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Embedding design patterns in a methodology for a design science of e-Learning

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Abstract

The discourse of research and practice in e-learning has been dominated by two extremes. On one hand, ethereal abstractions, which provide sound principles but do not lend themselves to implementation. On the other hand, detailed anecdotes which provide fascinating insights but pose a challenge to generalization. The void in between these two extremes calls for representations which capture transferable and modular elements of design knowledge.

Design patterns originated as a form for democratizing design knowledge by exposing the timeless principles at the heart of expert knowledge, and making them accessible to all. They hold a promise to redress the design divide (Mor & Winters, 2008) in e-learning: the unequal distribution of knowledge of how to effectively design and use technology. Design patterns appear to be ideally suited to the role of enabling design-level conversation across the disciplines involved in e-learning. Yet, in order to fulfill this role, we need to develop scientifically sound and pragmatically relevant methodologies for eliciting, developing, validating and utilizing design patterns and pattern languages.

This chapter argues for a design science paradigm of e-learning, and offers a pattern-based methodological framework for such a paradigm. As a concrete manifestation of the framework, I present a pattern language for collaborative reflection and participatory design workshops, which has been developed for and used by several e-learning design research projects.

Embedding Design Patterns in a Methodology for a Design Science of e-Learning

This volume examines the role, and potential role, of design patterns and associated approaches in the field of e-learning. The current chapter positions design pattern approaches to e-learning within a larger tradition of a design paradigm for educational research. The last couple of decades have witnessed a growing trend towards design based research in education, and e-learning in particular (Barab & Squire, 2004; Barab, Thomas, Dodge, Squire and Newell, 2004; Bell, Hoadley and Linn, 2004; Béguin, 2003; Brown, 1992; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Collins, 1992; Collins, Joseph, & Bielaczyc, 2004; Edelson, 2002; Lesh and Sriraman, 2005; O'Donnell, 2004; Reeves, 2006; Sandoval and Bell, 2004; Wittmann, 1995). Design based approaches focus on the process of developing innovative tools and activities as means of understanding learning and advancing educational practice. While this trend has moved towards centre stage in recent years, its roots go back to the 1960s.

Yet, when I try to introduce this perspective to my peers, practitioners and academics alike, I often find myself struggling with the basic definition of design. Christopher Alexander defines design as: “The process of inventing physical things which display new physical order, organization, form, in response to function” (Alexander, 1964, p.1). Middleton et al. characterize the activity of design as “a subtle but complex interaction between the designer and contextual constraints and is accomplished by proposing the form of an artifact, system or process, which in turn drives its behaviour, which in turn can be compared with its desired function” (2008, p. 22, original emphasis). Herbert Simon summarises: “everyone designs who devises courses of action aimed at changing existing situations into desired ones” (Simon, 1969, p 129).

e-learning is concerned with bringing about change in learners’ knowledge by using technology to enrich the social and individual environment of learning. Over the last few

decades, many studies have shown a positive correlation between the use of technology and attainment in mathematics (Wenglinsky, 2005; 1998; Kulik, 2003; 1994). Yet most of these studies emphasize that this link is far from universal. It is contingent on the details of the design of technology, as much as on the educational activities in which it is embedded. For example, Wenglinsky (1988) found that the use of simulation and higher order thinking skills software gave students an advantage of up to 15 weeks over the control group, but students who used drill and practice software performed worse than students who did not. In view of such findings, the role of research in e-learning is to identify how technology could be designed to promote given educational goals.

Many scientific disciplines turn their attention to questions of learning: cognitive and developmental psychology, linguistics, neurology and computer science, to name a few. The science of education is distinguished by its focus on how learning is induced and directed to a specific agenda. Diana Laurillard identifies the key challenge for educational research as "how to identify and provide what it takes to learn" (Laurillard, 2008, p 140). This distinction identifies educational sciences as the study of designed learning.

Herbert Simon (1969) distinguishes between the natural sciences and the sciences of the artificial. While the former have been the flagships of intellectual activity since the days of Newton, the latter are habitually suppressed as ‘practical’ sciences or ‘vocational arts’. Yet most of our lives are situated amidst the artificial. At the core of the study of the artificial, Simon places the science of design. He asserts that design thinking is a defining feature of the human mind. Whether driven by survival instincts or by intricate desires, we are continuously engaged with the problem of manifesting desired situations under the constraints imposed by our environment. Thus –

"... the proper study of mankind is the science of design, not only as the professional component of a technical education but as a core discipline for every liberally educated person" (ibid, p 159)

Simon's (1969) concept of design science entails more than a shift in the subject of study. It calls for a change in scientific agenda, or more broadly what Kelly et al (2008) call the commissive space: the substrate of explicit and implicit rules and assumptions which bind the discourse of a scientific community. Whereas natural science is concerned with what is, design science asks what ought to be. As Kelly et al (2008) argue, "a central question for educational research is how to design interventions that move beyond 'what is?' or confirming 'what works?' to designing 'what strategy or intervention might work better?'" (p. 3). When shifting our focus from engineering to social subjects – such as learning mathematics – the value aspect of design sciences becomes salient. Arguably, while other sciences ask how humans learn, the study of education is concerned with how their learning may be improved and directed. The questions of education, by their imperative nature, are evidently derived from the observers' (often implicit) ethical or political agenda. Reeves, Herrington and Oliver (2005) go further in claiming that a "realist" approach is fundamentally unsuitable for studying artificial phenomena such as education. Such an approach would assume that the objects under observation are governed by immutable laws of nature, whereas the raison d'être of artificial systems is human intentions, and by extension their values and beliefs. The same intentions, values and beliefs motivate researchers investigating these systems, and ignoring them would create a dissonance.

Juuti and Lavonen (2006) identify pragmatism (in the sense of Peirce, 1935) as a philosophical foundation for DBR. "The goal of these researchers, educators, and designers moves beyond offering explanations *of*, and onto designing interventions *for*. In fact, and consistent with pragmatists such as Dewey, Pierce, and James, to some degree it is the latter

functional constraint that constitutes what is a useful explanation *of*." (Barab and Kirshner, 2001:11; original emphasis). Such a stance sees knowledge as instrumental, its worth measured as a derivative of the action it engenders. The tension between Pragmatism and Purism is familiar to the educational sciences. To what extent are we driven by a pure quest for knowledge, and to what extent are we committed to influencing educational practice? If we see contribution to good practice as a primary goal, then the outputs of our research should have direct bearing on it. This argument is echoed in the call for a socially responsible study of education (Reeves, Herrington and Oliver, 2005). The authors argue that a study of education must be socially relevant, and in order to do that is should not focus on how education works, but on how to make it work better. It should be measured by its practical impact as well as its disciplinary rigor.

One corollary of this stance is a flexibility and pluralism in theoretical and methodological choices. Design research assumes that more than one theory may be required to describe, explain, or predict a single phenomenon (Kelly at al., 2004). Since the primary commitment is towards action, design science will prioritize a comprehensive and proactive understanding of the situation over theoretical aesthetics. Lesh et al. (2004:138) adamantly reject the "the naïve wishes of those who hope to use design science as a methodology for translating (a single) theory into practice" and "the naïve claims … that each research project should be based on (a single) theory", arguing that design science is inherently multidisciplinary.

Analytical science proceeds by decomposing complex problems into simpler ones and then synthesizing the results into comprehensive systems of knowledge. Design science is interested in purpose, intent and the shaping of the world to these ends. Therefore, Simon proposes function as the appropriate axis of decomposition (Mor & Winters 2007).

Simon (1969) characterizes the subjects examined by design science as complex man-made systems. Lesh and Sriraman (2005) suggest that this characterization finds a perfect match in the field of education. Ann Brown (1992) highlights the complexity of classroom situations. Similarly, Hoadlay (2004) characterizes educational settings as dominated by multitudinous interdependent variables that would be hard to control in randomized experiments. Lesh, Kelly & Yoon (2008) suggest that mathematics education occurs in complex systems – involving multiple agents, partially conflicting goals, feedback loops, second-order effects and emergent properties. Hoadley (2004) argues that under these conditions, the premises of randomized control experiments are violated, and the results of standard experimental results are at least hard to interpret and at worst meaningless and misleading.

A design approach to e-learning research is inherently amenable to synergy with other paradigms. It borrows methods and results from other fields insofar as these can inform the design process. The complexity of the experimental situations and the difficulties in extracting controlled data demand that methodological tools be selected, adjusted and calibrated per case. Design methods can also be utilized in studies where the dominant paradigm is derived from a different tradition, as a means of testing specific conjectures.

Towards a Model of Design Knowledge in e-learning

The product of design science should be the systematization of design knowledge. In light of the observations above, this chapter proposes a characterization of design knowledge in e-learning as:

• *Problem driven, solution oriented, value laden:* design is always concerned with "changing existing situations into desired ones". Thus, design knowledge always departs from an undesired situation, i.e. a problem, and aims to move to a desired one, i.e. a solution. The ascription of desirability measures to world states is a matter of values. This is evident in

the case of e-learning, which is always directed towards change: conceptual, behavioral and social.

• *Situated in context:* the orientation towards states of the world also entails that the specifics of the circumstances to which an act or product of design apply are crucial. Problems and solutions are only valid with respect to a particular context, and that context needs to be articulated. Indeed, the field of e-learning is often partitioned by context: primary vs. secondary or tertiary, formal or informal, etc.

• *Holistic (inherently inter-disciplinary):* a focus on solving problems entails attention to all aspects of the issues under consideration. When the primary axis of decomposition is functional, it cuts across structural distinctions. Problems are dissected into sub-problems, but might retain the structural character of the whole. Thus, for example, the problem of designing an online course can be decomposed into the design of separate sessions, but each one will still need to consider social, cognitive and pedagogical factors.

The goals of e-learning are ambitious, and its challenges complex. Design research offers a sophisticated response to these challenges, but this sophistication makes it hard to communicate. This difficulty is amplified by the shortage of clear consensual methodological frameworks, as noted by many leaders in the field. Internal critics of the paradigm have called for a discussion of its commissive space and argumentative grammar. The former refers to the explicit and implicit rules and assumptions which bound the discourse of a scientific community, and the latter to the logical system by which claims are presented and justified, independently of their content. Together, these contribute to the epistemic infrastructure of the field. Some desirable features of such an infrastructure emerge from the discussion:

• *Accessibility:* the arguments made by researchers should be readable by the scientific community, both the immediate and the broader scope of neighboring fields, as

well as practitioners, and policy makers. All these parties should be able to judge the validity of claims and interpret the results to their needs.

• *Transparency and traceability:* the full cycle of a design study should be observable by an external reviewer, and most importantly the path that leads from theory to conjecture through experience and back to theory.

• *Expressiveness:* the forms used for communicating design research should allow for the articulation of all that is needed to support the above requirements. They need to be able to capture process and product, connecting personal experience and generic abstractions.

• *Functional-pragmatist orientation:* the mechanisms used to organize and communicate knowledge in the design science of e-learning need to be aligned with the nature of this knowledge. Given the pragmatist foundations and functional axis of design knowledge, the research community needs means for organizing this knowledge accordingly. For example, indexing findings by the problems they solve more than by the means they use to do so, by the conditions under which they are relevant more than by their academic heritage.

• *Cumulativity:* finally, the forms of presenting claims and arguments need to afford easy aggregation of knowledge, building new results on the basis of prior art. At the same time, this demand needs to be balanced with an acknowledgement of individual and local voice, creativity and the uniqueness of any given human situation.

Towards a Methodological Framework

Design approaches to educational sciences project a young and vibrant research tradition, stemming from multiple roots and evolving simultaneously in multiple locations. Nevertheless, a review of the field identifies the emergence of shared practices and pockets of expertise. Among the common methodological characteristics are a dual focus on practical and theoretical contributions, a highly interventional and agile attitude, and a cycle of

iterative research. This cycle includes phases of theory, design, implementation, execution (experiment / practice), articulation of experience, interpretation, evaluation and analysis, and feedback to both theory and design. The products of this cycle are validation or critique of existing theory, evidence regarding the effectiveness of artifacts and practices in well-defined settings, and innovations in practice and theory. A frequent by-product of research is the synthesis of multiple frameworks.

Common Cycles of Scientific Process

DBR is commonly described as a cyclic process. At the core of this process is the design experiment, which oscillates between theoretical and practical innovations. Most authors situate the cycle of design experiment within the context of their research setting. However, when the various descriptions are compared and the contextual details blurred, a stable image emerges (Figure 1).

As in most scientific endeavors, a design experiment would typically start from a theoretical stance, which the researcher would project into a particular problem domain to derive a conjecture. This conjecture is examined by designing artifacts (tools and practices) that embody it. The artifacts are implemented and used in action, ideally in a realistic educational setting. The researcher collects evidence of the successes and tensions arising from the use of the artifacts, with respect to the learning aims. This evidence is interpreted, analyzed and evaluated, and the results fed back into a revised theory.

Although scientific enquiry often stems from a theoretical stance, the cyclic nature of design experiments suggests that other options are just as valid, e.g. a study led by a teacher and originating from her classroom experience.

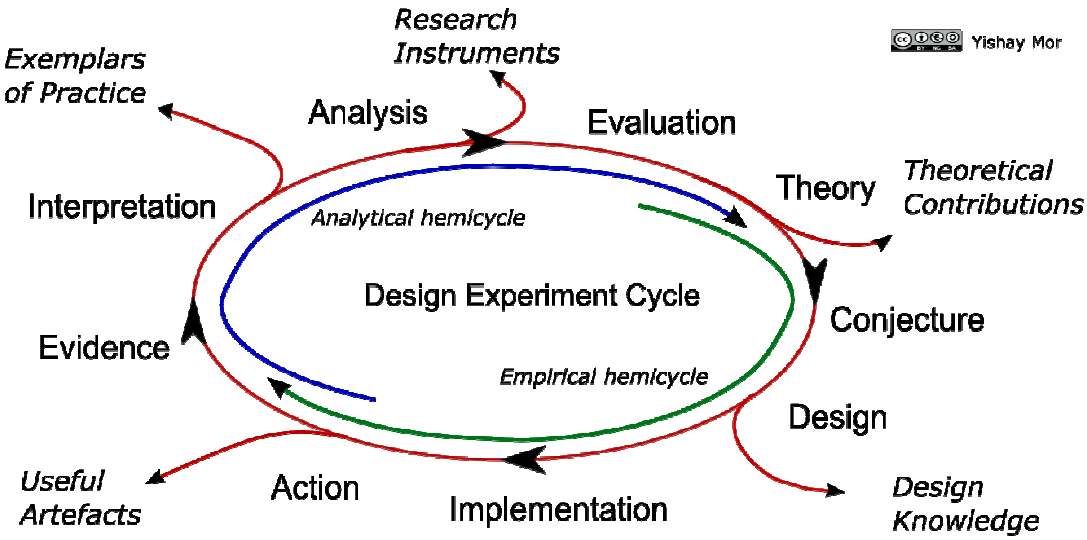

Figure 1: the design experiment cycle. Research conjectures are derived from theory, and explored by design, implementation and field testing of new artefacts (tools and activities). The evidence from the field trials is collected, interpreted, analysed and evaluated – feeding back into theory and on to the next iteration. This cycle is embedded in the broader framework described in Error! Reference source not found.**.**

A design science of education pursues a double-edged agenda to produce theoretical as well as practical innovations. Figure 1 illustrates how these aims are reflected in the outputs derived from the different phases in the cycle. The empirical hemicycle proceeds from theory to action through design and implementation, ultimately producing artifacts (technological tools, curricular materials, teaching methods, etc.) which should be useful for practitioners operating in similar situations. The evidence collected from the action phase and its interpretation produce exemplars of practice, which provide practitioners with valuable insights as to how to make effective use of the artifacts. As noted by Schwartz et al. (2008), the study of innovative artifacts demands innovative research instruments. The development of such instruments is a likely by-product of the interpretation and evaluation phases. Some of these instruments are specific to the situation being studied, but others are useful for peers studying similar situations.

The pinnacle of the analytical hemicycle, starting from the end of the action phase, is the contribution to an updated theoretical stance. This contribution has two facets: a reflection

on the underlying theory, validating or challenging the premises of the experiment, and local theories and ontological (diSessa and Cobb, 2004) or epistemic innovations (Schwartz et al., 2008) referring to the specific problem domain. These theoretical innovations feed back into the design process, along with direct input from the analytical outcomes. The outputs of the design phase are representations of design knowledge derived by projecting the theory into the problem domain, and adjusteding to meet the pragmatic constraints imposed by the learning context. Given appropriate representations, such design knowledge should be valuable beyond the unique situation being studied.

Design experiments are embedded in a broader cycle of design research (Middleton et al., 2008; Gravemeijer and Cobb, 2006; Pratt, 1988). This cycle include a preliminary phase where the research problem is framed, an empirical phase consisting of an iterative design experiment, like that described above, and a longitudinal reflective phase of retrospective analysis (Figure 2).

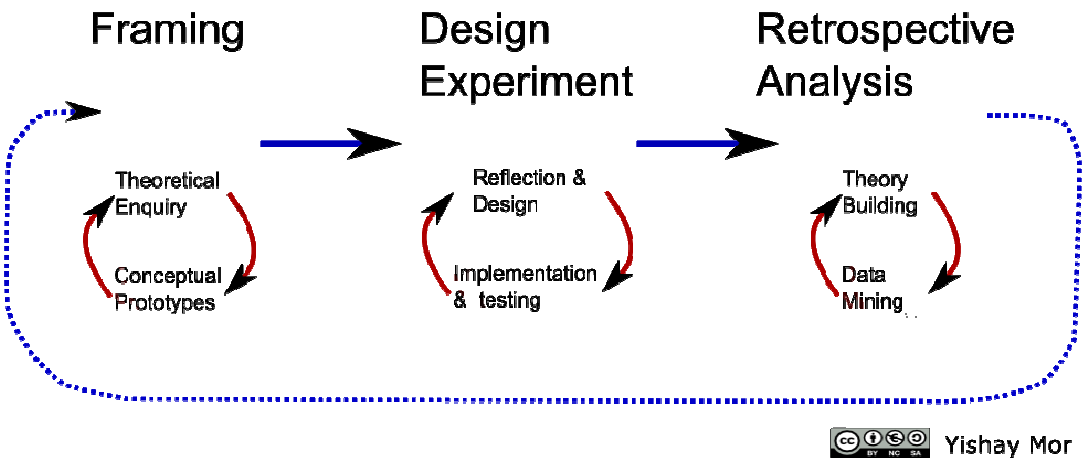

Figure 2: design research meta-cycle. The life cycle of a design study begins with a framing phase, iterating between theoretical enquiry and prototyping. This is followed by multiple iterations of the design experiment cycle described in Figure 2. The study is concluded by a retrospective analysis phase, considering data from across the multiple empirical iterations.

The framing and retrospective analysis phases are by and large context independent; they are conducted by the researcher at the comfort of her desk and thus are not constrained

by the experimental setting. In fact, the retrospective analysis does not differ significantly in structure from similar phases in other research paradigms, although the actual sources of data and methods of analysis do. The framing phrase does reflect the unique nature of design science, in its underlying premise of the link between knowledge representation and artefacts. This principle, which underlies many of the research questions, also motivates the researchers' own process of understanding and interpreting theory. The framing phase oscillates between reviewing existing literature for theoretical concepts and reifying these concepts in quick prototypes. Such prototypes are primarily used as a means of understanding the theory, as a form of "armchair experiments", and would most often be discarded before the next phase.

The design experiment phase iterates along the path described above. The number and nature of iterations varies, but they are expected to be expansive; each iteration extends the scope or validity of the previous ones (Middleton et al, 2008). At some point the cycles of the design experiment are concluded, and the study shifts to a retrospective analysis, taking in a long perspective covering multiple iterations and calibrating with other studies. This phase is also iterative; building theories and mining the history of the project for supporting data. In reality, the boundaries between the three phases are often blurred.

Design Narratives

Design research operates "at the edge of chaos"; research settings and problems are complex, messy and often unique. This creates a challenge in terms of the replicability expected of a scientific experiment. Several authors have noted this difficulty and proposed the construct of design narratives as a means of addressing it (Bell, Hoadley and Linn, 2004; Hoadley 2002; Barab et al, 2008). The main argument in favor of design narratives is that they provide a "thick description" of the design experiment, allowing critics to assess the validity of the researchers' claims, and trace them back to evidence. At the same time, design

narratives provide sufficient contextual information for those who wish to conduct a similar experiment in proximal settings, be they fellow researchers or practitioners wishing to apply the research findings.

Design narratives are accounts of critical events from a personal, phenomenological perspective. They focus on design in the sense of problem solving, describing a problem in the chosen domain, the actions taken to resolve it and their unfolding effects. They provide an account of the history and evolution of a design over time, including the research context, the tools and activities designed, and the results of users' interactions with these. They portray the complete path leading to an educational innovation, not just its final form – including failed attempts and the modifications they espoused. Narrative, notes Hoadley (2002:454), "is only one way of making sense of design-based research" but "to really convey what happened, though, requires a story."

Despite the prevalence of the narrative form in reports of design research (Bannan-Ritland, 2003), it raises several methodological and practical issues. In the words of Shavelson et al. (2003:25), "there is nothing in narrative form that guarantees veracity". Practically, narrative accounts do not fit well into academic publication format (Reeves et al, 2005). One apparent source of methodological vagueness is the lack of upfront discussion of the narrative tools used by researchers. With a few notable exceptions (e.g. Barab et al, 2008) most studies intuitively use a narrative style of report without explicitly formulating it as a methodology. The term design narrative itself is rarely used, although many papers are in essence design narratives. Even when the form is discussed, it lacks a rigorous definition: what is the core structure of a design narrative? How are its boundaries set? How are events selected and details filtered out? How should we judge if the narrative warrants the researchers' claims?

Another source of difficulty lies within the inherent nature of narrative. In a well-crafted narrative, the message of the story is left implicit (Mor and Noss, 2007). This feature may be epistemically powerful, as it provokes the reader to infer the message and construct her own logical structure to support it. However it is incompatible with scientific discourse, which demands that the path from evidence to arguments to conclusions be exposed to peer scrutiny. The implication is that design narratives are incomplete as a scientific form, and need to be accompanied by a representation of the derived knowledge. Bell, Hoadley and Linn (2004) propose design principles (Kali, Levin-Peled and Dori, 2009), while the following section suggests design patterns. Both are structured abstractions of design knowledge. Whereas design principles are arguably self-contained, and thus more readily accessible, I find the structure of design patterns more amenable to scientific cumulativity, while at the same time retaining a sense of narrative.

Finally, it is important to remember the interpretive quality of narrative. A narrative is not a neutral recount of events; it is the outcome of the narrator's immediate attempt at making sense of events, a conjecture regarding the semantics of occurrences. Arguably, this is common to all manner of organizing evidence: the statistical analysis of a randomized experiment reflects the researchers' choice of parameters and variables. Yet in the case of statistical analysis, another researcher using the same choice of material could have produced the same result. A narrative is unique to its narrator. This subjectivity may be appropriate in design research, where the researcher is part of the phenomena, but nevertheless needs to be accounted for.

Towards a formalization of design narratives

In order for design narratives to provide an effective form of discourse for design research in education, they need to be shaped in a way that would adhere to scientific standards, acknowledge the agenda of design science, and retain the essential qualities of

narrative. This may seem a tall order, but in fact carefully designed forms and procedures for design narratives could allow us to align these forces.

A scientific standard demands a transparent audit trail from reliable data to conclusions, and a clear articulation of refutable claims. Where subjectivity is inevitable, it should be reported honestly. A design science stance dictates a functional (pragmatic) focus linked to a value dimension, attention to context and representation, and an awareness of the complexity of human situations. Narrative form entails a clear context description, a protagonist, a plot – a temporally and semantically linked sequence of events – and an implied moral. Combining these three delineates the requirements for design narratives as a scientific instrument. A design narrative should:

• Tell the story of an aspect of a design experiment in the voice of the researcher conducting it.

• Clearly delineate the context of the design experiment and its educational goals.

• Present a documented record of the researchers' actions and their effect.

• Incorporate data collected and processed in appropriate scientific methods.

• Decouple reporting events from their evaluation and reflection.

• Be followed by a statement of the derived conclusions and the warrants linking them back to the narrative.

The conclusion derived from a design narrative is a design claim, i.e. a statement about how to achieve a particular educational effect in a particular context. This claim is external to the design narrative, but it guides the narrator's choice of which events to include in the narrative. Consequently, there can be multiple narratives of the same experiment. All are just as valid, as long as they meet the criteria.

Bruner identifies *Canonicity and breach* as a defining quality of narrative, arguing that "for to be worth telling, a tale must be about how an implicit canonical script has been

breached...” (Bruner, 1991, p 11). In the case of design narratives this implies they should either capture a new solution to a known problem, or a new problem. The uniqueness of the single narrative is complimented by its *Accrual* (Bruner, 1991): the manner in which it connects with other narratives to form a coherent body of knowledge.

Bruner (1991) enumerates ten qualities of narrative: Narrative diachronicity, Particularity, Intentional state entailment, Hermeneutic composability, Canonicity and breach, Referentiality, Genericness, Normativeness, Context sensitivity and negotiability and Narrative accrual (Nardi, 2007; Sinclair, Healy and Sales, 2009). Canonicity and breach and Accrual have been mentioned above as criteria for delineating the whole set of narratives. The others serve as guidelines in the construction of the narratives themselves. These principles require adaptation in order to comply with the norms of scientific discourse.

The construction of design narratives is a suitable instrument for the interpretation of the raw evidence arising from the empirical actions. The resulting narratives should be useful in themselves, as exemplars for practitioners and peers. However, in terms of the design research process, they need to be processed further in the course of analysis and evaluation. Design patterns offer a paradigmatic form suitable for the analysis and evaluation of the outcomes captured in the design narratives.

The Promise of Design Patterns

The previous section raised the need for semi-formal notation to be used in conjunction with design narratives to help capture the design knowledge derived from them. Several forms have been suggested for capturing abstractions of design knowledge in education, among them design principles (Kali, Spitulnik and Linn, 2004; Kali and Ronen, 2005; Kali, 2008; 2005; Kali, Levin-Peled and Dori, 2009), scripts (Miao et al., 2005; Kobbe et at., 2007) and sequences (Dalziel, 2006). McAndrew, Goodyear and Dalziel (2006) compare a few of these. This section considers the qualities of the design pattern form, which

make it a suitable candidate for complementing design narratives as a component in an epistemic infrastructure for a design science of education.

The core of a design pattern can be seen as a local functional statement: "for problem P, under circumstances C, solution S has been known to work". Such a structure reads like a direct generalization of the narrative form of "something happened to someone under some circumstances", when that narrative is a record of a problem solving effort – in other words, a design narrative.

By forefronting the problem, the structure of a design pattern acknowledges the functional axis of decomposition and the value dimension, identified in section 2.2 as tenets of design science emerging from Herbert Simon's work. These features are further expressed in the links between patterns, inherent to the pattern format. Christopher Alexander (1979) explicitly highlights what he calls the "moral" and "generic" qualities of pattern languages, and asks whether these are present in the way the idea has been appropriated by computer science.

Complexity and context-dependence are characteristic of design based research in education. The design patterns approach is sensitive to these issues, and reflects them by restricting solution statements to compact classes of problems in clearly delineated contexts. In this sense, a design pattern can be seen as a representation of a local theory or a modular ontological innovation, to rephrase diSessa and Cobb (2004).

The modest nature of design patterns can also be seen as an expression of a pragmatist philosophy, suggested by several authors as the foundation of design-based research. This philosophy supports the notion of ontological innovations, which diSessa and Cobb (2004) derive from the need to address the gap between practice and theory. Design patterns were described as abstractions of expert knowledge; they generalize from successful practice without detaching from its context. As such, they offer a two-way bridge between practice

and theory: opening practical wisdom to theoretical scrutiny and allowing theory to be projected into practice. A pragmatist perspective leads many design researchers to seek holistic frameworks, calling on diverse mixes of theories and methodologies in the service of comprehensive solutions. The core structure of design patterns is conducive to such an approach, as it demands precision in description of problem, context and solution, and subjects to them theory and evidence.

The functional, holistic, compact form of design patterns also makes them promising candidates to serve as boundary objects in design-level interdisciplinary discussions. Following Bowker and Star (1999), there is a growing acknowledgement that practitioners from different communities interfacing in a joint enterprise may inhibit distinct activity systems (Tuomi-Gröhn and Engeström, 2003). Consequently, the conceptual spaces that these communities form around the joint enterprise would diverge, impeding communication and coordinated resolution of emerging issues. Boundary objects are artifacts that might help to calibrate the diverse perspectives towards a shared canon of knowledge situated in common problems (Noss et al., 2007; Bakker et al. 2006). Educational design is an inherently multi-disciplinary activity. An effective study of design – whether scientific or practical – demands linguistic and symbolic tools which will enable boundary crossing and facilitate discussion between the various interested communities, to ensure that solutions and analysis take into account all factors they deem significant. Design patterns – if carefully crafted as products of interdisciplinary discussion – may emerge as such boundary objects.

Finally, design patterns have been used extensively in object-oriented programming for over a decade. Apart from their popularity amongst software designers, recent studies indicate measurable benefits in terms of cognitive load (Kolfschoten et al., 2006), software quality (Guéhéneuc et al., 2006) and system maintenance (Prechelt et al. 2001). Evaluating the effect of design patterns is neither trivial nor conclusive; as noted by Khomh and

Guéhéneuc (2008) they can also have negative consequences. Furthermore, it would be irresponsible to suggest a simple analogy from software development to education. Nevertheless, such results do raise the possibility of added value for both educational design as a practice and its scientific study.

A Pattern Language for Collaborative Reflection and Participatory Design

The theoretical and methodological framework presented above may be a bit of a mouthful for busy practitioners – teachers, learning technologists or software developers. Nevertheless, it can be used as the foundation for more lightweight approaches.

Over the last few years, I have been involved in developing participatory methodologies for practical patterns; Practical in the sense of "related to practice", and Participatory in the sense that they are recorded by the practitioners from their own experience. These methodologies originated in a series of practitioner collaborative reflection workshops, conducted in the course of the Learning Patterns project. They have since been used and refined by the Pattern Language Network project, and adapted to individual research in support of my personal research.

These workshops brought together teachers, content and software designers and academics to contemplate their use of games in support of learning, compare cases and distil generalisable design postulates. The outcomes were formalized as design patterns and linked to form a draft pattern language. Inter alia, the techniques used to facilitate these workshops solidified and a methodology took shape (Mor & Winters, 2008; Winters, Mor and Pratt, forthcoming). This methodology was supported by a bespoke web-based collaboration system which we designed. It also led us to a broader reflection on design approaches to educational research (Mor & Winters, 2007) and participatory design in particular (Winters & Mor, 2008).

The methodology and the supporting tools provided the basis for the work of the Pattern Language Network project (Finlay et al, 2009). During this project we expanded and elaborated the methodology, and used it to facilitate several themed series of workshops. These resulted in collection of cases and patterns in particular domains, such as formative e-assessment (Pachler et al, forthcoming) and digital identity (Warburton & Hatzipanagos, forthcoming).

The methodology includes both an overall framework for single and multiple workshops and a "toolkit" of specific activities used in their course. This methodology is presented in its own terms: as a pattern language.

Structure of the Language

At the heart of the methodology is the PARTICIPATORY PATTERN WORKSHOPS pattern, which describes the interrelation between three COLLABORATIVE REFLECTION WORKSHOPS: a DESIGN NARRATIVES WORKSHOP, a DESIGN PATTERNS WORKSHOP and a DESIGN SCENARIOS WORKSHOP. Apart from these, the language includes a "toolkit" of support patterns, which address critical points in the process or specific recurring needs.

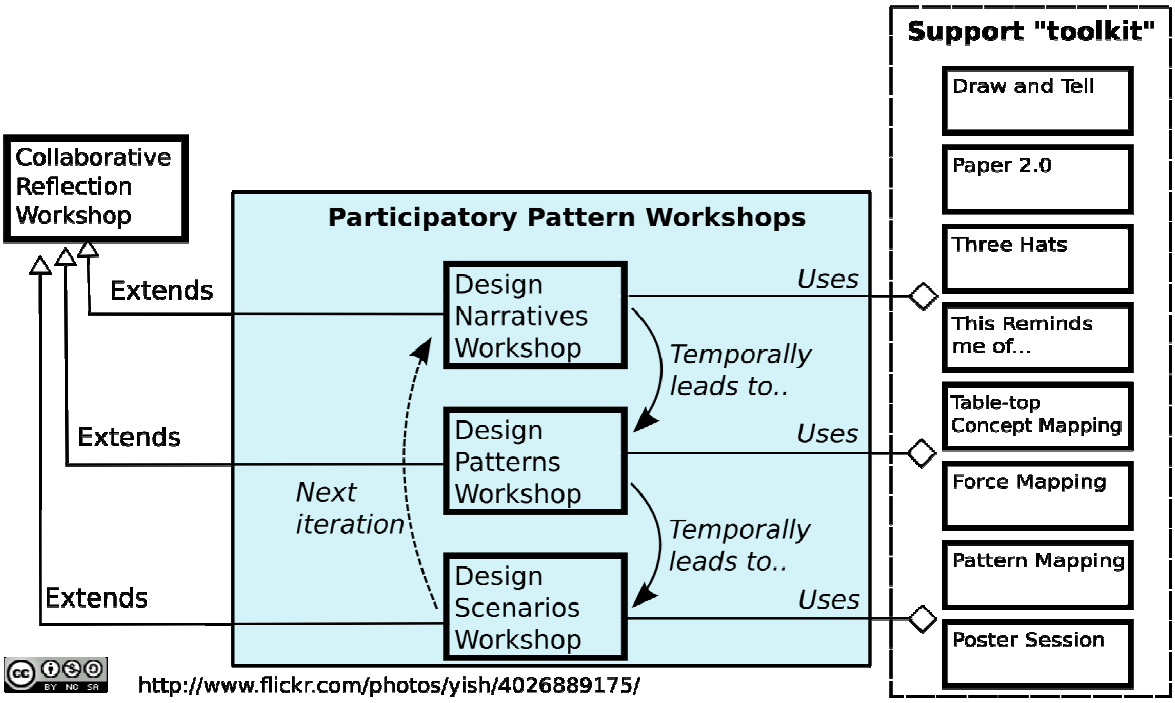

Figure 3. Map of patterns in the language.

Workshop patterns

The main workshop patterns are the core of the methodology. They are described in detail below.

PARTICIPATORY PATTERN WORKSHOPS	The *Participatory Methodology for Practical Design Patterns* was developed by the Learning Patterns project and refined by the Planet (Pattern Language Network) project. It is a process by which communities of practitioners can collaboratively reflect on the challenges they face and the methods for addressing them. The outcome of the process is a set of Design narratives, design patterns and future scenarios situated in a particular domain of practice. At the heart of this process are three COLLABORATIVE REFLECTION WORKSHOPS.
COLLABORATIVE REFLECTION WORKSHOP	Elicit design knowledge by sharing, analysing and scrutinising personal experiences. This is the base structure, the "super-pattern" for all workshops.

DESIGN NARRATIVES WORKSHOP	Engender collaborative reflection among practitioners by a structured process of sharing stories.
DESIGN PATTERNS WORKSHOP	Use comparative analysis of Design narratives to define proto-patterns[1]. Elaborate the proto-patterns to alpha-state patterns[2], by articulating the problem, context, core of the solution and related patterns.
DESIGN SCENARIOS WORKSHOP	Put patterns to the test by applying them to novel problems in real contexts.

Table 1: Workshop patterns

Support toolkit patterns

The support patterns are invoked as needed in the course of the various workshops. Due to space limitations, they are provided as "thumbnails" only.

DRAW AND TELL	In a conversational activity, start off by a structured task in which participants represent a personal reflection in drawing and present it to the group. The subject of the task should be related to the theme of discussion at an abstract level so that it inspires the ensuing conversation.
PAPER 2.0	Paper is a wonderful technology, but web2.0 has some nice features. Why not combine the best of both?
THREE HATS	I tell a story, you write it down, and she will present it.

[1] Proto-patterns represent the first iteration of a pattern that captures the basic elements of the problem, solution and context.

[2] Alpha-state denotes patterns that have undergone refinement through a number of iterations to a state where they can be released for general use and testing by designers.

THIS REMINDS ME OF ...	Provoke collaborative reflection on a design narrative or scenario by asking peers to suggest similar stories.
TABLE-TOP CONCEPT MAPPING	Establish a shared vocabulary by negotiating a concept map of the problem domain.
FORCE MAPPING	Alexander defines a pattern as equivalent to a diagram resolving a set of interacting and conflicting forces. Many pattern authors see the articulation of forces and relations as key to the problem description. Others claim that the notion of forces causes confusion, and is an obstacle to novice pattern writers. To resolve this conflict, groups of authors are asked to represent forces as icons and draw the links between them.
PATTERN MAPPING	Groups create and compare visual maps of an emerging pattern language.
POSTER SESSION	At the end of a group activity, each group produces a poster presenting its work and hangs it on the wall. Each group in turn stands before its poster and presents its work to the rest.

Table 2: Support toolkit patterns

PARTICIPATORY PATTERN WORKSHOPS

The Participatory Methodology for Practical Design Patterns is a process by which communities of practitioners can collaboratively reflect on the challenges they face and the methods for addressing them. The outcome of the process is a set of Design narratives, design patterns and future scenarios situated in a particular domain of practice.

Figure 4. Sketch of a Participatory Pattern Workshop

Problem

Domains of technology-infused social practice are dominated by accelerated change. Examples of such domains appear in almost every aspect of our life: any activity that involves (digital) technology and other people is subject to the rate of technological developments on one hand and the ever-shifting social conventions, practices and norms in using technology. In such domains, the dynamics of design knowledge questions two of the fundamental assumptions behind the design pattern paradigm: timelessness and expertise. Timelessness refers to qualities of artifacts which have been refined over an extensive period of use. Expertise suggests that design knowledge has a focus of locus.

Alexander's seminal work (Alexander et al.' 1977) was focused on the design of built environment. In this domain, there are certain problems, and associated solutions, which are rooted in fundamental characteristics of human existence, and have been refined over millennia - for example, the form and location of doors and windows in a building. Architects' expertise relies on tacit knowledge of these design patterns. The agenda of the patterns movement included an attempt to democratize the design of buildings, giving

residents greater ownership over their living spaces. When the rate of change is such that new solutions are afforded and new problems emerge every day, no one person can keep apace of all changes. Expertise becomes highly distributed: an early adopter of one technology may become an expert in its use, while falling behind on other fronts. The challenge is no longer one of pushing design knowledge down from experts to laypeople. Instead, we have a much more complex problem of continuous sharing of design knowledge across networks.

In order to elicit powerful and contemporary design patterns from communities of practitioners, and make these patterns useful for broad audiences, we need a structured process of guided design-level conversation, leading participants from their personal experiences to coherent pattern languages.

Context

The methodology is aimed at interdisciplinary communities of practitioners engaged in collaborative reflection on a common theme of their practice. These can be ad-hoc communities e.g. participants in a workshop, but a sense of community is nonetheless a prerequisite, in the sense of a common commitment to an inquisitive process and a genuine attempt to establish a shared discourse.

The methodology assumes a blended setting: at its heart it is a series of workshops; co-located (on-site) meetings of 4-8 hours. In between these meetings, participants communicate and develop their ideas using an online collaborative authoring system. During co-located meetings, participants refer to the online materials or use the system for archiving their work for later reference. This system could be a standard wiki or CMS, or a bespoke tool designed to support editing and discussion of narratives, patterns and scenarios. Examples of such tools can be found at http://lp.noe-kaleidoscope.org/workspace/patterns/ and http://patternlanguagenetwork.xwiki.com.

This pattern is an “envelope” for the rest of the patterns in this paper, and the context described here is the baseline for all the others. The context descriptions of the following patterns will only include the elements specific to them.

Solution

The methodology is based on two fundamental assumptions: we are all experts, and we are all designers. This methodology utilizes narrative epistemology: practitioners are prompted to recount their experiences as design narratives, and discuss these with their peers. The construction and discussion of these narratives are scaffolded by a set of tools and activities to extract transferable and verifiable elements of design knowledge in the form of design patterns.

This methodology defines a process by which individuals and groups elicit structured design knowledge from their experience through a series of open yet directed activities. In an ideal setting, this process would have the following phases:

• Sharing expertise through structured stories of problems in the target domain and their resolution.

• Scrutinizing and refinement of these stories by guided conversation with peers.

• Comparative analysis with respect to similar cases.

• Extraction of common features across similar cases, in terms of problem, context and method of solution.

• Grouping triplets of context, problem and solution as proto-patterns.

• Articulation of problem description by collaborative mapping of forces.

• Collaborative composition of a map of key concepts emerging from the cases and the analysis.

• Articulation of alpha-state design patterns based on the proto-patterns using the vocabulary derived from the concept mapping.

• Developing these patterns to beta-state, by providing support, in the form of triangulating cases and theoretical rationale.

• Introduction of novel problems, in the form of future scenarios.

• Validating the patterns and demonstrating their use by applying them to the scenarios.

This process is realized by a series of Collaborative Reflection Workshops, typically:

1. A DESIGN NARRATIVES WORKSHOP

Engender collaborative reflection among practitioners by a structured process of sharing stories.

2. A DESIGN PATTERNS WORKSHOP

Eliciting patterns by reflecting on and comparing design narratives.

3. A DESIGN SCENARIOS WORKSHOP

Addressing validation and dissemination by applying the patterns to novel problems from real situations.

Ideally this would be a series of 3-4 full-day workshops, with 1-2 months in between. However, this process can be condensed or stretched as circumstances dictate. Needless to say, expectations should be adjusted to match the allocated resources.

COLLABORATIVE REFLECTION WORKSHOP

Elicit design knowledge by sharing, analysing and scrutinising personal experiences.

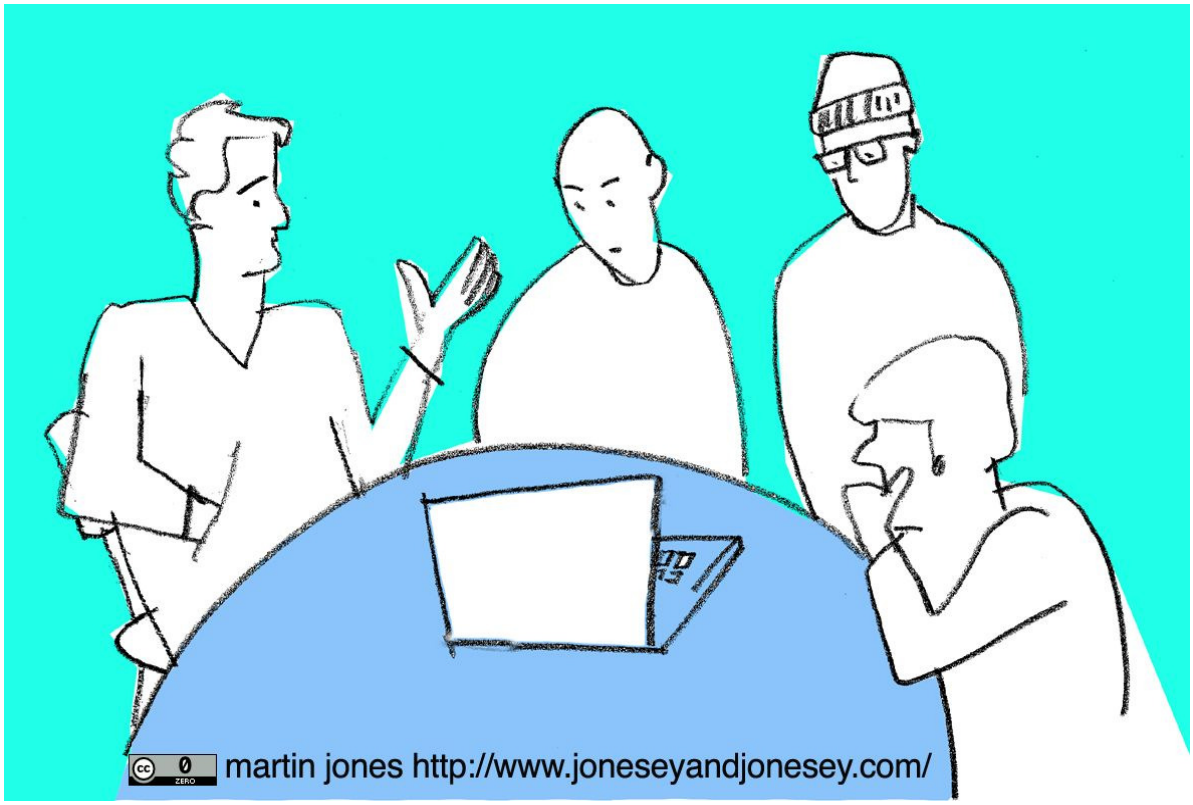

Figure 5. Sketch of a Collaborative Reflection Workshop

Problem

Technology-infused social practices produce complex and dynamic problems. Addressing such problems requires on-going design-level conversation between designers and practitioners involved in diverse aspects of the problem domain. Such a conversation is most effective when it is grounded in actual experiences, concrete problems, relevant to the participant's current work, which have been solved or are still pending solution.

In order for such a discussion to be fruitful, it needs to be open, trusting and convivial. At the same time it should be critical, focused and output-directed. These qualities tend to create conflicting forces, in particular in ad-hoc communities, which cannot rely on established norms and relationships.

Context

This pattern assumes a co-located (on-site) half to full day workshop with 20-40 participants, and with a collaborative authoring system to support a-synchronous contributions before, during and after the workshop.

It can be adapted to smaller or larger groups, and to a shorter time-frame. A cohesive community could also adapt it to a distributed location event using audio-graphic conferencing.

This pattern relates to a single workshop, either a one-off event or, preferably, part of a series. Each workshop is conducted in a venue which can host 20-40 participants for both group work and plenary discussions. Participants will typically use their laptops and the venue will supply internet access. Participants will register to the workshop several weeks in advance.

This pattern is the basis for the three workshop patterns, and all three assume a similar context. The individual context statements hereafter will only include specific expansions of this one.

Solution

Identify a theme of interest within the domain of practice. This theme should be focused enough to assume is would draw people who can benefit from each others' experiences, and wide enough to support rich examples and dilemmas.

Convene a workshop where participants work in groups to explore the selected theme through sharing personal experience.

Before the workshop

• Enlist the participants well in advance, ideally 3-4 weeks before the event.

• Establish a reliable medium of communication with all participants (e.g. a mailing list)

• Provide a tool for collaborative authoring of multi-media texts, and mark a clear space for the workshop within that space.

• Introduce the workshop in terms of aims, rationale and methods.

• Ask all participants to make a contribution:

• Contributions should follow a common theme, or answer a common question.

• They should also adhere to a common structure, realised by a template.

• Provide an example of the desired output.

• Follow-up by:

• Encouraging those who have not submitted a contribution to do so.

• Commenting on the submitted contributions, and asking authors to iterate on them.

• Pointing out links between contributions and provoking authors to comment on each other work.

On the day

Briefly present the theme, methods and objectives of the day. Introduce the first activity, and split the participants into groups.

Working in groups of 3-6, participants:

• Begin with an inspirational exposition activity, e.g. a DRAW-AND-TELL game. The aims of this activity are:

• To establish an open, honest and fearless tone of conversation.

• To provoke participants to abandon entrenched forms of discourse.

• To provide a fresh and humoristic perspective on the theme of the day.

• Each group selects a contribution of one of its members, elaborates and scrutinises it in a structured discussion, e.g. by means of a THREE-HATS discussion. Provide the groups with a list of questions to guide the discussion.

• Use a THIS REMINDS ME OF exercise to elicit comparable experiences, either from the existing repository or from participants memory.

• Use a TABLE-TOP CONCEPT MAPPING exercise to elicit key concepts and focal issues from the contributions tabled by the group (optional).

• Instruct the groups to produce a concrete artefact, which can be shared with other groups and with a broader audience, e.g. a diagram, document, or paper prototype.

Converge to a plenary, in which each group presents its work. This presentation can take the form of a POSTER SESSION. Conclude with a feedback and reflection discussion, in which participants recap their experience from the day.

After the workshop

Prompt participants to

• Publish any new contributions that emerged on the day.

• Add details and artefacts (images, illustrations, diagrams, links, etc.) to their contributions.

• Comment on the contributions, noting questions that have emerged from the discussion

DESIGN NARRATIVES WORKSHOP

Engender collaborative reflection among practitioners by a structured process of sharing stories.

Figure 6. Sketch of a Design Narratives Workshop

Problem

Schank and Abelson (1977) argue that stories about one's experiences, and the experiences of others, are the fundamental constituents of human memory, knowledge, and social communication. They call for a shift towards a functional view of knowledge, as Schank (1995) explains: “intelligence is really about understanding what has happened well enough to be able to predict when it may happen again” (p.1). Such knowledge is constructed by indexing narratives of self and others’ experiences, and mapping them to structures already in memory.

While everyone enjoys a good story, not everyone trusts their ability to tell a good story. People who base their confidence on a professional image often hesitate to share personal stories in public.

When people are induced to share stories, they tend to harness them to three interleaved goals: understanding the world in which they operate, establishing their identity, and identifying methods of problem solving ("where am I, who am I, how do I get where I want?"). In order to establish a productive design-level conversation, we need to subdue the first two and amplify the latter.

Context

This workshop will typically be the first in a series, followed by a DESIGN PATTERNS WORKSHOP and a DESIGN SCENARIOS WORKSHOP. If run as a one-off event, it would be modified to include elements of the other two workshops.

Solution

Establish a case-driven discussion of common problems and solutions in the target domain, by facilitating a COLLABORATIVE REFLECTION WORKSHOP, focused on participants' stories of their own experiences. The discussion is instigated by prompting participants to post their design narratives in a shared space. It culminates at a workshop, where the scenarios are analyzed by groups of 3-6 participants. After the workshop, participants and facilitators revisit the cases, patterns and scenarios that were discussed.

Apply the COLLABORATIVE REFLECTION WORKSHOP structure, adding:

Before the Workshop

Instruct participants to contribute a story from their own experience, using a *STARR* template:

Situation

What was the setting in which this case study occurred?

Task

What was the problem to be solved, or the intended effect?

Actions

What was done to fulfill the task?

Results

What happened? Was it a success? What contributed to the outcomes?

Reflections

What did you learn from the experience?

Here is an example of the template as a PowerPoint presentation: http://www.slideshare.net/yish/star-case-study-template. Remember to provide guidelines for 'good stories', for example http://www.slideshare.net/yish/case-study-how-to-presentation.

On the day

Provide guiding questions for the THREE HATS and THIS REMINDS ME OF … discussions, such as:

- What is the story about?
- What is it an example of?
- What was successful, what was not so successful?
- What was the critical element of design behind success?
- What was the critical contextual factor?
- When would it fail?

Notes

The use of narrative to encode knowledge rests on extensive psychological research. Bruner (1986; 1990; 1991; 1996) identified narrative as the predominant vernacular form of

representing and communicating meaning. Humans use narrative as a means of organizing their experiences and making sense of them. A narrative is always contextualized. It habitually begins with an exposition, which lays out the context: time, location, props and characters. These ideas are supported by recent findings in neuropsychology and cognitive psychology (Mar, 2004; Atance and O'Neill, 2005; Atance and Meltzoff, 2005).

DESIGN PATTERNS WORKSHOP

Use comparative analysis of Design narratives to refine candidate patterns. Elaborate the candidate patterns to full patterns, by articulating the problem, context, core of the solution and related patterns.

Figure 7. Sketch of a Design Pattern Workshop

Problem

DESIGN NARRATIVES WORKSHOPS guide practitioners in articulating problem-solving narratives from their experience. Narratives are a fundamental form of capturing and communicating knowledge. Yet they fall short in several accounts:

• The endpoint of a narrative, its central message, is always implied. In order to expose it to scrutiny it needs to be made explicit.

• Narratives are loosely structured, and thus do not lend themselves to modularisation.

• Practitioners reporting on their experience often take critical factors for granted, both in terms of the context and in terms of the key actions they took.

Design patterns provide a semi-structured form which exposes the gaps and hidden messages in the Design narratives, while eliminating superfluous detail. However, the transition from Design narratives to patterns might seem insurmountable for the uninitiated. Many pattern communities rely on "pattern scouts", experienced pattern authors who mine practitioners' stories for potential patterns. While this approach may guarantee quality, it does not scale, and it looses the intimate knowledge of a first person account.

Context

This workshop is typically a second in a series. Ideally workshop participants should have conducted a DESIGN NARRATIVES WORKSHOP prior to the event, but alternatively the two workshops can be combined to one. A community dominated by experienced software designers might choose to start from this workshop, drawing on Design narratives collected from other sources.

Solution

Facilitating a COLLABORATIVE REFLECTION WORKSHOP which shifts the conversation from a case-driven discussion to a pattern-based discussion of common problems and

solutions in the target domain. Present groups with Design narratives from a previous DESIGN NARRATIVES WORKSHOP and prompt them to compare the cases and identify recurring patterns. Guide them in articulating these patterns in full.

Apply the COLLABORATIVE REFLECTION WORKSHOP structure, adding:

Before the workshop

• Collate a selection of Design narratives pertinent to the workshop theme, including both previous contributions of the workshop participants and notable contributions from other sources.

• Prompt participants to comment on these cases and identify possible links.

On the day

Introduce the selected cases using an exercise which provokes attentive reading, e.g. use them as inputs for a TABLE-TOP CONCEPT MAPPING exercise.

Instruct participants to

• Identify parallels between the cases in terms of context, problem and solution. These should be noted succinctly on cards or small note paper.

• Choose one of these notes, and elaborate it as a full-bodied pattern.

First, ask the groups to present a short portrayal of the new pattern, by providing:

• Name

• Short description

• Illustration

Next, guide them in using a pattern template, for example:

Name

Naming is important. Think of a short catchy phrase that captures the essence of your pattern. Pattern names are often imperative - 'do this'.

Summary

Try to capture the essence of the pattern in 2-3 sentences. Focus on function - what it does, not how it is built. The summary will appear as a tooltip on the index page.

Illustration

Metaphoric or inspirational image or graphic, which captures the spirit of this pattern.

Problem

What is the problem that this pattern addresses? What does it try to achieve? One useful method of defining the problem is as a conflict between the two main forces dominating the situation.

Context

When and where is this pattern most relevant? To which settings can it be extended?

Solution

Describe the core of the solution in such a way that it can be directly implemented a million times without doing the same thing twice.

Diagram

Structural or narrative graphic which supports the detailed description of the solution.

Related Patterns

List other patterns related to this one, under categories such as component, assisting, conflicting, uses this, etc.

Support

Source

The original design narrative from which this pattern was derived.

Triangulation

Additional supporting cases where this pattern was observed

Theoretical justification

Reference to relevant domain theories which explain why this pattern is expected to work, and link it to larger bodies of knowledge.

Verification

Scenarios / solutions which were developed using this pattern

Provide specific guidance on articulating each one of the core components.

For example: http://www.slideshare.net/yish/stories2patterns-presentation

DESIGN SCENARIOS WORKSHOP

Put patterns to the test by applying them to novel real problems in real contexts.

Figure 8. Sketch of Design Scenarios Workshop

Problem

Design patterns provide a powerful language for such a conversation, enabling stake-holders to identify potential problems as early as possible and make an informed choice of solutions. Paradoxically, often as more expert knowledge is embedded in a pattern language it becomes less accessible to novices. In order for patterns to be used effectively by their prospective audience, they need to be presented in an approachable manner.

Furthermore, many patterns suffer from lack of validation; while they may seem compelling, this impression is not backed by unbiased empirical evidence. This reduces the audiences' confidence in patterns, and creates a second obstacle to their adoption.

Such problems can be overcome by careful editing of patterns and pattern languages. Yet, with the abundance of candidate patterns which can emerge from any design discussion, for example at a DESIGN PATTERNS WORKSHOP, we need a mechanism for prioritising efforts.

Context

Although this workshop would typically be the third in a series, following a DESIGN NARRATIVES WORKSHOP and a DESIGN PATTERNS WORKSHOP, alternative combinations may be more fruitful in some cases. For example, one option would be to start from scenarios and then select cases that seem to share similar problems. Alternatively, when a one-off two-day event could be organised as a DESIGN NARRATIVES WORKSHOP followed by a SCENARIOS WORKSHOP, leaving the patterns implicit.

Solution

Establish a scenario-driven discussion of Design narratives and design patterns in a domain of practice, by facilitating a COLLABORATIVE REFLECTION WORKSHOP in which participants share concrete problems in the form of future scenarios, compare them to past

cases, and identify the patterns most applicable to form a solution. The discussion is instigated by prompting participants to post their scenarios in a shared space. It culminates at a workshop, where the scenarios are analyzed by groups of 3-6 participants. After the workshop, participants and facilitators revisit the cases, patterns and scenarios which were discussed.

Follow the COLLABORATIVE REFLECTION WORKSHOP structure, adding:

Before the Workshop

Instruct participants to contribute a rich description of a real problem they are confronted with in their practice, using a template, which prompts them to specify:

Situation

What is the setting for this scenario? Describe the educational, technological and institutional setup.

Task

What is the problem to be solved, or the intended effect?

On the day

Tag the scenario and the cases with keywords and concepts highlighting the essence of the context and the problem. Find patterns that match the same tags, and consider their utility in solving the problem.

Describe a possible solution, based on applying the selected patterns.

Note how the patterns themselves evolved in the process.

The template should provide additional slots for capturing these outputs, thus producing a coherent description of the problem and its proposed resolution:

Patterns

Identify patterns appropriate for the situation and the task. How would they inform the solution?

Solution

Describe a possible solution derived from the patterns you selected.

Expected Results

Concrete, measurable criteria for success.

Lessons Learned

What have you learned from writing this scenario?

After the workshop

Prompt participants to

- Publish any new Design narratives, patterns and scenarios that emerged on the day.
- Add details and artefacts (images, illustrations, diagrams, links, etc.) to their scenarios.
- Comment on the patterns, noting questions which have emerged from the discussion.

Conclusions

The current chapter positions design pattern approaches to e-learning within a larger tradition of a design paradigm for educational research. Design based approaches focus on the process of developing innovative tools and activities as means of understanding learning and advancing educational practice. The last couple of decades have witnessed a growing trend towards design based research in education, and e-learning in particular.

Many scientific disciplines turn their attention to questions of learning. The science of Education is distinguished as the study of designed learning. This observation led to a consideration of the study of education as a design science. Simon's (1969) concept of design

science entails more than a shift in the subject of study. It calls for a change in scientific agenda, a value aspect of enquiry, pragmatist perspective, a functional axis of decomposition, and flexibility and pluralism in theoretical and methodological choices.

This chapter argued for a design science paradigm of e-learning, and offered a pattern-based methodological framework for such a paradigm. A pattern language for collaborative reflection and participatory design workshops was presented as a concrete manifestation of the framework.

These observations gave rise to some guidelines for a model of knowledge in e-learning, as problem driven, solution oriented and value laden, situated in context and holistic. A methodological framework was derived from this characterization, which centres on two embedded cycles of research. Two constructs were proposed as complementing elements for this framework: design narratives and design patterns.

The proposed theoretical and methodological structures were demonstrated in a concrete methodology which has been refined through extensive series of workshops.

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