Initial design principles for establishing a learning community for public health professionals through authentic e-learning

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Abstract: The storage, transportation and distribution of time and temperature sensitive pharmaceutical products (TTSPPs) such as vaccines within the appropriate temperature conditions are important public health concerns. The personnel who handle pharmaceutical products must have high levels of expertise so they can take actions to ensure that the TTSPPs are not negatively affected by sub-standard practices. This paper describes the first phase of a multi-year educational design research project designed to enhance expertise in the field of pharmaceutical cold chain management. The paper describes the process of developing design principles to guide the conceptualisation and prototyping of authentic e-learning capable of enabling public health personnel to develop the skills required for effective pharmaceutical cold chain management and to establish a learning community extending beyond the course. Five design principles are shared along with examples of how they were instantiated in the prototype e-learning.

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1   Introduction

With the growing introduction of new vaccines and other biotech medicines, there is increased concern about how time and temperature sensitive pharmaceutical products (TTSPPs) are stored, transported and distributed to end users (Milstien et al., 2006). Anyone handling these products must accommodate TTSPPs with different characteristics; all being sensitive to high temperatures and some being highly sensitive to freezing. The impact of high temperature on these products is cumulative and may damage the product to unacceptable levels. Freezing of freeze-sensitive TTSPPs damages the physical structure of the products, rendering them inactive (Kurzątkowski et al., 2013). There are individual and public health risks involved with the exposure of TTSPPs to unacceptable temperatures. For example, someone's diabetes may not be controlled if that person injects insulin that has been frozen; or a national immunisation campaign may at the very least waste time and money or, in the worst case, result in illness or death if damaged vaccines are used (Edstam et al., 2004).

To keep these TTSPPs at an appropriate temperature range (typically 2–8°C), a cold chain is utilised. A cold chain is the integrated system of equipment (such as shipping containers, refrigerators, trucks), procedures, records and activities used to handle, store, transport, distribute and monitor time and temperature sensitive products (Afsar and Kartoğlu, 2006). The allusion to a chain is apt. As with a physical chain, a cold chain is only as strong as its weakest link. People are a critical element of a cold chain; they must correctly execute procedures and take appropriate actions in the event of problems.

Beyond the requirements that most countries have covering the manufacturing and testing of all pharmaceutical products known as good manufacturing practices (GMPs) are legal requirements for the distribution and handling of TTSPPs known as good distribution practices (GDPs) (United States Pharmacopeia, 2013a, 2013b; World Health Organization, 2010, 2011). These requirements require that personnel who handle and distribute pharmaceutical products have the education, training and experience required to perform their jobs effectively (Vesper, 2001). In short, they must have expertise.

2 Developing expertise

Expertise is the hallmark of an expert. It includes an in-depth set of knowledge, cognitive and motor skills, as well as the analytical ability to determine how to approach a given situation. Dreyfus and Dreyfus (2005) quoted Aristotle in saying that the expert straight away does "the appropriate thing, at the appropriate time, in the appropriate way" (p.788). In the context of handling TTSPPs, expertise involves more than just knowing the rules and requirements of national authorities. Rather, it requires that people be able to apply those requirements and solve sometimes very complicated, conflict-filled problems in a way consistent with the 'spirit' of the requirements. This includes identifying potential risks and strategies to control or mitigate them. This type of expertise requires higher-level thinking as illustrated by Bloom's taxonomy (Anderson and Krathwohl, 2001).

Because of its international scope and work in the area of vaccines, the World Health Organization's Global Training Network for Vaccine Management [now called Global Learning Opportunities (GLO) for Vaccine Quality] recognised the need to strengthen and enhance the knowledge and skills of those involved in the vaccine cold chain. To address this need, GLO developed a unique training course, pharmaceutical cold chain management on wheels (PCCMoW). The course takes 15 carefully selected participants from public and private health sectors on a bus trip in Turkey where they can make direct observations at the storage, distribution and healthcare facilities that they visit as they physically travel with mentors down the length of the cold chain. Throughout the course journey, guided observation exercises take place at the visited facilities. Participants are provided with notes and tools to support their critical observations and they interact with operational staff and management at these facilities. Presentations and group discussions take place on the bus, in restaurants and in the open air before and after the visits to the facilities (Vesper et al., 2010). Turkey was selected as the course venue because of its cultural practice of hospitality, the availability of a complete cold chain operation within a relatively short distance and the availability of a local tour coordinator who arranged the logistics and helped with the extensive planning required (World Health Organization, 2005, 2008).

With only 15 participants in each bus course and only one course conducted each year, only a very small number of health professionals can be accommodated, compared to the thousands of people world-wide who could benefit from gaining expertise in cold chain management. This formed the key challenge of the project: to develop an authentic e-learning programme equivalent to the bus course, but capable of providing a quality learning opportunity to many more participants and establishing a community of learners that would last beyond the temporal span of the course. The rest of this paper describes the process of developing theoretically-based design principles to guide the conceptualisation and prototyping of a technology-based virtual bus course capable of developing deep knowledge and skills for handling TTSPPs and establishing a learning community.

3   Goals and potential benefits of the project

While the intensive experience of the PCCMoW is very effective for a small group (Vesper et al., 2010), providing an online learning opportunity would allow many more people to develop the expertise required to strengthen the cold chain and contribute to positive public health outcomes, especially in developing countries. The learning benefits for participants had to include:

- being actively engaged in the learning process with mentors and other participants

- acquiring insights into how experts make judgments and decisions

- experiencing a very different approach to learning (i.e., authentic tasks and collaborative learning) and identifying opportunities where they could apply these models in their own practices

- building relationships with other participants and mentors that would help to contribute to a vibrant and productive ongoing community of practice.

It was important that the technology-based learning solution included design elements that would result in the very strong sense of community similar to that developed among participants on the physical bus journey. Establishing a learning community wherein participants could move from a peripheral role to a more fully participative one within a worldwide network of cold chain management expertise was a primary goal of this project.

Learning objectives from the physical PCCMoW bus course were examined for use in the virtual course, but it was clear that they needed to be revised to better fit the affordances of authentic e-learning design (Herrington et al., 2010). Table 1 shows several of the original bus course objectives and the revised objectives for the e-learning course. As the team considered the objectives, they intentionally re-wrote them to so they would be higher order, that is, more connected to the higher taxonomic levels of analyzing, evaluating and creating (Anderson and Krathwohl, 2001).

Table 1 Comparison of sample objectives from the physical course to the e-learning course

Learning objectives for physical bus course	Initial learning objectives for e-learning course
Identify the major operational components in a pharmaceutical cold chain	Identify the major operational components in a pharmaceutical cold chain
Discuss the concepts of 'GDP' and what GDP includes	Identify deficiencies in given situations using the 'GDP' guidelines
Describe the inputs, activities and outputs of each operational component of a pharmaceutical cold chain	Illustrate the inputs, activities and outputs of each operational component of a pharmaceutical cold chain
Discuss the role of quality agreements, what they contain and how they are used in cold-chain operations	Develop a quality agreement that is appropriate to a given situation
Discuss the risks to pharma/biopharma/vaccine products that can occur during each cold chain operational phase	Given a cold storage facility, assess and control the risks to pharma, biopharma and vaccine products consistent with GDP
	Given a mode of transportation, assess and control the risks to pharma, biopharma and vaccine products consistent with GDP

4 EDR and the development of design principles

This project utilised an educational design research (EDR) approach (Reeves, 2006; McKenney and Reeves, 2012). EDR first and foremost focuses on real world problems as experienced by everyday practitioners. Awareness of problems related to handling TTSPPs has grown significantly in the past several years. New requirements and expectations have been issued (World Health Organization, 2011) and pharmaceutical manufacturers, shipping companies and distributors are seeing what cold chain failures mean and cost (Brown, 2012). However, expertise in dealing with such complex issues is not keeping pace. During the needs assessment phase of this EDR project, discussions with experts in the field and the project sponsor clearly identified gaps to be filled. Specifically, an effective means was needed to train greatly increased numbers of personnel involved in handling of TTSPPs and to develop a professional learning community related to cold chain management.

EDR is a genre of research approaches rather than a specific research methodology. Labelled as 'design-based research' (DBR) in North America and Australasia, it is more commonly referred to as 'EDR' in Europe (Plomp and Nieveen, 2013). Figure 1 illustrates DBR as it has been applied in this project (Reeves, 2006). This paper is primarily focused on the first phase of the four phase model, analysis of a real world problem aimed at the identification of preliminary design principles that would guide the rest of the EDR project.

Figure 1   DBR model (see online version for colours)
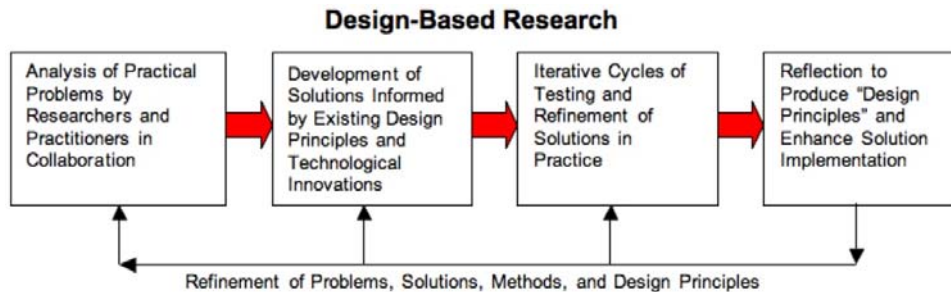
Source: Reeves (2006)

Analysis and exploration of the problems associated with handling TTSPPs were researched not only through the literature but also through discussions with practitioners and cold chain management experts. This type of in-depth analysis of real world problems is a key distinguishing process of EDR. A daylong meeting with the WHO sponsor, creative director of the project, project research advisor and researcher was held in Turkey to discuss the problems in more detail and explore ideas for the proposed learning solution. The discussions focused on identifying and characterising the audience and sharing ideas and expectations for the solution and its ultimate form. Several different models and metaphors had been discussed earlier in the process, but there had been no real agreement on the most appropriate model to pursue. For example, one early option that had been considered was a completely self-contained, asynchronous e-learning solution. But at the daylong meeting, the team decided instead to adopt an authentic learning model and use an open source learning management system similar to Moodle. The course would require participants to sign in and work in small collaborative teams. At the same time, some of the learning materials (e.g., overview videos, printed documents) would be made available to other interested persons who were not full participants in the course.

In the PCCMoW course, all participants are in close physical proximity for a week – sharing meals, riding on the bus, creating presentations, experiencing cultural tours – contributing to a unique community of learners who would cooperate and collaborate during that week and in many cases, develop personal and professional relationships that extend beyond the course itself. At the outset, the WHO course director wanted an e-learning course that would result in similar outcomes achieved in the physical course. It was this functional requirement that led an examination of some of the underlying design principles for establishing a community of learners online. To guide the design of such an e-learning programme capable of matching or exceeding the outcomes of the physical bus course, design principles were identified and used in creating the e-learning prototype related to factors such as establishing a community of learners and specifying the role of mentors.

5   Community of learners

Community of learners and *learning community* are terms commonly used but with purposes and definitions that vary widely (Kovatcheva and Kommers, 2008). Brown and

Campione (1996) stated that the fundamental activities of a community of learners are to conduct research, share outcomes and perform a consequential task. Perry and Edwards (2010) further developed the meaning of an online learning community by defining it as a "shared culture in the online classroom, including shared values, norms and beliefs" (p.132). Similarly, Boyer (1995) noted that a community of learners shares a "purpose, good communication and a climate with justice, discipline, caring and occasions for celebration" (p.20). Other writers, such as McLoughlin (1999), have used the term community of learners in the context of providing a learning environment and solution that meets the needs of a diverse group of learners, whether geographically or culturally dispersed.

Communities of learners can exist as a study group in a library study room that may be informally self-organised (Amhag and Jakobsson, 2009) or more formally as "an intentional structuring of the students' time, credit and learning experiences to build community and foster more explicit connections among students, faculty and disciplines" [Smith, (2001), p.5]. A distinguishing aspect of a community of learners is that no matter whether they self-organise or are randomly or selectively placed into a team, the members actively learn through cooperative and collaborative communication and activities (Biasutti, 2011). Members connect themselves with the learning expectations and goals (Abrami et al., 2011). Social learning theorists have long advocated that learning with and from others is fundamental in the acquisition of knowledge and skills (Bandura, 1977).

How does a community of learners differ – or not – from a community of practice? Wenger (1998) describes a community of practice where "collective learning results in practices that reflect both the pursuit of our enterprises and the attendant social relations. These practices are thus the property of the community created over time by the sustained pursuit of a shared enterprise" (p.45). Wenger (1998) also added that a community of practice "includes learning, not only as a matter of course in the history of its practice, but at the very core of its enterprise" (p.215). Learning occurs in both communities of practice and communities of learners, but the enterprise of a community of practice is to help the community member to develop an identity aligned with the practice. Wenger wrote, "we accumulate skills and information, not in the abstract as ends in themselves, but in the service of an identity" (p.215). While there is considerable overlap in these two types of communities, the differentiator is the enterprise or goal. For participants in a typical classroom or in an e-learning course, the enterprise is learning. Rovai (2001) summarised the benefits of a community of learners, including: increased persistence in courses, an increased flow of information, cooperation among group members, a heightened sense of engagement and feelings of less stress.

Two key characteristics of a successful community of learners are collaboration and cooperation. With respect to collaboration, learning occurs through 'interactions of individuals with other individuals' and as 'individuals exercise, verify, solidify and improve their mental models through discussion and information sharing' to construct a shared understanding [Leidner and Jarvenpaa, (1995), p.268]. The more knowledge is shared, the more it is learned. When we collaborate, we work together – 'co-labour' – on the shared goal of accomplishing a task and learning in the process.

When learners cooperate, they coordinate their individual efforts as they accomplish a group task or activity. Nam and Zellner (2011) identified three components of cooperation:

1   positive independence, where each learner realises that each and every member of the learning community needs to succeed if the community is to succeed

2   individual accountability is when the success of one individual is shared fairly with other members of the community

3   group processing is when the members of the learning community evaluate the members and outputs of the group in order to make improvements to the group's activities.

Group processing would include the control, monitoring and evaluation that take place as the community works to achieve its goals (Beishuizen, 2008; Biasutti, 2011).

The characteristics of learners in a community are important to accomplishing authentic tasks and learning in the process. Based on the literature analysis outlined above, the working definition for community of learners used in this project is 'an interdependent set of individuals that cooperates and collaborates as they conduct research, share outcomes and perform a meaningful task'.

6   Success factors for an online community of learners

A community of learners can exist in a physical space or it can be mediated virtually through computer-mediated communication (CMC). The online formation and maintenance of communities of learners has been the subject of much research in recent years (cf. Blitz, 2013). To create and maintain a successful online community of learners – that is, an environment in which the desired outcome of learning and the additional benefit of establishing an ongoing learning community can be achieved – there are a number of factors that ideally must be present. These include retention; social presence; safety, respect, and trust; and multiculturalism.

6.1   Retention of community members

If a community of learners is to work collaboratively and cooperatively, the learning environment (whether online or face-to-face) must first acquire and then retain learners in that community. Dropout rates for online courses are usually much higher than dropout rates of face-to-face courses (Boston and Ice, 2011). The reasons for this higher attrition rate are due to a combination of issues associated with instructional design, the instructor/facilitator, technology and learner characteristics (Gaytan, 2013). Researchers have identified individual learner characteristics that are important for an e-learner to be successful. For example, the e-learner needs to be self-regulated and self-monitored (Tsai et al., 2013); self-directed, that is with high curiosity and a willingness for self-learning (Chu et al., 2012); and have a mastery orientation which emphasises 'comprehension over performance' [Salas et al., (2002), p.144]. Unfortunately, some participants in e-learning programmes fail because they do not have the ability to self-regulate their own learning; many learners have only had traditional classroom experiences and they are not prepared to function in a distant e-learning environment (Rossett and Schafer, 2003), perhaps because of a lack of social presence.

6.2 Social presence

Social presence was first defined as, "the degree of awareness of another person in an interaction and the consequent appreciation of an interpersonal relationship" [Short et al., (1976), p.65]. Garrison (1997) defined it as the "degree individuals project themselves through the medium verbally or nonverbally" (p.6). Perry and Edwards (2010) concluded that the interaction of learners in an online learning environment is connected to the 'experience of social presence' (p.132). They described designs and methods that can be used to facilitate interaction and social presence that in turn strengthen a community of learners. Tu and McIsaac (2002) identified four dimensions that positively influence social presence: social context, online communication, interactivity and privacy. These dimensions can be affected by:

- underlying technology and technological environment (e.g., some types engendering a more positive or negative response, due in part to ease-of-use; affordances; availability and location of equipment)

- design of the course (e.g., selection of group size for learning activities and tasks)

- characteristics, skills and attitudes of the participants (e.g., computer literacy skills, timeliness of responses to messages)

- characteristics, skills and attitudes of the facilitator/instructor (e.g., communication strategies, informal conversation style).

6.3 Safety, respect and trust

Several authors (cf., Quan-Haase, 2005; Stoll et al., 2006) have identified trust as a critically important element in a community of learners. Taylor (2002) puts it simply, "Collaborative teamwork is too risky to happen without a culture of trust. [Learners] must believe it will be OK if they make a mistake or try something new and it doesn't work out" (p.43). For successful learning to take place, there must be a safe learning environment (Bruffee, 1993). Based on surveys, Tu and McIsaac (2002) found that trust issues played a very critical role in online interaction among students. In the CMC environment, it requires more time for students 'to become acquainted and to develop a trusted relationship' (p.142). Respecting the diversity of those in a community of learners contributes to learning when a climate of trust is nurtured and risk taking is encouraged (Garrison, 2011). Learners who feel less comfortable and safe in a learning community are those who contribute less in various forms of communication. An important element in developing a safe community of learners is respect and sensitivity for different cultures or what is now being called cultural competency (Keengwe et al., 2014).

6.4 Multi-culturalism

The enormous growth in e-learning world-wide means that communities of learners are becoming more and more diverse in terms of nationalities, backgrounds and culture (Wang and Reeves, 2007). The current understanding of what culture is goes beyond the work of Hofstede (1980) that considered a person's 'culture' was primarily attributable to the person's nationality and ethnic origins; rather, culture is now seen more broadly. For example, Branch (1997) expressed culture as "the patterns shaped by ethnicity, religion,

socio-economic status, geography, profession, ideology, gender, and lifestyle" (p.7). In the design, production and on-going use of the e-learning programme, designers, developers, and facilitators/instructors must be sensitive and aware to multicultural issues. Edmundson (2009) stated, "e-learning courses are cultural artifacts, embedded with the cultural values, preferences, characteristics and nuances of the culture that designed them, and inherently creating challenges for learners from other cultures" (p.42). Unfortunately, multicultural sensitivity is often not included in e-learning environments. For example, Rogers et al. (2007) point to several examples where there was a "severe lack of attention among instructional designers as a whole towards important issues of cultural diversity, resulting in the alienation of many learner groups" (p.199).

Another key multicultural aspect of establishing and supporting a community of learners online is the need to utilise instructional and visual design features that are sensitive to the participants from multiple cultures that will use it. Factors such as pedagogical interactions, interface design, icons, colour, tasks, internal/external support, and examples need to be considered (Chen et al., 1999; Herrington et al., 2010; McLoughlin and Oliver, 2000; Wang and Reeves, 2007). Since culture has an impact on ways students: learn (Rogers et al., 2007); provide, receive, and value feedback (Uzuner, 2009); and reason (Bentley et al., 2005), these factors must be taken into consideration as an e-learning course is being designed. Effective visual and learning design contribute to the success of individual learners and collective community of learners.

7   Mentors in a community of learners

In addition to the 'students' who are participating in the community of learners, instructors, facilitators, and mentors will influence the community's success, through active involvement in monitoring and evaluating online dialog. Further, collaboration with facilitators can help individual learners and teams of learners achieve higher levels of understanding and learning (Amhag and Jakobsson, 2009). Lee and McLoughlin (2010) identified special challenges facing distance learners using web technology, including "lack of feedback and instructor contact, feelings of isolation and alienation, lack of experience in studying at a distance, and lack of technical training in using the technologies involved with web-based learning" (p.65).

Instructors and mentors must be actively involved in monitoring postings and communications among the learners and helping along those learners who may not be contributing. A challenge for instructors particularly, when working with a culturally diverse community of learners is when and how to intervene, for example, when a learner has been lurking rather than actively participating (Oh et al., 2014).

8   Initial set of design principles

Achieving a community of learners where cooperation and collaboration occurs in a physical or virtual environment requires that designers, developers, and instructors/facilitators create, enable, and sustain a safe, respectful, multi-cultural setting with learners who are willing and able to contribute and be active participants. The relationship among the elements is critical in creating an effective community of learners.

Below, we describe the design principles that emerged from the consultations with practitioners and literature review to guide the creation of such a community of learners among public health professionals.

Table 2   Five initial design principles

	Design principle	Meaning	How it is implemented
1	Utilise instructional and visual designs that support and are sensitive to multicultural learners who bring different learning and reasoning styles along with different communication, language, technological, and problem solving skills.	The underlying instructional design of the learning solution is the foundation on which the course is developed and implemented. When making design decisions, the underlying question needs to be how learners from a variety of cultures might view the content or activity.	• Have meaningful content that reflects real-life outcomes and situations. • Use inclusive design principles for information that assumes non-native English speakers. • Use a mixture of synchronous and asynchronous activities/events. • Size teams with three to four people per team. • Have clear instructions for each activity. • Develop and have learners use an online diary that the facilitator/instructor can monitor to provide direct, unique feedback. • Use graphics, illustrations, icons, etc. that are not culturally inappropriate in a multi-cultural environment.
2	Create safe structured and unstructured opportunities, methods, and tools for learners to meet, develop relationships, and actively collaborate with each other.	Learners will participate and contribute to the community if the right conditions are present. This includes helping learners get to know one another and develop some knowledge about the other learner's 'context' and points of view.	• Create initial icebreakers so people can meet others in their community of learners • Provide different modes of communication that learners and facilitators can use (e.g., real time chat, email, postings). • Provide a 'profile' page where learners can post information about themselves and as much of their personal and professional lives as they are comfortable in doing • Limit the situations or technical options where someone might unwittingly embarrass someone from a different culture. • Create an activity or event so all participants can value peer-to-peer feedback and learning. • Minimise changing or mixing of small group members.

Table 2   Five initial design principles (continued)

	Design principle	Meaning	How it is implemented
3	Select and develop technology that is appropriate to the learners, their location, available infrastructure, and culture and that supports multiple 'channels' for communication.	The underlying technology used for the e-learning programme should be able to be used without problems by the intended users. The affordances that the technology provides should contribute to the goals and objectives of the course and the valid expectations of the users and facilitators.	• Identify minimum technological standards (hardware, communication, applications, etc.) that are as broad-based as possible. • Match the information technology and learning technology with learning theories. • Keep the technology as simple as possible. • Use technological tools that will contribute to higher amounts of social presence.
4	Identify and communicate learner roles and responsibilities that set the expectations for the learners.	When potential learners are inquiring about the course, they should be provided not only with course goals, objectives, topical outline and responsibilities, but also with information to help them decide if they are a good candidate for this type of e-learning programme.	• Develop a questionnaire to help potential learners decide if they have the characteristics and learning styles needed for success in the course. • Set expectations about reading, thinking about/reflecting, and responding to postings and assignments. • Identify ways that learners can request additional support from peers and facilitators. • Provide learners a 'roadmap' of the course and what is included.
5	Identify and communicate facilitator roles and responsibilities that provide the expectations and guidance for the course leaders.	Facilitators and mentors are critical for maximising the flow of correct information and knowledge sharing as well as monitoring and guiding individuals and group dynamics. For many mentors, facilitating a virtual e-learning solution is a new experience; having guidance to help them succeed is needed.	• Establish guidelines that cover: providing timely feedback, supporting peer learning, monitoring learner comments and diary entries to guide individuals and groups to deeper levels of discussions, and providing affective support. • Provide culturally informed guidance on ways people may respond or not respond. • Provide guidance on 'faders' who may be withdrawing from active participation.

The draft design principles presented in Table 2 were developed after an extensive review of the literature and extensive consultations with content and e-learning design experts as well as practitioners. These design principles were used to guide the design and implementation of a prototype e-learning version of the PCCMoW course. Throughout the EDR process involving the multiple implementations and iterations of the solution,

the design principles will be refined and enhanced. As Table 2 shows, the draft design principles are broad-based statements from which more concrete actions, design features, or opportunities can be derived and are used in the e-learning programme.

The developers of the e-pharmaceutical cold chain management course used specific design principles and ideas identified in Table 2 to guide the design of several initial prototypes of the programme. For example, Figure 2 shows a sketch of a proposed icebreaker activity, 'two truths and one lie' which aims to instantiate design principle 2: *create safe structured and unstructured opportunities, methods, and tools for learners to meet, develop relationships, and actively collaborate with each other*.

Figure 2 Screen capture of icebreaker activity from prototype e-learning course (see online version for colours)

Design principle 2 is also instantiated by the provision in the e-learning course for learner and instructor 'profile' pages that allow all participants to upload personal information that may be of interest to the group to build identity and foster community. Design principle 4: *identify and communicate learner roles and responsibilities that set the expectations for the learners*, and design principle 5: *Identify and communicate facilitator/instructor roles and responsibilities that provide the expectations and guidance for the course leaders* are accomplished by providing clear guidance in the course as to what would be appropriate or not appropriate in communications. Design principle 1: *Utilise instructional and visual designs that support and are sensitive to multicultural learners who bring different learning and reasoning styles along with*

different communication, language, technological, and problem solving skills involves using a website that follows guidelines and heuristics related to multicultural usability (Downey et al., 2005).

9   Discussion

This paper describes the first phase of an EDR study focused on a significant public health problem. The incorrect handing of TTSPPs has the potential to impact negatively on the lives of many people around the world, especially in developing countries. One negligent act in the chain of events – that takes a vaccine from the point of manufacture to the location where it will be administered – has the capacity to undo the correct handling of every other person in the chain. The EDR approach enabled the research team to study this serious problem in context and to begin the process of conceptualising and developing a solution, in this case, an e-learning course that retains all the complexity of a real-life 'bus course' (Vesper et al., 2010).

Design principles have an essential role in moving a project of this nature forward. Once the e-pharmaceutical cold chain management course is implemented and evaluated according to the design principles established in phase 2 in the EDR study, the principles will be revised and implemented in further iterations of the e-learning course. After all iterations in the study are complete, design principles will be revised and shared with the research and development community, this time in a revised and refined form that ideally will be able to inform the design of learning environments in other contexts and fields.

In both physical and virtual learning situations, participants form groups – communities of learners – to collaboratively accomplish tasks or activities that contribute to their learning. As illustrated above, there are many factors that can support or detract from that community. In creating a specific e-learning course, the designers, developers, and researchers are using design principles based on sound theory and practice to promote this community and – through evaluation at key points during the e-learning course's development – identifying and confirming best practice guidelines for the design of future projects that foster online learning communities.

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