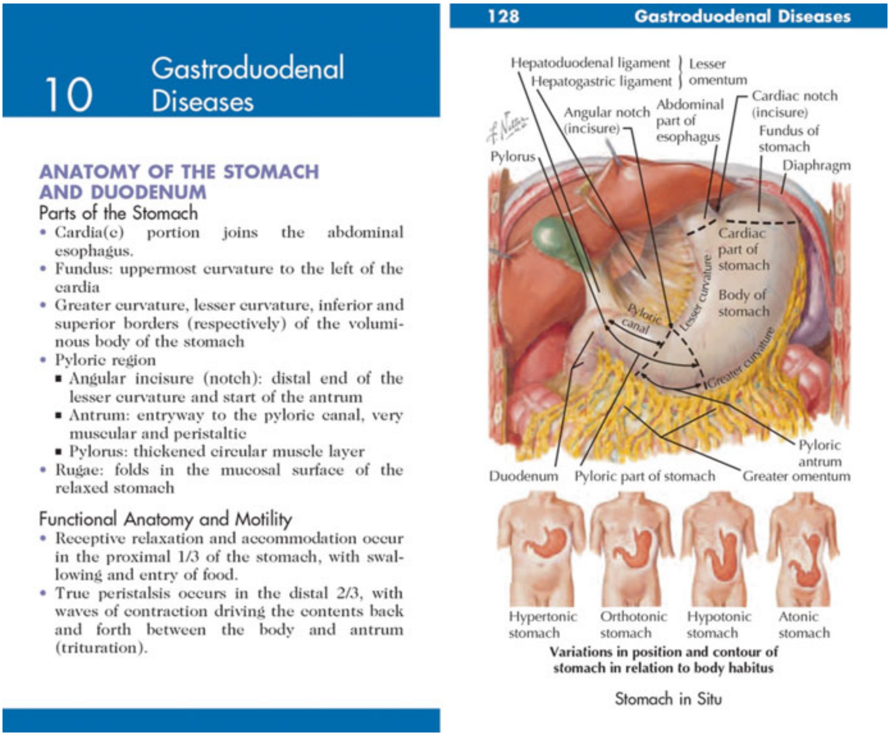
With the maturing development of the surgical anatomy review project, it was further decided to develop specialized reader applications ("apps") that would present the XHTML resource content somewhat like an e-book reader, but significantly, one that navigated through chapters, subsections, and detailed color figures by using hyperlinks, more like a familiar web browser. This additional development "fork" was considered reasonable effort to undertake, given that major e-book file formats (e.g., EPUB) were based internally on XHTML encoded text.

Surgical anatomy review mobile apps were programmed in Objective-C (for the Apple iPhone smartphone, iPod, and iPad tablet) and in Java (for Android smartphones). The overall resource functioned like a familiar touch-based Web browser, with the page display scrolling continuously vertically within each chapter and jumping to hyperlinked text sections, subsections, images, and other chapters. Images could be touch-zoomed to 2.5× the starting (1×) screen size. The iPhone app version was also tested for compatibility on an early iPad released in May 2010. Figure 12.2 shows examples of the app's Gastroduodenal Diseases chapter and section content on a smartphone screen.

Print and smartphone products from the project were formally adopted for publication in mid-2009, with the first edition of a pocket-sized print book released by the publisher in summer of 2010 (Trelease, 2010), followed by iPhone and Android smartphone apps in fall of that year. In winter of 2011, a web-based version compatible with PC displays and smartphones was mounted on a secured server at UCLA and made freely available for use for all general surgery clerkship rotations. Distribution of print books, mobile apps, and e-books was tracked by the publisher, and institutional access for the free web-based resources was recorded via server log files. Elective unstructured feedback on the electronic publications was collected by distributor websites.

12.3 What Lessons Were Learned: Results

There were substantial qualitative and functional differences between the final products developed in this surgical anatomy review project. The conventional print book was produced as a top spiral-bound 3″ × 6″, 420 page volume, with 26 organ/system disease chapters organized in seven color-coded, bottom-tabbed sections (Head and Neck, Back and Spinal Cord, Thorax, Abdomen, Pelvis and Perineum, Upper Limb, and Lower Limb). Figure 12.3 shows Gastroduodenal Diseases chapter content comparable to Fig. 12.2, as adjoining print pages in the final layout format.


10 Gastroduodenal Diseases

ANATOMY OF THE STOMACH AND DUODENUM

Parts of the Stomach

- Cardia(c) portion joins the abdominal esophagus.
- Fundus: uppermost curvature to the left of the cardia
- Greater curvature, lesser curvature, inferior and superior borders (respectively) of the voluminous body of the stomach
- Pyloric region
  - Angular incisure (notch): distal end of the lesser curvature and start of the antrum
  - Antrum: entryway to the pyloric canal, very muscular and peristaltic
  - Pylorus: thickened circular muscle layer
- Rugae: folds in the mucosal surface of the relaxed stomach

Functional Anatomy and Motility

- Receptive relaxation and accommodation occur in the proximal 1/3 of the stomach, with swallowing and entry of food.
- True peristalsis occurs in the distal 2/3, with waves of contraction driving the contents back and forth between the body and antrum (trituration).

128 Gastroduodenal Diseases

Fig. 12.3 Final version of the surgical anatomy review content in top-bound pocketbook print format

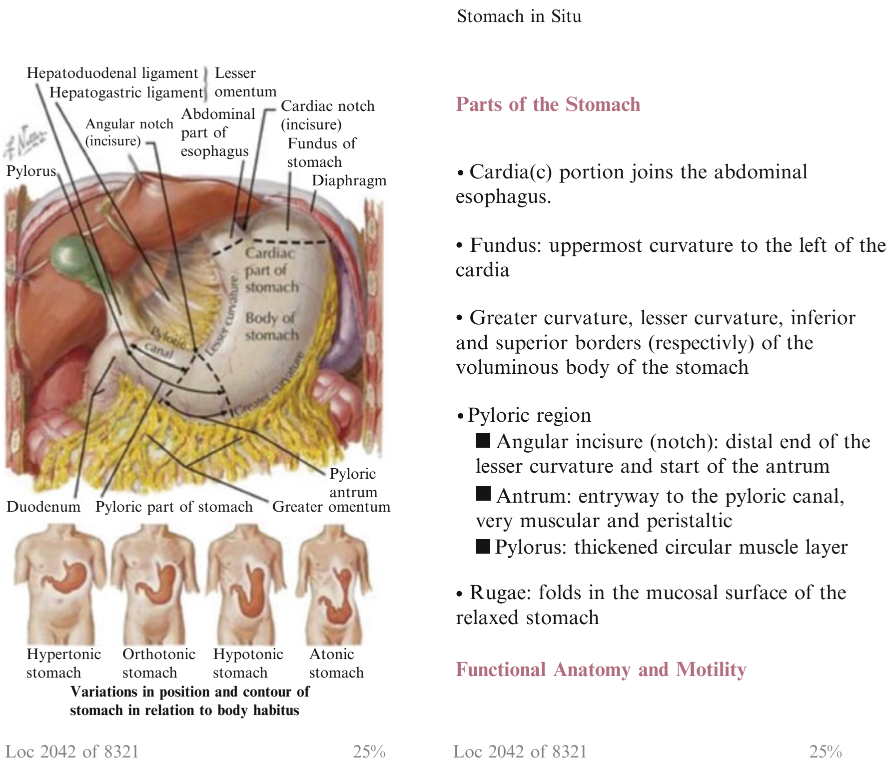


Fig. 12.4 Final version of the surgical anatomy review content in Kindle format, shown as two screen capture images from a 5th generation Apple iPod (comparable to iPhone 5) running the Kindle reader application

The Kindle, EPUB, and other e-book versions were essentially reproduced digital versions of the printed text, preserving the linear order with fixed-length pages and images, comparable to the PDF (portable document format) page proofs produced by the publisher. These e-books had no internal hyperlinks to sections, images, chapters, and indexing, although the Table of Contents provided hyperlinks to chapters. Individual pages "touch-turned" to subsequent or previous pages, in accordance with the current page-turning metaphor of most major e-book readers, and keyword searches could be made for desired structures and terms. Figure 12.4 shows Gastroduodenal Diseases chapter content comparable to Figs. 12.2 and 12.3, as screen capture images from a mobile device running an e-book reader application.

The mobile device application and web-based versions of the surgical anatomy review functioned nearly identically like "web-apps". Versions were comprised of 26 chapter files containing an Index (Table of Contents) and abundant in-chapter submenus and in-text hyperlinks that jumped between specific chapters, sections, subsections, special topics, and multiregion subjects (e.g., hernias and cancers). Each chapter consisted of a single XHTML file with embedded images, and when displayed, each chapter could be scrolled continuously from top-to-bottom or navigated

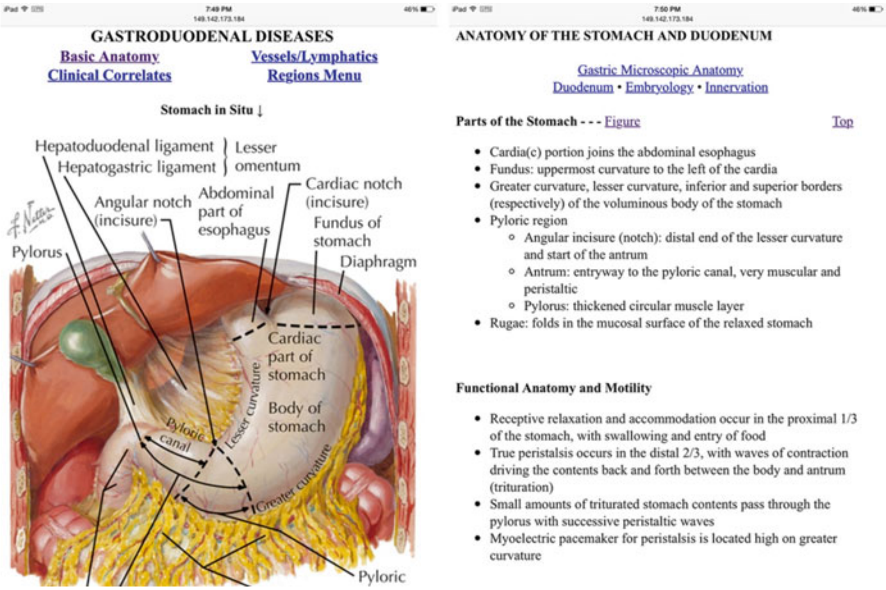


Fig. 12.5 Final version of the surgical anatomy review content in XHTML format downloaded from a web server, shown as two screen capture images from an Apple iPad Mini 2 (7″ screen) running the Safari web browser

in a nonlinear fashion using hyperlinks, like conventional webpages. The overall resource functioned like the iPhone app version shown in Fig. 12.2. Images could be touch-zoomed to 2.5× the starting (1×) screen size. Figure 12.5 shows Gastroduodenal Diseases chapter content comparable to Figs. 12.2 and 12.3, and as screen capture images from an Apple iPad Mini 7″ tablet running the Safari web browser.

Several different kinds of quantitative data and different analytic outcomes were available for the distribution of separate web-based, conventional print book, smartphone app, and standard e-book format surgical anatomy review resources. Analysis of data calculated from Apache 2 Web server access log files and Internet Protocol (IP) addresses showed 2237 downloads of the local free-access surgical anatomy review resource over a 3-year period (May 2011–June 2014). Cumulatively, approximately 500 medical students participated in the 12-week surgical clerkship rotations during that period. On further analysis of the data according to individual chapters and Internet Protocol address for accessing systems, there were a total of 1205 individual chapter downloads. Further tabulation of download data by file names revealed a characteristic order of accessed chapters by frequency which is shown in Table 12.2. The number of downloads ranged from a maximum of 109 for Anorectal Diseases to zero for Pelvic Fractures, with the next least number of downloads being 18 for Ulna and Radius Fractures and for Wrist and Hand Fractures.

Comparison of these data with the original patient log data (Table 12.1) revealed general similarities in the order of the most commonly encountered diseases/diagnoses and the ranked order of chapter downloads. This suggested that student

Table 12.2 Web-based surgical anatomy resource usage for 3 years (May 2011–June 2014), ordered by number of individual downloads per chapter

Chapter	Number of downloads
Anorectal diseases	109
Colon diseases	84
Hernias	82
Biliary tract diseases	74
Gastroduodenal diseases	69
Thyroid diseases	65
Esophageal diseases	61
Skull and face fractures	57
Pancreatic diseases	53
Appendix diseases	51
Hip and thigh fractures	45
Knee and leg fractures	44
Prostate diseases	44
Humerus fractures	42
Uterus and adnexal diseases	42
Kidney diseases	41
Breast diseases	40
Small intestine diseases	35
Liver diseases	27
Pectoral girdle fractures	26
Ribs and thoracic fractures	26
Vertebral fractures	26
Ankle and foot fractures	22
Ulna and radius fractures	18
Wrist and hand fractures	18
Pelvic fractures	0
Cumulative fractures chapters	324

access of specific anatomy review chapters was generally related to the frequency of encountering specific diseases and diagnoses, although differences in the data groupings, resource design, and actual student usage data precluded valid statistical analysis. In designing the resource, individual chapters were made for fractures, although fractures as a group were the second most commonly encountered diagnosis in patient log data. Cumulatively, fractures chapter downloads accounted for 324/1205 (26.9 %) of individual surgical anatomy review chapter accesses, far more than the individually most common Anorectal Diseases chapter (109/1205, 9 %).

Different data and perspectives were produced by the distribution of print and electronic versions of the surgical anatomy review. Print book distribution was calculated from publisher accounting records sent to the author. Because of the delayed introduction of a variety of e-book formats following the release of the smartphone apps and delayed electronic distributors' accounting cycles, only 2 years (2012 and 2013) of standard e-book data were available. The total 2-year distribution of all different e-book formats totaled 310 copies. Adding these to the 1068 smartphone app units distributed, there were a total of 1378 electronically published copies of the surgical anatomy review distributed, or 34.8 % of 3958 total copies distributed in all formats.

When the data were partitioned based on the last 18 months for which accurate accounting was available (July 2012 through December 2013), calculations emerged which may more reliably represent the most recent relative frequencies of print versus electronic format distribution. During that period, there were 442 print copies (31.1 %) distributed, 712 iOS apps (50.2 %), and 265 total e-books in all formats (18.7 %), for a grand total of 1419 copies of the surgical anatomy review. Electronic versions thus outsold print copies by a ratio of 2.2:1.

Online voluntary feedback from app users was very sparse on electronic distributor's websites, typically reflecting simple "likes" or "dislikes" for the surgical anatomy review. However, a few emphatic reviews pointed out that there should have been content included on heart diseases. Although this subject matter was not included in the original design, primarily due to lack of cardiothoracic diagnoses and problems reported in general surgery clerkship data, additional chapters on heart diseases and lung and airways diseases were developed. These new chapters were formally added to an update of the iOS smartphone app in late 2013, and plans were made for incorporating this new material into a formal second edition print and e-books in 2015.

12.4 Thinking Further: Discussion

The most striking qualitative lessons were directly related to exploiting the historically unprecedented, rapid evolution and widespread popular diffusion of smartphones and functionally related new mobile devices, their accompanying application programmes, and e-book technologies. It soon became apparent that smartphones, mobile applications, and e-books represented useful new educational technologies that demanded flexible programming and adaptive design in order to integrate with other existing resources for adult learning.

Although the web was initially viewed as the primary channel for distributing the anatomy review for surgical clerkships to PDAs, adaptive XHMTL code was developed for downloading the resource on networked PCs as well as on wirelessly connected smartphones and tablets. Furthermore, the project was expanded to programming dedicated iPhone and Android reader applications to present the surgical review's XHTML content in any location, without the need for a network connection. At the same time, the rapidly growing market for e-books for smartphones and tablets led the publisher to distribute the surgical anatomy review in multiple e-book formats. Over the first 3 years, this increased the number of different types of mobile devices and PCs that the electronically published content could be used on, including dedicated e-book readers (e.g., Amazon Kindle and Barnes & Noble Nook), and led to extensive national and international distribution of the resource for medical students and surgical residents.

Conservatively interpreted, the different patient log and web-based surgical review access data may reflect the combined dynamic effect of multiple factors including clerkship- and service-related stochastic differences in patient trauma and disease/diagnosis encounters, the partitioning of general disease/diagnosis information across multiple chapters (e.g., fractures, vascular access, bowel obstruction), as well as variations in individual students' familiarity with clinically relevant anatomy and motivation to access the available online resources. The absence of downloads of the Pelvic Fractures chapter may most directly represent the strong association of such injuries with major motor vehicle collision multisystem trauma, rarely encountered on general surgery service, given institutional trauma management practices.

These project results appear to reflect relatively frequent, voluntary usage of the freely available web-based surgical anatomy review by students on clerkship rotations at the author's school. On the other hand, successful ongoing multiformat distribution of the published resource since 2011, as applications, multiple e-books, and a print version, demonstrates national and international self-adoption, with continuing demands for multiple media/formats for self-directed mobile learning (m-learning). Although publication-specific user demographic data are not available, this larger external audience may include a greater proportion of postgraduate surgical residents to medical students, given that selective local distribution of the free web-based resource was driven by cyclically introducing it to students on each surgical clerkship rotation.

As noted in the introduction, contemporary, post-constructivist UME curricula at many medical schools have increasingly integrated reduced anatomy class time into systems-based preclinical learning activities (Drake et al., 2009) variably employing group-oriented, problem-based learning (PBL),"flipped instruction" laboratories, online learning resources, and clinical ("doctoring") experiences, with abundantly allotted "self-study" time (e.g., for preparing learning issues for discussion). The author's institution, David Geffen School of Medicine at UCLA, introduced such an integrated systems-block/PBL/clinical-experiential preclinical curriculum in 2003. The mobile surgical anatomy review resource was intended to accommodate additional in-situ third- and fourth-year clerkship-related knowledge acquisition, subsequent to the reduced dedicated anatomical learning time in the first 2 curricular years.

In such a curricular context, evidence suggests that current generation medical students make varying use of multiple available anatomical learning resources, including textbooks, online references, interactive multimedia, and discussion forums, in ways that correlate with individual learning preferences and personality characteristics, which can be differentiated into "sensing" versus "intuitive" or "perceiving/judging" dimensions, as measured by the Myers-Briggs Type Indicator test (McNulty, Espiritu, Halsey, & Mendez, 2006; McNulty, Sonntag, & Sinacore, 2009). Thus, it could be argued that medical students with "sensing" preferences may elect to use computer-aided learning resources more than those with "intuitive" or "perceiving/judging" characteristics, with the lattermost most strongly preferring interactive discussion learning activities. Comparable individual differences would be expected to have influenced the voluntary use of the free, locally distributed surgical anatomy review.

Turning to general e-reading trends, the most recent survey from the Pew Research Center Internet Project (Zickuhr & Rainie, 2014) reported that the percentage of US adults reading e-books rose from 23 % in 2013 to 28 % by early 2014, with about 70 % of the general population reporting reading print books. These data demonstrate the persistence of preferences for print books in the overall population of reading adults, although the use of e-books is substantial and continuing to rise. Overall, only 4 % of respondents in this latest survey reported being "e-book only," with 47 % of readers under 30 reporting having read an e-book in 2013. Furthermore, more than half of the adults in the January 2014 Pew Survey reported owning either an e-reader or a tablet computer, up from less than 4 % in 2010, and e-book readership was shown to have grown with tablet ownership. Considering health science learners more specifically, in an unpublished 2013 survey of all UCLA first-year medical students, approximately 44 % reported that they owned a tablet, with 100 % of students reporting smartphone ownership (UCLA, 2013). The prognostic significance of such statistics on e-book reading and mobile devices should be considered in the context of other data about the learning characteristics of current generation medical students.

In proposing a practical technical framework for redesigning current anatomy educational methods as part of their comprehensive review of research on the current generation of "millennial students," DiLullo, McGee, and Kriebel (2011) emphasized a broad range of evidence for the diversity of individual learning strategies and variations in aptitude for learning with technology. Such current student cohort variability is consistent with that previously cited by McNulty et al. (2006, 2009), as well as with Pew Internet Research Project findings for younger adults for the use of conventional books versus e-books (Zickuhr & Rainie, 2014). However, in specifically noting how such electronic media use has grown rapidly in the few years since the introduction of mobile tablets, the latter authors have projected further growth in e-reading, suggesting good reason to expect further evolution in student technology adoption trends. Data for the published surgical anatomy review indicated that cumulative electronic versions (apps and e-books) have surpassed print distribution in the most recent year.

Although "millennial" medical students who grew up with web-based information resources have diverse individual preferences for which specific tools and reading sources they use for learning, they also have strong common expectations about the availability of basic e-learning resources for their education (DiLullo et al., 2011; Wallace et al., 2012). Current recommendations urge instructional design and resource development strategies that accommodate student diversity and individual learning preferences (Andrew et al., 2014; DiLullo et al., 2011; O'Brien & Irby, 2013). As the "postmillennial" generation matures through primary and secondary education with widespread access to wireless mobile devices and tablet-based instructional content, medical schools may expect more students who have stronger expectations and demands for comprehensive clinically oriented mobile learning resources.

12.5 Conclusions

Early studies have suggested that mobile devices can have mixed benefits as clinical learning tools (Alegría, Boscardin, Poncelet, Mayfield, & Wamsley, 2014; Bibault et al., 2014; Nuss, Hill, Cervero, Gaines, & Middendorf, 2014). However, because it is relatively early in the implementation history of such mobile learning technologies, the need remains for a greater body of definitive educational effectiveness research, like that established for PBL in the health sciences (Bridges, McGrath, & Whitehill, 2012). The evolution of the resources outlined in this chapter indicates that contemporary developers must adopt flexible production and distribution strategies for multiformat tools that postmillennial students will self-adopt and use autonomously, in order to produce usage data for assessment. The challenge thus continues for medical educators and instructional designers to evolve and to assess new appropriate methods for using changing learning technologies to address societal needs for training more physicians most effectively in time- and cost-effective ways.

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ERRATUM

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Susan Bridges, Lap Ki Chan, and Cindy E. Hmelo-Silver

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Prof. Cindy E. Hmelo-Silver's contact address was incorrect on the website and print pdf. The contact address has been corrected in the current version of the book as below.

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ERRATUM

Chapter 6
How Do Health Sciences Students Use Their Mobile Devices in Problem-Based Learning

Lap Ki Chan, Susan Bridges, Iain Doherty, Manwa Ng, Jun Jin, Neel Sharma, Nam Kiu Chan, and Henrietta Y.Y. Lai

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Appendix A: Data Collection Form

*Required
[Between brackets specification of the type of answer field]

How to Fill in This Form

This form starts with a few questions to identify the article, followed by the questions whether it fulfils the criteria for inclusion in the literature review. If not, the rest of the questions does not have to be answered.

If a question is difficult to answer for a certain article, then please describe in the comments why. Some questions ask for a short description. Some keywords are usually enough. You can answer in English or Dutch.

If there is more than one article describing the same application or study, you only need to fill in one form (n.b. these articles are usually by the same first author and, therefore, should end up with the same reviewer).

Finally: For a discussion at the end of this project I would like to select a small set of articles that are especially innovative, well-implemented, or relevant for other reasons. If you think that an article belongs in that set, you can indicate that at the end of the form.

WARNING: you cannot save this form half way and continue later on. If you have to submit a half-filled form please warn the first author.

S. Bridges et al. (eds.), *Educational Technologies in Medical and Health Sciences Education*, Advances in Medical Education 5,
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Reviewer

Name of reviewer * [select from list]

- Daniëlle Verstegen
- Jeroen Donkers
- Jean van Berlo
- Nynke de Jong
- Karen Könings
- Jeroen van Merriënboer
- Annemarie Camp

Date of review * [text field]

Identification of the Article

NB: If two or more articles describe the same implementation you only need to fill in this form once!

First author of the article: * [text field]

Add a second author or year of publishing if there is more than one article with the same first author. Add several years or first words of titles if this form concerns more than one article.

Comments [text field]

In or Out?

Criteria:

1. *The article concerns the use of e-learning (ICT/internet/simulation/etc.):*
   - *To support the learning process.*
   - *Which is implemented and used or at least elaborated into a concrete design (i.e. not only vague plans or the potential benefits of e-learning).*
2. *The article concerns PBL in groups, i.e. where students collaborate at least part of the time. Resources for self-study are only included if they are designed to support the PBL groups. Excluded are:*
   - *No collaborative learning: students do not collaborate (e.g. using applications to learn problem-solving individually).*
   - *No constructive learning: students learn straightforward tasks that are not complex or ill-structured (e.g. using word or power point).*

3. *The article contains enough information to be able to understand how e-learning was used (or will be used) to support learning.*
4. *Possible other reasons to exclude? Please describe in 'Other'. If you are in doubt, you can fill in a question mark under 'other'. Please explain in the comments why you are not sure.*

Should this article be included in the literature review? * [select from list]

N.B. Sometimes an article that needs to be excluded based on the criteria can be interesting/inspiring for the discussion. If so, please say so in the comments. In this case it would be nice if you could fill in the rest of the form anyway.

- Yes
- No, it is not about e-learning
- No, it is not about PBL groups
- No, there is not enough information
- No, for other reasons (please describe in comments)
- I don't know

Would you like a second opinion on the inclusion/exclusion of this article? [select from list]

If so, please briefly describe the reason in the comments below

- Yes
- No
- Maybe

Is there any other reason for a second opinion on this article? [select from list]

If so, please briefly describe the reason in the comments below?

- Yes
- No
- Maybe

Comments [text field]

General Information

Level of education [select from list][1]

You can tick more than one box, if necessary, or give your own description under 'Other'

- Primary education
- Secondary education
- Vocational education

[1] Articles regarding implementations in primary or secondary education were later excluded.

- University education (bachelor–master)
- Post-academic education
- Education for teaching staff
- Other: [text field]

Distance or face-to-face education [select from list]

- Only distance-based learning activities
- Mostly distance-based learning activities
- Blended (a mix of distance-based and face-to-face learning activities)
- Mostly face-to-face learning activities
- Only face-to-face learning activities
- I don't know
- Other: [text field]

Domain/Learning goals Describe briefly what students are learning (keywords) [text field]

Place in the curriculum Describe briefly where this fits in the curriculum (keywords) [text field]

Tools Describe briefly which e-learning tools are used (keywords) [text field] [text field]

When are e-learning tools used in this case? [select from list]

You can choose more than one option or specify yourself

- Before, i.e. to prepare for the moment of collaboration
- During, i.e. to enable collaboration
- After the moment of collaboration
- Other: [text field]

Learning activities/workforms [text field]

Please describe briefly: which learning activities/work forms were used, what the role of the tutor was and how students collaborated (incl. size of group)

What was the motive to introduce e-learning (if mentioned)? [text field]

Which goals were the authors trying to achieve (if mentioned)? [text field]

Comments [text field]

Categorizing the Article[2]

In this section you will be asked to categorize the type of e-learning. If this is difficult for a certain article, then please describe why in the comments.

[2] Two other ways to categorize the use of e-learning were included in the form, but subsequently not used for analysis.

Function in the PBL process [select from list]

This question is meant to get a grasp on what function e-learning can have in supporting the PBL group process. In some cases the answer might be 'none', e.g. when tools are used to enable communication at a distance without any effort to improve the interaction between students (compared to face-to-face communication).

You can tick more than one answer or give your own description under 'Other'.

- Activation of prior knowledge
- Cognitive elaboration
- Structuring and restructuring of information
- Stimulating cooperative learning
- Learning in context
- Ownership or self-directed learning
- I don't know
- None of these specifically

Comments [text field]

Implementation and Evaluation

If tried out: how many students were involved? [text field]

If tried out: how many teachers were involved? [text field]

Comments [text field]

Does the article give evaluation results? [select from list]

If the answer is no, you can skip the rest of this section.

- Yes
- No
- Other: [text field]

Which type of evaluation study was done? [select from list]

- Experimental design
- Quasi-experimental design
- Case-study(s)
- Descriptive study
- Other: [text field]

Which kind of evaluation data are described? [select from list]

You can tick more than one of the checkboxes • *Data about the implementation process*

- Use of an application (e.g., log data)
- Attractivity to students (e.g., satisfaction, opinions)
- Attractivity to teaching staff (e.g., satisfaction, opinions)

- Efficiency in the sense of the use of resources (e.g., of teaching staff, teaching time)
- Efficiency in the sense of involving students (or others) at distance
- Effectivity in the sense of reducing drop-out
- Effectivity in the sense of learning results
- Other: [text field]

Please describe the evaluation results briefly (in keywords) [text field]
Comments [text field]

Final Questions

Your opinion: does this application of e-learning support PBL groups? Does it strengthen the PBL learning concept? Why? [text field]

Did you encounter (secondary) references to other articles that should be included in the literature review? [text field]

Should this article be included in a small set of especially interesting or relevant articles? [select from list]

You can explain why in the comments section below, if necessary.

- Yes
- No
- Maybe

Do you have any other comments? [text field]

Appendix B: Transcription Conventions (Jefferson, 2004; Sacks, Schegloff, & Jefferson, 1974)

F	Facilitator
S(n)	Students (1, 2 …)
Ss	Multiple students
↑	Rising pitch/intonation
↓	Falling pitch/intonation
.	Certainty, completion (typically falling tone), not necessarily the end of a sentence
,	Continuing intonation, not necessarily between clauses
?	Rising or questioning intonation
(12.2)	Numbers in parenthesis indicate elapsed time within and between same or different speaker's utterance
	12.2 means 12.2 times one tenth of a second
(.)	Micropause; noticeable pause shorter than five tenths of a second (including regular pauses between sentences)
[	Speakers start at same time, beginning of overlapping utterance
]	End of overlapping utterance
((XXX))	Transcriber's comment: contextual information, non-verbal features.
A: XXX=B: =XXX	Equal signs indicate no break or gap, e.g. B's utterance is latched onto A's
:	Prolongation of the immediately prior sound (more colons indicate greater length, e.g. sou:::nd)
°XX°	Indecipherable utterances; uncertain hearing
<u>XXX</u>	Stressed words

S. Bridges et al. (eds.), *Educational Technologies in Medical and Health Sciences Education*, Advances in Medical Education 5,
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Appendix C: Modified DISCERN Instrument Used in the Assessment of Wikipedia Articles

S. Bridges et al. (eds.), *Educational Technologies in Medical and Health Sciences Education*, Advances in Medical Education 5,
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1. Are the aims and objectives of the topic clearly stated at the beginning of the article?

No		Partially		Yes
1	2	3	4	5

2. Does the article cover the needed subtitles, and key concepts related to the topic?

No		Partially		Yes
1	2	3	4	5

3. Is the information provided throughout the article scientifically correct and in agreement with current valid resources and textbooks?

No		Partially		Yes
1	2	3	4	5

4. Is the article neutral and not based on personal views?

No		Partially		Yes
1	2	3	4	5

5. Is the article balanced and unbiased?

No		Partially		Yes
1	2	3	4	5

6. Is it clear what sources of information were used to compile the publication (references, links to professional websites)?

No		Partially		Yes
1	2	3	4	5

7. Has the article been regularly updated and amended?

No		Partially		Yes
1	2	3	4	5

8. Are there key areas in the article completed and do not need further addition?

No		Partially		Yes
1	2	3	4	5

9. Do the images, figures and tables provided in the article support the information given and enhance understanding of points raised?

No		Partially		Yes
1	2	3	4	5

10. What is your overall rating of the whole article as a source of information to medical students?

Serious or extensive shortcomings		Potentially important but not serious shortcomings.		Minimal shortcomings.
1	2	3	4	5

Appendix D: Therapeutic Health Concepts Scale

How important are the following subjects for your therapeutic thinking and acting?	
1	Functionality
2*	Diagnosis
3*	Science
4*	Evidence-based methods
5	Limited activity of a patient
6*	Standardized tests
7	Limited participation of a patient (in the social environment)
8*	Medical guidelines
9	Mental health of a patient
10	Requirements of the patient's everyday life

Six-point Likert scales for measuring the biomedical and the biopsychosocial health concepts; the asterisks (*) indicate biomedical items.

S. Bridges et al. (eds.), *Educational Technologies in Medical and Health Sciences Education*, Advances in Medical Education 5,
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Index

S. Bridges et al. (eds.), *Educational Technologies in Medical and Health Sciences Education*, Advances in Medical Education 5,
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