Embedding Experiential Learning and Constructivism into E-learning Courseware

Fiona Chatteur; Dr. Andy Dong
Design Lab, Faculty of Architecture, Design and Planning, University of Sydney
fker9420@mail.usyd.edu.au; a.dong@arch.usyd.edu.au

Abstract. Creating e-learning courseware design so as to make best use of learning theories can add complexity to an already complex design task. By using pedagogy distilled from two learning theories as a design philosophy, this research outlines how to embed these theories into "design for pedagogy" patterns for e-learning. These design patterns cater not only for the designers of e-learning courseware, but also for those tutors/academics that use it. This paper discusses the development of the "design for pedagogy" pattern and a reflective inquiry based on experiential learning on the task of creating a tool to help write the pattern, a "pattern pack". The "pattern pack" uses an experiential learning approach to teach pattern writers how to extract pedagogically-based design solutions and teaching practices from courseware and peer-reviewed literature. It is used to write a pattern for e-learning forums. Writers need knowledge of the pedagogical theories, current research on best practice and examples of forums from which to extract visual and interactive design and pedagogical elements. The "pattern pack" contains instructions, background readings and two sets of cards. One set of cards identifies design elements seen in e-learning courseware (menu navigation, threaded discussion pages, etc.) and the other identifies pedagogical practices based on experiential learning and constructivism (abstract conceptualization, active experimentation, reflection etc). E-learning forums are examined and a hierarchy is created using the cards, like a flowchart. The cards enable the organization of the visible design elements linked with the supporting pedagogy. The hierarchy is recorded for each of the three forum examples and writers reflect on the hierarchies. Recurring design and pedagogical elements are identified. These are in turn organized into a hierarchy and this is used to write the design for pedagogy pattern.

1. INTRODUCTION

A "trying out" or experience-based approach is at the core of Kolb's experiential learning theory, and if encapsulated in a collaborative learning space provides the real-world context outlined in social constructivist theory. Experiential learning theory stems from a set of assumptions that ideas are not fixed; rather they are constantly reformed through experience. [8] Experience is always modifying thoughts, and that is why no two thoughts are ever the same – experience always intervenes.

A personalised 'what-if' ability available in e-learning is a primary difference between e-learning and classroom-based learning, and, according to both experiential and constructivist learning theories affords additional opportunities in the consolidation of knowledge.

This paper outlines a method of embedding experiential learning theory and constructivism into the design of e-learning courseware, and the development of a tool, the "pattern pack" to help pattern writers create a "design for pedagogy" pattern. These theories offer instruction-based ways to conceptualize what type of interactions should take place between the learner and the materials. This research places these theories within a pedagogical framework, [7] thereby becoming the overriding pedagogical philosophy.

2. E-LEARNING – A "WICKED PROBLEM"

Designing an e-learning application is a complex task. Design is recognized as being a "wicked" problem [9] – one that has numerous stakeholders with conflicting perspectives and that cannot be accurately modelled or addressed by the techniques of science and engineering. Wicked problems have multiple solutions which integrate multiple facets.

One way of dealing with a wicked problem is to use design patterns. A design pattern is a problem/solution set that "describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" [1]. A "design for pedagogy" pattern shows the relationships between pedagogic strategies associated with the design elements appearing in the e-learning courseware and those associated with the general and abstract ways of thinking about education including the social (e.g., public, private, parochial) and the educational context (e.g., science, mathematics, humanities) of the learning, the preferred teaching practices of the instructors, and the tactics for engaging students. In short, the pattern makes explicit the pedagogy to be conveyed, and how it is articulated through image, text, simulations, and interaction. It is a modification of the classic pattern language structure and should be seen in context with larger-to-smaller elements in an entire pattern language. (See Figure 1.) These links to the greater pattern language are seen in the 'Pattern context' section which links to patterns higher in the pattern language, and in the 'Consider these other patterns' section which ties the current pattern to smaller patterns which are needed to complete and embellish it.

There are higher level pedagogical issues to deal with as well. Goodyear [7] describes this as the "pedagogical framework" that defines the educational problem space, which includes a pedagogical philosophy, high level pedagogies, strategies and tactics. The pedagogical framework in used in the 'Teaching strategies' section

of the pattern. Placing the two pedagogical theories within the pedagogical framework gives the 'Teaching strategies' section a clear structure for use with instructional design.

Embedding pedagogical theories into a "design for pedagogy" pattern document is a complex task in itself. The "pattern pack" addresses difficulties encountered by pattern writers in formulating the design solutions in terms of the learning theories and pedagogical framework and uses a "hands on" experiential approach to do so.

Title: A descriptive title for the pattern.
A picture showing an archetypal example of the pattern [if possible.]
Pattern context: An introductory paragraph setting the context for the pattern.
◆◆◆
(to mark the beginning of the problem)
Problem: A headline, in bold type, to give the essence of the problem in one or two sentences
The body of the problem
Solution: in bold type. The field of physical and social relationships which are required to solve the stated design problem in the stated context. Always stated as an instruction, it describes the solution in terms of learning outcomes relating to constructivist and experiential learning theories.
A diagrammatic representation of the solution
◆◆◆
(to show the main body of the pattern is finished)
Teaching Strategies: A paragraph outlining teaching strategies that can accompany this design solution [pedagogical tactics]. These strategies are expressed in the context of constructivist and/or experiential learning theories and express how these strategies complement and enhance both the theoretical framework of the pattern and the design solution itself.
Consider these other pedagogical solutions: A paragraph outlining the solution in terms of differing pedagogical theories [differing pedagogical philosophies if applicable].
Consider these other patterns: A paragraph tying the pattern to the smaller patterns which are needed to complete and embellish it.
Case Studies: [As optional inset sidebar boxes: narrative examples of the solution in practice or short case studies]
References: A list of references for further study

Figure 1: The design for pedagogy pattern structure for e-learning.

3. DEVELOPMENT AND EVALUATION OF THE "PATTERN PACK"

Initially, we developed a methodology for the development of "design for pedagogy" patterns for e-learning [2]. The methodology followed the process:

1. *Peer-reviewed text search for identification of pattern problem.*
2. *Definition of problem.* Using a text search of literature and media, the problem is defined.
3. *Text search for solution*s. Case studies and teaching strategies are also found, in conjunction with a critical examination of existing e-learning environments.
4. *Create solution in terms of constructivist and experiential learning theories.*

Step one involves a peer-reviewed text search to identify recurring problems in the design of e-learning courseware. By identifying problematic areas in the design and structure of e-learning the 'Problem' area of the pattern can begin to be defined. Each problem needs to be identified with consideration given to the patterns that surround it in the pattern language structure. The writing of the problem statement should exclude issues dealt with by surrounding patterns and should complement them.

In step two, defining the problem more thoroughly, the pattern writer examines both peer-reviewed research and existing courseware. This combination is designed to bridge a perceived gap between current theories on e-learning and practice. The gap was highlighted during conversations with e-learning practitioners. In this manner existing problems in e-learning practice could be compared with best practice as outlined in the peer-reviewed literature search. If the problem persists in both arenas, it is worthy of attention in a design for pedagogy pattern for e-learning, and for inclusion in the pattern language.

The solution search focuses on, but is not limited to those solutions that make use experiential learning theory and constructivism. Solutions which provide a best fit with alternate pedagogical theories should also be noted by the pattern writer, as the pattern structure allows space for these solutions, in the 'Consider these other pedagogical solutions' section. Pattern writers also note teaching practices that should accompany the design solutions, so that the pattern works on two levels: for designers who create the screen designs and information architecture, and for teachers/academics who have to use the final design. In this way the designs are used in practice in the manner that is intended.

The final stage in the methodology is for the pattern writer to complete the design pattern, which should be using 'Solutions' and 'Teaching strategies' that promote experiential learning and constructivist theories.

By basing the text-based research on this meta-strategy, the embedding of pedagogical theories into the design for pedagogy patterns has become operationalized.

3.1 Extracting design solutions based on learning theories

We trialled this methodology in the early pilot studies with three pattern writers, with a basic set of documents: primers on constructivism and experiential learning theories, and pattern template documents. After each pilot these documents which subsequently formed part

of the "pattern pack" were evaluated and updated, based on qualitative feedback.

When the methodology was put into practice, it became apparent that writing a design for pedagogy pattern was a complex task in itself. The problem became how to make it easy to extract design solutions and associated teaching strategies based on constructivism and experiential learning from the courseware and the readings. The "pattern pack" is a tool designed to make this process easier.

Existing literature on the writing of pattern languages for computer-based interaction places the emphasis on a customer-centred design approach using focus groups and usability testing to aid the design process [11] or makes the pattern problem definition process user-centred [10]. Once the pattern problem is defined in this approach, it is given to a pattern writer who completes the pattern. The process of design pattern writing itself is not outlined, nor is a defined methodology presented. Our approach defines the pattern writing methodology so that future "design for pedagogy" e-learning pattern writers have a clear and repeatable process for creating the pattern language.

In our first pilot study, the pattern writer was provided with the basic set of documents: the two primers, one each on experiential learning and constructivism, two template documents, one filled in with explanations as to what to write in each section of the "design for pedagogy" pattern and one empty template to be filled in. The pedagogical framework [7] is explained in the teaching strategies section of the 'template explained' document.

During the first pilot study of pattern writing, the participant used their research into the sociology of learning within a discipline. This resulted in a design for pedagogy pattern called Exploring Knowledge and Knower Structures. This pilot proved that the overall strategy produced patterns that linked design with pedagogy – a welcome result. The pattern writer expressed that the task of writing the design pattern was extremely difficult. This was despite the fact that the writer was familiar with the pattern topic, as it formed part of the participant's research. This raised the question as to how difficult the process would be when creating design for pedagogy patterns using background readings and research that is not familiar to the research participants. The pattern writing process was expected to take 3-4 hours per pattern. The first pilot study took over 8 hours. The participant also questioned some of the wording in the "template explained" document, and requested that it become bullet points. Using the participant's own research additionally made the pattern difficult to evaluate and to generalize the method.

3.2 Experimental design

The evaluation of patterns produced by the research participants is focused on a two step approach. The design for pedagogy patterns will be evaluated against an existing published computer-based interaction pattern. The first step is to have a set of eight similar "design for pedagogy" patterns written using our methodology and then evaluated by a panel of four experts. The best pattern will then be used by a set of sixteen designers and compared with a design pattern that does not use the methodology, but uses a similar pattern problem. The aim is to see if the methodology results in design patterns that facilitate the design of e-learning courseware, over those that do not use pedagogical theories or frameworks.

Finding a comparable published pattern that maps onto the e-learning domain reduced the scope of available pattern topics for our study. After an extensive literature search, a pattern based on an internet forum was found that fulfilled the criteria of being a published pattern that could be used in the e-learning domain, so it was decided to use a forum as the topic of our study. [10] E-learning forums also lend themselves to design solutions and teaching practices that take a social constructivist approach.

3.3 Piloting the forum pattern

The set of documents given to the second pilot subject was expanded to include peer-reviewed literature based on internet based e-learning forums and a brief instruction sheet outlining the task, in a step-by-step format. The writer was also given a fully worked example pattern and a set of two forums, one an e-learning forum and the other a social forum as a contrast. The second participant was videotaped and used a "talk aloud" approach as he wrote the pattern. The instructions, particularly in the 'template explained' document, were not focused enough to result in consistent results. The participant struggled with the task, being unsure as to the requirements. The peer-reviewed readings which focused on the pedagogy associated with e-learning forums took a long time to complete and made the task unclear. Embedding constructivist and experiential learning theories into the pattern was also extremely difficult for the second pattern writer.

Some of the background research undertaken on design patterns for information technology outlined that they should be written using a "constructive approach" – meaning that they should be written in a way that the users could use them, rather that describing what the pattern does [4]. The template documents were written in a constructive way. This approach was mentioned in the "template explained" document:

"The writing style of the pattern should constructive, explaining how the pattern can be used in context."

The use of the terminology "constructive" in the same context as documentation on "constructivism" led to a great deal of confusion and a lack of comprehension of what was required. It took some time for the participant to understand the approach. Finally the comment was made:

"I'm using constructive and experiential ideas in creating design patterns. Somebody to create e-learning software. So the person creating the e-learning courseware is the person I'm writing this for… they are not looking at constructive or experiential, what I'm doing is using constructive and experiential learning ideas to create a design pattern to help them create the e-learning courseware."

It took nearly forty minutes for the research participant to come to this understanding, and it was clear that the instructions and methodology needed to be adjusted.

One useful comment that helped focus the next stage of the research was this one:

"These instructions make a lot of sense, but I'd like a more general overview of what's going to happen. These are like do this do this, it would be nice to feel if you're in control of what you're doing. So – in this task you will be working towards creating your own study pattern to do with e-learning. First of all you will have to familiarise yourself with the background literature. Then you will be guided through a template to create your own study pattern, this should take approximately three hours. Yeah that kind of stuff, make you feel more oriented in it." This comment subsequently resulted in the production of an illustrated brochure outlining the "design for pedagogy" pattern writing task, the problem and the methodology for the next stages of the piloting process.

The resulting pattern from the second pilot focussed on the development of e-learning courseware, rather than an internet e-learning forum, which illustrated that further clarification was necessary for the writers. The result was inconsistent with requirements. The writer gave the task four hours, but was unable to complete the task within the required time constraints. The last three sections of the pattern were left incomplete.

At this stage the 'template explained' document was designed to be a generic document that could be used for all "design for pedagogy" patterns. It neither described the pattern problem, nor did it state specifically that the pattern should be about e-learning forums. This was supposed to be apparent from the readings, a detail that was missed by the pattern writers.

The same set of documentation was given to a third pattern writer, with major revisions to the instruction sheet. This participant completed the background readings, but felt that the task was so ill-defined that it was impossible to achieve. Being someone who was previously familiar with information technology design patterns, several usefully critical comments were made that led to the further development of the "pattern pack". The participant firstly stated that design patterns are usually more modular, in that elements are slotted in to the overall design to create the final pattern. It was also stated that the readings made it unclear that the task was to design a pattern for a forum specifically. The subject of the proposed pattern was a topic which was the participant's area of specialised instruction. However after spending five hours on the readings the writer did not understand the task and abandoned the pilot.

The failure of the third pilot led to a great deal of reflection on the pattern writing process. Distilling generic design and pedagogical elements from literature and media examples alone was a complex task, and the linking of pedagogy with the design elements was proving prohibitively difficult. The pattern subject and problem were unclear, which was leading to inconsistent results from the participants. Clearly a tool was required to make the process easier and clearer.

3.4 Using an experiential learning approach for the pattern writing process

It was decided to take a different approach with the development of "design for pedagogy" patterns. The task of associating and embedding the pedagogical theories with the design needed to be made simpler and clearer. A methodology based on an experiential learning approach was developed. Using all four elements of the Kolb learning cycle, [8] the writers would be asked to transform their concrete experience of the online forums and peer-reviewed readings through reflective practice using a tool to form theories (abstract conceptualization) about the generic structures linking pedagogy with design in e-learning forums. This would then be put to use in writing the design for pedagogy pattern (active experimentation). Based on experiential learning theory and constructivism (see Figure 2), techniques outlined in the peer-reviewed literature and the design and architecture of three online e-learning forums, two sets of cards were developed.

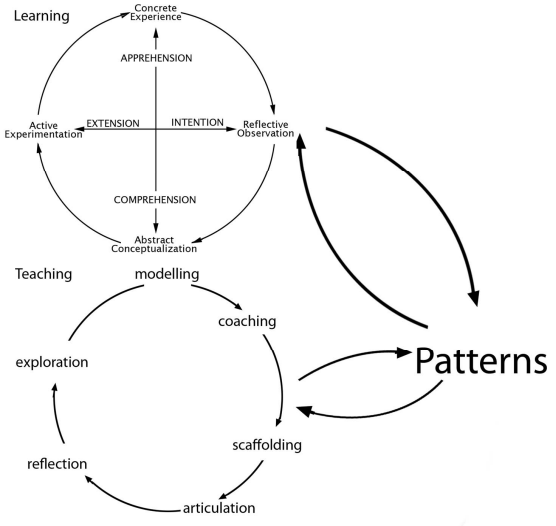

Figure 2: Kolb's experiential learning cycle [8] and Chee's constructivist teaching cycle [3] inform the patterns which in turn inform the courseware.

For the first set of cards, the focus was on the design of an internet e-learning forum. The elements outlined on the design cards were firstly identified by examining the

three e-learning forums and capturing what was seen. Each design element (e.g. menu navigation, threaded discussion, student login, bread crumb links etc.) was analysed using the Function-Behaviour-Structure framework [6] as an ontology to describe a design work with the focus being on the *structural elements* of the design.

The Function-Behaviour-Structure ontology describes the relation between the function of a design element, (i.e. the interaction and pedagogic functions), with the courseware's behaviour (i.e. how it performs a function) with the structural element (i.e. the visible elements seen on screen). This analysis was helpful in defining the design and pedagogical elements to be included in the cards. (See Table 1). The fronts of the design cards display the *structural elements* of an e-learning forum. (See Figure 3.)

Table 1: Examples of design card analysis using the FBS framework.

Function	Behaviour	Structure
Allows users to see their path from the main login page	Allows user to navigate up the site hierarchy seeing where they have been.	Bread crumb links
Allows user to post a new message.	User inputs data to be saved in forum database.	New message page
Displays links to main areas of course site	Allows users to navigate to the main site areas.	Menu navigation
Displays a list of what users are currently logged into forum.	Accesses login information from the database to see what users are currently logged in.	Online status display

What resulted was a set of 22 design cards that could be used to create a hierarchy similar to a flowchart. By creating this hierarchy the writer is able to recreate the information architecture of the internet forum. In making the design structure clear, the writer is then able to determine the areas where they see pedagogy taking place.

Table 2: Examples of pedagogy card analysis using the FBS framework.

Function	Behaviour	Structure
Make discussion objectives clear	Avoids confusion as to discussion task	Moderator posts an initial outline of discussion objectives.
Ask open ended questions	Allows for student Articulation	Moderator posts questions that must be elaborated on.
Encourage social interaction	Allows for social learning	Moderator allows and encourages off-topic social posts

Using principles taken from the primers on the two pedagogic theories, along with teaching practices and best practice outlined in the peer-reviewed literature, an additional set of 20 pedagogy cards for a forum was developed. The pedagogy included elements based on experiential learning theory, e.g. reflection/reflective observation, abstract conceptualization etc. and elements based on constructivism, e.g. scaffolding, modelling, articulation, etc. as well as forum specific pedagogies such as "Ensure each message has a reply", "Create a calm and friendly atmosphere" and so forth. (See Figure 2.)

The FBS framework was again used, this time with the focus on the *function* of the pedagogical elements. (See Table 2). In this case the pedagogy cards displayed the *function* of the FBS analysis, as the structure (i.e. how the pedagogy is realised on screen) is variable.

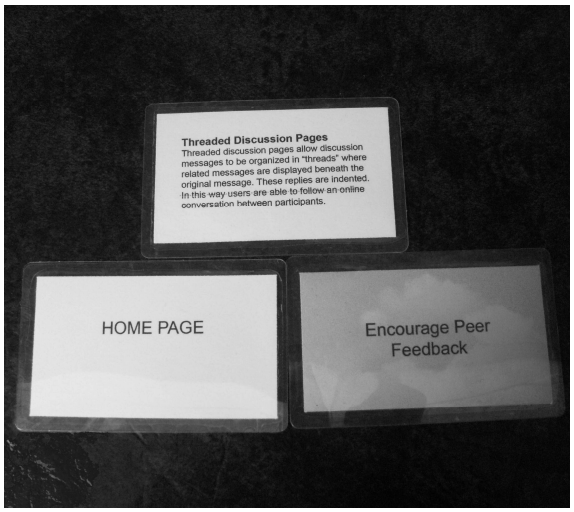

Figure 3: Design and pedagogy cards and glossary.

Once a hierarchy is created with the design cards, the pattern writer finds areas in the example e-learning forum where they see pedagogy taking place. The pedagogy cards help identify and clarify some the types of teaching and learning that are used by practitioners, based on the two learning theories. The writer then places the appropriate pedagogy card in the corresponding area in the design card hierarchy.

A hierarchy linking design with pedagogy is thereby developed for each of three online e-learning forums. The final structure is recorded, using a digital camera. Using these images as reference, the pattern writer reflects on the hierarchies and develops a single hierarchy based on design and pedagogical elements that are generic – those that are seen again and again. The process allows the writer to apply the knowledge gained from the real e-learning forum examples into a model which only uses generic elements. This final conceptual hierarchy is subsequently used to help the writer to create the "design for pedagogy" pattern. (See Figure 4.)

The design cards in the final hierarchy are used in the 'Solution' area of the pattern. The pedagogy cards are used in the 'Teaching Strategies' section. In this way the teaching strategies are linked with the design. As the cards represent the design of an internet e-learning forum in a modular fashion, appropriate design element cards can be distilled into a "design for pedagogy" pattern itself. In this way an entire "design for pedagogy" pattern language for e-learning can be developed.

The use of the "pattern pack" follows an experiential learning model. The primers, peer-reviewed literature and forum examples provide the concrete experience for pattern writers. Analysis of each of the three e-learning forum examples and the creation of the hierarchies linking pedagogy with design encourage reflective observation. The process of creating a unique conceptual hierarchy of frequently seen design and pedagogical elements, and then using these elements to write the pattern completes the cycle. These employ abstract conceptualization, or the formulation of new theories, and then put those theories into practice.

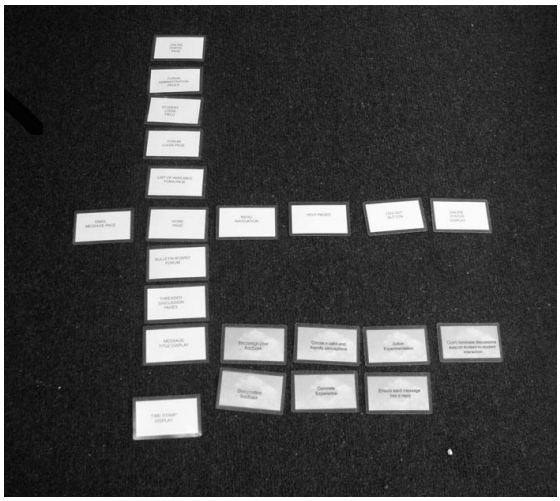

Figure 4: A card hierarchy.

The 'empty template' document was changed to incorporate the pattern name and problem statement, so as to make the task unambiguous. Examples of associated pattern titles were also included, as design patterns are difficult to evaluate on their own, and should be encapsulated in a pattern language. [1] As this pattern language is not complete, it was felt that examples of smaller and larger "design for pedagogy" pattern titles should be included, as an indication of future work.

The cards, brochure, CD containing peer reviewed literature, internet forums to be examined and a glossary were placed in a custom-made brief case. Initially the cards were given magnetic backs so that they could be used on a whiteboard, along with a set of whiteboard markers, so the writers could create lines between the design elements to link them together.

3.5 Piloting the "pattern pack"

The "pattern pack" was then piloted by the first pattern writer. The feedback was very positive. The task of writing the pattern was much easier and was made much clearer. The resulting pattern was on topic and focused on an e-learning forum, the "pattern pack" was eliciting the desired results.

The writer did state, however, that reading the peer-reviewed literature was very time consuming and was continuing to confuse the task. Reading the literature consumed approximately three and a half hours of the research time. The participant suggested that the important elements of the literature should be distilled into an executive summary. Summarizing would reduce the time required to complete the entire task. It would also focus the readings and keep them on-topic. The entire process took over eight hours at this pilot stage. The magnetic strips on the cards were not deemed necessary, as the adhesive was not effective and it was easier just to lay the cards out on a table, or on the floor.

The participant also stated that the entire process was tiring and suggested that it be broken down into two sessions: one that involved completing the readings and the card hierarchies and one writing the pattern. Being a trained cognitive psychologist, the participant stated that this would reduce the cognitive load on the pattern writers.

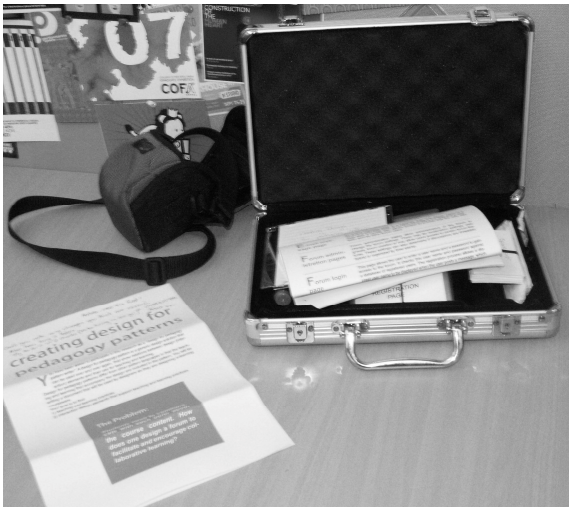

Figure 5: The pattern pack.

Taking these comments into account, an executive summary was written, distilling out the relevant main points of the peer-reviewed literature, the brochure was updated to encourage a two stage process, and the fifth pilot study was undertaken.

The fifth pattern writing pilot was completed by a participant who was also the moderator of an online e-learning forum. The task was completed in less than four hours, in two separate sessions - a halving of the time of the previous pilot. The participant enjoyed using the "pattern pack" and found the process clear and easy to use. This writer also suggested that the magnetic

strips were unnecessary and that the individual card glossaries could be reproduced on the back of each card. The pattern produced was on topic and clearly linked the design elements for an e-learning forum with the teaching and learning solutions.

These changes have been incorporated into the "pattern pack" and it is currently being used to create "design for pedagogy" patterns for e-learning forums.

4. CONCLUSION

By using a tool that takes an experiential approach in the development of "design for pedagogy" patterns for e-learning the cognitive load for the pattern writers has been alleviated. It reduces the complexity of the task and allows the research participants to quickly learn how to write the pattern. The tool allows the writers to link pedagogical theories with the design of an e-learning forum in a clear and unambiguous way and is producing the consistent results required for our study.

Future work would lead to the modularization and expansion of the pattern pack to include card sets for different problem statements and associated screen designs. These expansion packs would be specific to each problem solution, but would contain core cards that are common to all e-learning, such as menu navigation, breadcrumb links, student login, as well as the pedagogical elements encapsulated within experiential learning and constructivist theories. As pattern languages are designed to be modular, individual design cards could also be the subject of a "design for pedagogy" pattern, thus forming an integrated and complete pattern language.

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