## SUMMARY

## Design-based research for radiation safety requirements in a flexible learning environment

**Belinda van der Merwe**

**Central university of Technology (CUT)**

The aim of my TAU project was to find a solution to the educational problem concerning application and implementation of theory of radiation safety requirements in clinical practice. The outcome was the design of authentic learning and assessment tasks so that meaningful learning could take place. The mentioned tasks incorporated delivery of the activities on the student's mobile phone and the design of a website. The most exciting part however, was the journey to analyse the problem and to find the solution in phases, with a design-based research approach.

Design-based research has its focus on real world problems, and the overall goal of improving learning, rather than proving that one pedagogical approach is more effective than another. In the first phase of design-based research, a problem is analysed in-depth in consultation with the practitioners or teachers involved. A solution is then designed according to theoretical principles and with knowledge of recent technological affordances. The proposed solution (or intervention as it is sometimes known) is then implemented in two or more repetitions, with adjustments and improvements made between implementations, so that the emphasis remains on finding the best way to present the subject in the particular pedagogical context. The last phase is the creation of design principles based on the knowledge gained from the theory, practice and reflection of the previous phases (Herrington, Mantei, Herrington, Olney & Ferry 2008). The design-based research approach (Brown, 1992; Collins, 1992) has been summarised by Reeves (2006) into four phases (see figure 1).

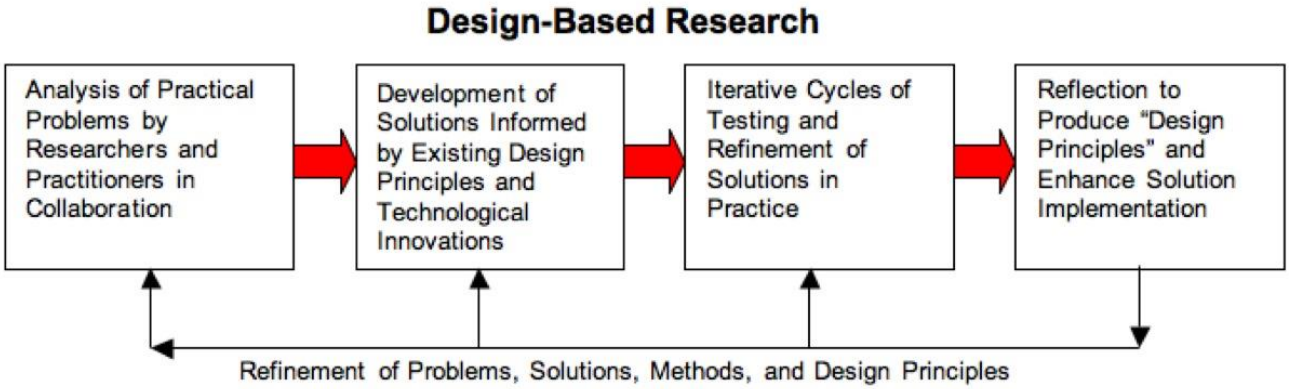



Figure 1. Four phases of design based research

The design of the current flexible learning environment was preceded by the following:
1. Radiation safety training and assessment were contextualised from the perspective of legislation and the content conceptualised by means of a Delphi survey involving 10 experts.
2. Teaching and learning activities (in a student and lecturer guide) were developed to align with the Delphi results.
3. The assessment criteria statements of the Delphi questionnaire were adapted and taken up in basic and advanced student questionnaires determining the knowledge regarding safety requirements of the first- and third-year students. Pre and post test results were recorded to plan remedial activities.

The four phases of this design based research project will be described consequently.

### 1. PHASE 1: Analysis of a practical problem

### 1.1 The problem

Radiography students spend weeks off campus at hospitals during work place learning and must apply theory of radiation safety in order protect self as well as the patient. The radiation safety module is presented over 4 years with three-month stages of placement in the imaging department. Students complete assessment on campus successfully but seem to overlook that the requirements apply in the clinical setting. The students work under supervision of qualified radiographers who are not necessarily role models in application of rules and

regulations. There is a need to engage students with the content not only to reference the information but also to provide authentic learning- and assessment tasks regarding radiation safety requirements. Authentic learning tasks can be the organising component of the safety requirements module and can motivate students to learn (Herrington, Reeves and Oliver 2010: 41). When radiography students are not on campus, flexible learning opportunities need to be provided so that they can reflect on the application of huge amount of theory in the different placements in the imaging department.

### 1.2 The practitioners

The researcher involved experts in the field of radiography as well as lecturers to explore the content that is important in order for the student to apply and implement radiation safety requirements in practice. The first step was to determine the content of the requirements relevant for South Africa.

The students were identified to take part in the study in two different categories namely, first year radiography students as entry radiation workers and third years as potential licence holders of x-ray equipment. The first year student should be familiar with basic concepts and the third year should be familiar with advanced concepts involving quality control of equipment.

Diagnostic radiographers who are specialists in the field as clinical practitioners or lecturers plus a physicist assisted with the decision of what content regarding radiation safety requirements is relevant for the students. The experts involved provided a confirmation of the conceptualisation of the content of the training and assessment. A Delphi technique was used to reach consensus on the content of the radiation safety regulations training course. The Delphi technique differs from other methods of gathering data from a group of people, because it involves a research team, who are involved collectively with the goal of enhancing the quality and utilisation of the research (Du Plessis and Human 2007). The Delphi technique was used in this study to establish a set of criteria needed for the development and implementation of a training course for diagnostic radiography students.

### 1.3 Data collection via collaboration

The purpose of the study is to develop radiation safety requirements content to provide flexible learning in a blended environment to the students in practice off campus. Blended learning defined as "the thoughtful integration of classroom face-to-face experiences with technology-enhanced learning experiences" (van der Merwe, Bozalek, Ivala, Nagel, Peté & Vanke 2015: 11). The original idea was that the students will receive a link to a website via a "sms" message in order to engage the student in a learning activity with assessment task in order to apply radiation theory in practice. The idea was slightly altered when the instructional designer at my institution introduced me to QuestionPro, a web based software tool.

With this software it is possible that the students can have access to survey response links via E-mail or sms or WhatsApp. With QuestionPro online surveys and polls can be created. Responses can be collected even offline using the Android mobile survey application. Results can be analysed with a full set of reporting features such as real-time summary, pivot tables, segmentation tools, trend analysis, and text analytics. The survey data can be exported directly to Excel, SPSS, or CSV. The results can be shared with formatted Word and PowerPoint reports or by generating info graphics (QuestionPro 2016 online).

### 1.4 The literature review to find solutions

A literature review focused on situated learning, authentic learning and assessment, design based research as well as mobile learning software available. Increased movement and flexibility influence how students use technology to support their learning. The students value the fact that there are no longer restrictions to be in a computer laboratory or on campus, but it is possible to work on assignments off campus accessing the internet, online resources with own devices (Brown and Pallitt, 2015:27). The classroom activities are thus extended outside the classroom to provide a flexible learning environment.

For meaningful learning to take place the pedagogical focus requires that learning tasks must be aligned with the learning outcomes and teaching activities. The prior knowledge and competencies of the students must be considered as well as the technologies available to the group of students (Bozalek and Ng'ambi 2015:7).

#### 1.4.1 Situated learning

The learning environment for this project draw on theories of situated learning that is a general theory of knowledge acquisition. Situated learning means that learning of a student takes place during social interaction by a process of increased participation and collaboration (Lave 2010). The radiography student under supervision of a professional in the imaging department is guided to master practical requirements and to apply theory in practice.

### 1.4.2 Authentic learning and assessment

The "Guide to Authentic e-Learning" (Herrington, Thomas and Olivier 2010) was a valuable resource in the design of the mobile content. For authentic learning to occur, students must be engaged in realistic tasks that provide opportunities for complex collaborative activities. That authentic learning can only take place in real work setting is a misconception - it is thus also suited on computer and web-based delivery. The technologies must be used as cognitive tools for learning rather than substitute delivery platforms (Herrington et al. 2010:3).

Herrington and others (2010:19-27) reiterated that in the designing of e-learning courses it is not sufficient to only provide examples from real-world situations to illustrate concepts but the purpose and motivation for learning must be provided. The lecturer must ask questions where and how the knowledge will be used to plan the activities. Student must have different perspectives from various points of view.

### 1.4.3 Teaching strategies on the digital platform

As more academic content becomes openly and freely available, students will look increasingly to the lecturer for support with their learning, rather than for the delivery of content (Bates 2014:10). The lecturer must first understand what his/her own epistemological perspective of learning is because that is the driver of teaching. This study uses constructivism and connectivism. Constructivists believe that understanding is achieved by integrating information, relating it to existing knowledge, and cognitively processing it. Connectivism it is the collective connections between all the connections in a network that result in new forms of knowledge. The knowledge is generated outside the level of the individual partakers, and is continually changing (Bates 2014: 52-54).

In a digital age, just choosing a particular teaching method such as a video or experiential learning is not going to be sufficient- different methods of teaching must be combined (Bates 2014:101). With mobile devices students can create multimedia materials for project work or for assessment purposes in the form of e-portfolios (Bates 2014: 274). The movement is away from teaching models to design models. During the design the following must be taken in to consideration, for example: "People learn better when a multimedia lesson is presented in user-paced segments rather than as a continuous lesson. Thus several 'YouTube' length videos are more likely to work better than a 50 minute video. Lecturers must heed against overload- focus on what students need to do to absorb, apply and evaluate. Plan for activities with some form of feedback (Bates 2014:398).

## 2. PHASE 2 Development of the learning environment

### 2.1 Design principles

The design principles that I identified as suitable for my project is summed up as follows:

| Design principle | Source/Reference |
|---|---|
| Radiation safety may best be facilitated by learning environments which are: | |
| Draft Principle 1: Flexible and blended (website accessible via a mobile phone) | Kilfoil 2015 |
| Draft Principle 2: Authentic task reflect the way the knowledge will be used in real life (provide authentic tasks and activities in fillable PDF format or delivered by QuestionPro) | Herrington 2006 |
| Draft Principle 3: Promote reflection to enable abstractions to be formed | Herrington 2010 |
| Draft Principle 4: Situated learning via collaboration (supervision and peer collaboration) | Lave 2010 |
| Draft Principle 5: Tasks from different perspectives with different solutions. Different methods must be combined (E portfolio) | Bates |
| Draft Principle 6: Complex tasks over a period of time | Herrington |

### 2.2 The design of the flexible learning environment

Three learning activities were planned for the first year students to align with learning outcomes confirmed during the Delphi process. The design principles guided me to formulate tasks so that students can explore the relevance of the theory in practice.

## 3. PHASE 3 Cycles of testing and refinement of solutions in practice

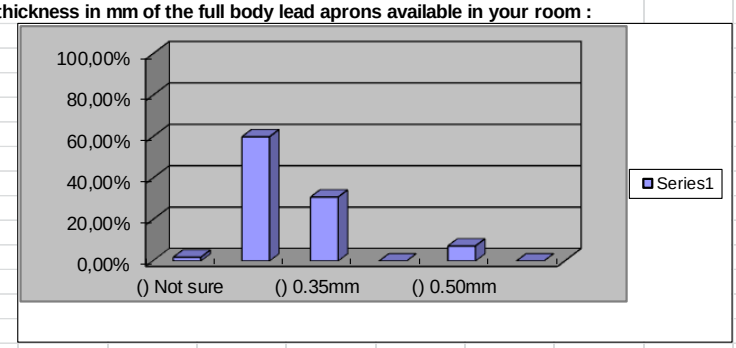
### 3.1 The first implementation/cycle

Students received an activity with instructions via WhatsApp and Email in PDF format. The activity involved group work as well as individual tasks. One example is to find the thickness of the lead aprons in the department

in the specific unit the student was rostered for that week. After one week the student received the assessment task via QuestionPro. The responses were recorded and the results displayed as per example.

**Q5. 5.Choose one of the following. The lead equivalent Pb thickness in mm of the full body lead aprons available in your room :**

| Answer | percentag | Count(N) |
|---|---|---|
| () Not su | 1,82% | 1 |
| () 0.25m | 60,00% | 33 |
| () 0.35m | 30,91% | 17 |
| () 0.45m | 0,00% | 0 |
| () 0.50m | 7,27% | 4 |
| () 1 mm | 0,00% | 0 |
| Total | 100,00% | 55 |
| Mean | 2,51 | |
| Confidenc | [2.282 - 2.736] | |
| Standard [ | 0.858 | |
| Standard E | 0.116 | |




**Analysis of data**:

All 54 second year radiography students responded to the QuestionPro survey. From the incorrect responses I could identify learning areas that needed revision. The survey also indicated areas in the hospitals that do not meet the requirements for safety- this was an additional benefit of the exercise. Although unplanned in the design phase, the students are now involved to find solutions how to communicate the non-compliance and how to address the resource challenge in the departments. This deepened their engagement with the theory.

The students completed a satisfaction survey regarding the mobile questionnaire when they returned after the clinical block period. 24% indicated that they made use of the survey link via cell phone, 22% via E-mail and 54% that they have used both. 93% indicated that the instructions were clear, 70% that they enjoyed the exercise and 94% that they did make use of the opportunity to consult peers. The responses indicated that they need more time for the completion and that will be changed for the next student group.

**After review and revision**

**Implementation 2**:

The remaining two learning activities were delivered to the students in similar format.

## 4. PHASE 4

## REFLECTION TO PRODUCE DESIGN PRINCIPLES AND TO ENHANCE SOLUTION IMPLEMENTATION

There are potentially at least three outcomes of design-based research namely: design principles, designed products and societal outputs, such as professional development and learning.

### 4.1 Design principles

After the implementation and evaluation of the proposed solution, the draft principles that have guided the design of the solution were revisited and are confirmed as follows:

1. A flexible mobile learning environment was created that will allow students to have access to information on demand in order to confirm the correct application of theory.
2. Knowledge was used in real life and investigates the learning from different perspectives/departments in real life and measure if they are effective performers with acquired knowledge. The theory was tested in practice- the student was required to check the specific technical requirements in each department.
3. The responses that were submitted involved reflection on own practice and implementation and application of the theory. Each student reflected on a different implementation.
4. Students completed assessment tasks relevant to what they experience in the clinical setting and were guided to reflect on practices in collaboration with peers. They reflected on role models in practice with specific examples.
5. Students will have the opportunity to explore different ways to execute quality testing- different solutions will be accepted and encouraged when they submit proof in a portfolio.
6. Require students to be effective performers with acquired knowledge. Application during fluoroscopy in theatre will be recorded on a checklist. Students will submit proof in a theatre portfolio over a period of time.

### 4.2 Practical output of design-based research

The need for a reference source on demand was confirmed by responses regarding the radiation safety requirements. Therefore was the content of the radiation safety course converted to be suitable for a website that is accessible with a mobile phone.

### 4.2 Societal output of design-based research

The collaboration that is so integral to the process of designing and accomplishing a design-based research project has an additional benefit in that it enhances the professional development of all people involved, not only the students. The researcher developed in design and planning of a Website and Questionpro surveys and acquired the skill to develop PDF forms for mobile delivery.

Ethical approval to execute the research project was obtained from the Ethics Committee of the Faculty of Health Sciences, UFS (Ethics Committee approval number ECUFS 74/2013). Approval was obtained from the Dean of the Faculty of Health Sciences of UFS as well as the Vice-Rector: Academic at the UFS.

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