PEDAGOGICAL TEMPLATES : A COMPARATIVE STUDY OF HIGHER ORDER REFLECTIVE MAKING

Sambit Datta, David Morison and Kim Roberts
School of Architecture and Building, Deakin University
sdatta@adelaide.edu.au

SUMMARY

Schon's notion of *reflection-in-action* implies a constructivist process of learning, especially valid in the teaching of professional disciplines such as architecture. Action becomes the instrument of conjecture and learning arises in the context of reflection upon the act. Such a process of interleaving action and reflection constitutes a "higher-order" process of reflective making. Research in design studies has shown that *strategies for making* differ markedly between professional and novitiate designers. Further, such studies have shown that skilled designers employ past experience and precedents to create context for new problem situations. To address the lack of context in novitiate learning situations, we propose the use of "pedagogical templates" for the promotion of "higher-order" strategies in design learning contexts for supporting beginning design students. We focus on the use of digital media, specifically for the design, implementation and delivery of constructive learning situations. This paper presents the use of a pedagogical template in the creation of constructivist contexts for two complementary courses, a traditional design studio and a computer-modelling course at Deakin University. The resulting implications for design learning and the integration of physical and digital forms of making through the use of a pedagogical template are discussed.

INTEGRATION OF DESIGN AND COMPUTER MODELING

The research premise of a Committee for University Teaching and Staff Development (CUTSD) funded research project[1] (Woodbury et al, 2001) forms the motivation and background for the work described in this paper. The application of Deakin University's Teaching and Learning Management Plan[2] (TLMP) to course development and delivery in design and computing courses provides the basis for integrating the findings of the research into teaching practice. Underlying the study were the central questions of how higher order strategies of reflective making might be taught to beginning design students and the question of how the new media of computing might be integrated with the traditions of the design studio. This paper presents the development and delivery of two courses in the School of Architecture and Building in Deakin University that benefit from this line of inquiry. The first course is a traditional second year design studio in which the possibilities of introducing computing and the barriers to integration are investigated. The second course is a course in 3D modelling in which the possibilities of introducing higher order strategies and reflective making in the learning material are explored.

The CUTSD project provided a unifying framework, the methodology and a critical stance within the existing practice of design teaching. The unifying framework of the study were the concepts of design learning, reflection, making, forms of assessment, digital learning resources and multi-institutional collaboration, all of which are tackled in the presentations of our colleagues. Our focus is on the investigation of how such a framework might allow the integration of design and computing. The methodology of the CUTSD project is predicated on the design, creation, delivery and assessment of "games", the details of which are also

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[1] Reflective Making: Higher Order Learning in Early Tertiary Education.
[2] Deakin University Teaching and Learning management Plan.2000-2002. The Competitive Edge.

tackled in other presentations. We adopt the spirit of the games template and adopt it to fit our circumstances, for the creation of a set of common reusable patterns for design, collection and delivery of learning material. Our *pedagogical template* is an attempt to synchronise the generic methodology proposed in CUTSD with the specifics of implementing the TLMP, which caters to the needs of Deakin University. Further, the template enables a common ground for the comparison of the teaching and learning outcomes of the two courses. Finally, and most importantly, the CUTSD project serves as a driver of critical thought and questioning of curricula in the design domain which facilitate the adoption of news forms of teaching and learning practice. In this paper, we explore the premise that the examination of architectural ideas by beginning design students and the learning associated with their examination can be considered within an integrated process of making, incorporating aspects of both physical and digital materiality. We present results from two courses in early design education, where the role of the computer as a device for reflection is investigated within a critical framework of higher order reflective making. The application of strategies for higher order making to early architectural education are mediated by our construction of a pedagogical template, which is discussed in the next section.

THE PEDAGOGICAL TEMPLATE

In the absence of a body of past experience and observation, learning through reflection in early design education is particularly difficult. To compensate for this lack of context, it is necessary to provide a structured process for making that promotes confidence and competence in design learning. The development of learning content for both courses had in common the aim of creating such a structured context, a *pedagogical template.* The template must provide a flexible scaffold in both courses, without resorting to the replication of its structure, allowing context to be created that suits the learning tasks and outcomes under consideration.

In addition to the provision of context, it is necessary to ensure that the template provides a structured process for assimilation, rework and revision, critical components of the TLMP. The emergence of computational structure as a medium of design (McCoullough, 1995), rather than an instrument of design provides a sound basis for developing such a structured process for inculcating higher-order reflective making. In developing this idea, we identified six characteristic processes that might facilitate reflective making, namely,

- *Progression*, proceed from the simple to the complex
- *Extension*, build on and extend the student's previous learning
- *Revision*, provide opportunities to revisit previous work
- *Introspection*, enable the students to record their reflections
- *Evaluation*, allow room for self and peer assessment
- *Mastery*, facilitate growth beyond the scaffolds provided by the template

On the other hand, the provision of a concrete frame of reference, case or structured methodology may result in *design fixation*, the inability of the beginning design student to see beyond the literal phenomenon (Heylighen and Verstijnen, 2000). Thus the development of the pedagogical template for learning about making must not only compensate for the absence of concrete experience, but also resist the urge to provide literal examples or cases that may result in fixation rather than freedom. A pedagogical template can be employed in design learning in varying ways. For example, the structure and movement of the human body can serve as a template for understanding notions of minimal space. An abstract transparent volume can serve as a device for organising a collection of spaces. Models of urban configuration can serve as a frame for generating design ideas about buildings. All three examples can be considered as templates that enable a *"higher-order reflective making* strategy based on concrete learning tasks but without resorting to literal examples, thereby avoiding the problem of fixation.

Another aspect of the template is a consideration of playfulness (Radford, 1997, Cheng, 1999). Play provides a frame for participating in reflective making. Metaphors of play and games in the use of digital media in architectural education can provide the environment for developing student confidence and abilities in spatial modelling, design composition, and form creation. Using the metaphor of play as an environment for learning can compensate for the absence of concrete learning examples and provide context. Thus, the requirements for a pedagogical template can be summarised as follows,

- the creation of context;
- the provision of structured processes,
- use of concrete, but metaphorical, rather than literal examples that do not resort to fixation and
- a consideration of playfulness.

In developing the curricula for the design and computing units, the pedagogical template functions as a working scaffold to develop the aims, objectives, and content and evaluation procedures for the subjects. In the design course, we devised three projects; *minima, domus and insulae*, incorporating the ideas set out in the template. We were interested in the relationship between the individual and the collective in society, sustainable and energy conscious architecture, student housing. In the computing course, we devised a further three projects, *form, function and fragment*, incorporating the ideas set out in the template. We were interested in the relationship between object and space, study of physical environments and digital media for architectural representation. In this paper we focus on a comparative study of the two units. First, we describe the four-week second year studio projects delivered in a traditional studio setting. Secondly, we describe the four-week computing units in 3D modelling. Finally, we present our findings on the design, implementation and delivery of the courses using digital media and directions for future work.

A scaffold for design learning

Schon (1983) introduced the notions of reflection-**in**-action and reflection-**on**-action to describe the process of design thinking undertaken by experts. In a skilled designer's hands, reflective making is a powerful tool, where a lifetime of professional experience, observation and judgement can be brought to bear on the design problem. Reflective making is predicated on the presence of background knowledge and experience. The lack of such experiential knowledge and meta cognitive reflection, becomes a limiting drawback for beginning design students. Studies of Le Corbusier's design practice (Kellet, 1990, Pauly, 1985) illustrate how higher order reflective making works in a complex conjunction of media, experience and meta-cognitive reflection. In the writings of Graves (1977) and Rossi (1981), among many others, such an analogous and metaphoric process incorporating drawing, thinking, reflection and design is observed. Indeed the contrasts in reflective learning between expert and novitiate design (Goldschmidt,1995, Casakin and Goldschmidt, 1999) actors are also noted in the literature on design learning. How can such a higher order process of reflective making be incorporated in design pedagogy?

The framework developed under the aegis of the CUTSD research project (Woodbury et al, 2001) proposes the development, delivery and evaluation of digital learning resources to support design and construction learning through reflective making. To support these objectives in the traditional design studio, the pedagogical template outlined above was employed to develop the curriculum content of a Second Year Design Studio. The course had 97 students, with three tutors, meeting each week for a 2-hour lecture and three 2-hour tutorial sessions over a 13-week period. The design studio explores the relationship between the individual and the collective and the context into which they can be embedded. The fundamental question underlying all aspects of coursework in this unit is:

- What is the relationship between the individual and the collective in the architecture of sustainable communities?

The unit considers the extent to which the needs of the individual lead to the collective and the influence of the collective on the individual. The unit is divided into three four week projects, *minima, domus and insulae* that lead the student from a consideration of a self-contained minimal space to a consideration of collective habitat framed by an abstract volume and finally to a physical site.

In Minima, a brief for a single living space for oneself is given. Ideas of minimal dimensions, anthropometrics, ergonomics and the movement of the human body in space provide the learning context. The students are asked to propose a minimal environmental envelope over a four-week module using traditional media. The project also introduces functional or utilitarian objects such as furniture and their affordances in defining the geometry of the spatial envelope. Minima revolves around specific issues such as, the idea of shaping, containing and defining of *minimal space*, the idea of placing activities and motion in space, the generation of spatial envelopes and its geometric aspects, the idea of spatial *structure* and *utilitarian* objects, the relationships between body, object and space, the representation and communication of the living space through sketches, 2D drawings and a working model or maquette. The students tackled the brief, which lacked a site or a written program, in various ways. In order to generate a formal understanding, they had discussions on what a minimal living space might mean and conducted anthropometric studies. The students were encouraged to think conceptually and convey their concepts through horizontal and vertical dissections of the space using physical media. An example of the constraints of the project and its interpretation is given in Figure 1.


Figure 1 A self contained minimal envelope. Study of and vertical and horizontal dissections, pencil on opaque paper.

The second project, *Domus*, re-considers the size, shape and proportion of the single living space from two distinct viewpoints. Firstly, when placed in the context of a collective of such minimal entities. Secondly, when energy, materiality and external constraints from the environment are introduced. It focuses on the significance of the inner, in-between and outer in addressing the making of architectural space. In creating domus, the students are required to provide a suitable living environment for a minimal collective. The project addresses questions of how a single minimal space could be aggregated into a collection of spaces and How do environmental and energy considerations influence design. In addition to the brief, we provided an abstract digital "site", a volume of space, whose external envelope and total volume are defined. The students used this abstract volume to organise their collective and also orient it in the physical world and the prevailing climatic conditions. Specific issues being dealt with are the generation of collective space, energy, materiality and environmental constraints, the representation and communication of the project through analytic drawings and building a kit-of-parts physical model supported by volumetric sketches and digital models. The students tackled the volume of space with varying strategies, with varying degrees of success. The introduction of the digital model created a dilemma and the students had to choose a medium of exploration. The students were also given the freedom to incorporate functions into the brief as they saw fit. The added increase in complexity caused students to either harness the powers of the digital media or to abandon it completely. Some avoided digital contact, by re-creating the volume in traditional media (Figure 2). Figure 2 provides a glimpse of the approaches that emerged out of their strategic thinking in making choices. The design using a physical model reduces the abstract volume to a minimal expression and felt no need to use the abstraction visually. The trace study uses the scaffold to outline the boundaries like a wire-frame. The digital model uses the scaffold volumetrically and introduces transparency and lighting to elevate the scaffold to a first class design entity. It is interesting to note that the use of digital media benefits most from the use of the abstract site volume. In the third project, Insulae, the site volume of the second project is inserted into an urban site, (the volume was derived from the site boundaries) and the size of the collective is increased to thirty units.

Finally, through structured and retrospective exercises on the computer based on the concept of a games template (Woodbury et al, 2001), the students are asked to reflect on, revisit and resubmit their initial ideas digitally. The retrospective nature of the game allows the students to reflect on their studio output after a sufficient time lag and revisit their design thinking within the ambit of the game. The material developed for this course illustrates how the pedagogical template finds application in a concrete case of curriculum development.

Firstly, in each of the three projects, context arises out of a consideration of the learning aims. In the first project, the emphasis on generating the envelope in a minimal fashion in relation to the human body creates a rich context for action. The approaches ranged from direct measurements and their translation to studying videos of human motion. In Domus, the context arises out of a consideration of how the abstract volume might be placed along the waterfront precinct of Geelong. In Insulae, the discussion of urbanity and the fact that the volume of their previous project now had a real physical context enabled the students to interpret context in fertile and sophisticated ways.
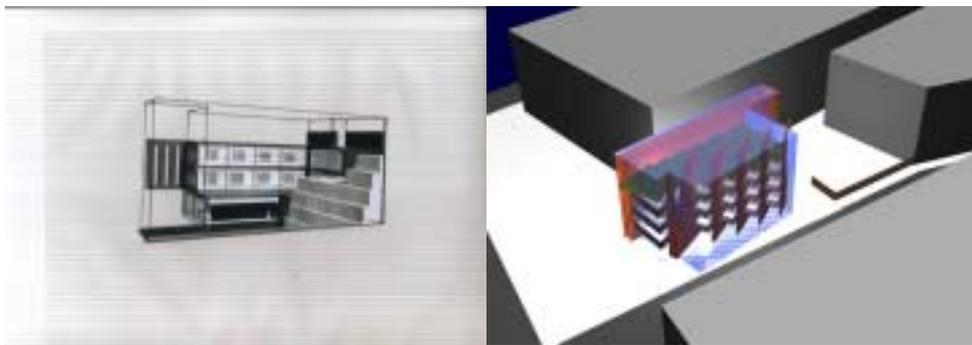
Figure 2.The interpretation of the abstract volume in Domus, left, pencil on trace study of the design framed by the edges of the site volume and right, digital massing model rendered transparent.

Secondly, the process of investigation followed four out of the six attributes of a structures process outlined in the pedagogical template. The material proceeded from simple to complex ideas. This enabled students to progress in a structured manner through the material. The projects emphasised what they already knew about design from previous units and built on those foundations. Some students who had entered the studio straight into second year found this challenging. The projects were linked together in various ways to enable the students to revisit and reflect on their earlier work and the work of their peers. The last two attributes, assessment and mastery were introduced in the review process but were integral to the delivery of the material. Thirdly, the absence of direct literal exemplars for the projects helped the students to work from first principles to address the problem of student housing. They did not have any preconceived ideas about how students might be housed, individually, or collectively, in a site of their choosing or in the context of the city. Finally, the projects and their group reviews were designed around a non-threatening, inclusive and facilitating environment of playfulness, where no ideas, however outlandish, were considered beyond serious discussion. The students were encouraged to play as a "team" in the tutorials and reviews, with the tutors working as peers to facilitate and direct discussion.

A scaffold for learning about computing

The second unit for beginning design students is a laboratory based hands-on unit in computer-aided architectural design. More recently, architects have experimented with and incorporated the potential and pitfalls of the electronic realm into an examination of their design ideas and in practice. Since that observation, simulation, generation and visualisation have dominated the impact of digital media in architecture. McCoullough (1996) argued that digital making has the potential for incorporating principles of craft from traditional media. Indeed, the thesis that *bits* had as much currency as *atoms* is a reflection (Mitchell, 1995, Negroponte, 1995) of the changing relationships between materiality and the structure of

design information. The interpretation of computational structure as a medium of reflection, as *paper* rather than as an instrumental *pencil*, poses important questions for the learning of design. In this paper we will revisit the idea of the computer display as a *lens* and explore its implications for design pedagogy.

The framework developed under the aegis of the CUTSD research project (Woodbury et al, 2001) proposes the development, delivery and evaluation of digital learning resources to support design and construction learning through reflective making. To support these objectives in the study of design computing, the pedagogical template outlined above was employed to develop the curriculum content of mixed year advanced course in 3D CAD modelling. The course had 26 students, with two tutors, meeting each week for two 2-hour tutorial sessions over a 13-week period. The computing course explores the relationship between physical objects and their digital representation. The pedagogical template was used to develop three distinct modules, called *form, function and fragment* that focus on the relationship between physical, solid objects in space and on explorations of their three dimensional representation using digital media. In this subject we discuss and explore ways, in which the core characteristics and capabilities of CAD systems enable certain modes of action and disable others, consequently promoting a new basis for perceiving form. The exercises range from the digital modelling of utilitarian objects to fragments of built and unbuilt designs. The unit aims to bring together the diverse strands that have been introduced in previous computing courses to a level that achieves or surpasses the minimum standards of competence in 3D modelling expected for professional competence. Figure 4 shows two models from an exercise on modelling design fragments and the exploration of light, shadow and materiality in the process of modelling. The fundamental question underlying all aspects of coursework in this unit is: How can the representation and generation of form be explored through 3D modelling?
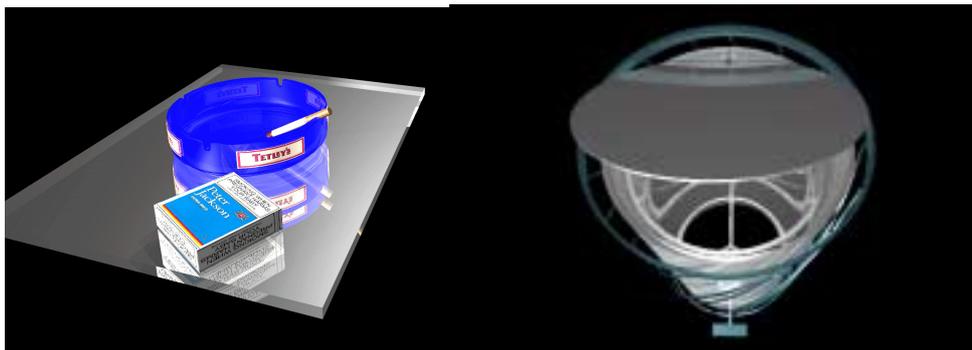

Figure 3. Two examples of Digital Form Processing, ashtray (left) and a bin (right).

unit opens up design and representation issues related to the 3D modelling of spatial and geometric objects, as shown in Figure 3. The pedagogical template supported the creation of this material in three ways.

Firstly, in each of the three projects, context arises out of a consideration of the learning aims. In the *Form* project, the emphasis on generating the fundamental form-giving characteristic of the chosen object creates a definitive task for guiding action. The approaches were varied and dependent on the choice of object. In *Function*, the context arises out of a consideration of how buildings are put together and hence how they might be desegregated into multiple interacting parts, yet retain their coherence as functional elements. The Waterfront Campus of Deakin University was used as the context for this exercise. Students selected parts of the building and worked in teams to create a coherent collection of interacting parts, both solid and void. Figure 4 shows how the simulation of physical building parts incorporated the modelling of structure, light, material and transparency. In Fragments, the discussion of architectural representation moved from a real physical context to the context of their design representations. Fragments provided the students to interpret parts of their studio or other creative work in fertile and sophisticated ways given the context of the two previous modelling

exercises. The output of the course-work can be viewed in the CUTSD Online Gallery[3]. Secondly, the process of investigation followed four out of the six attributes of a structured process outlined in the pedagogical template. The material proceeded from simple to complex ideas. This enabled students to progress in a structured manner through the material. The projects emphasised what they already knew about 3D modeling from previous units and built on those foundations. Provision was made for some students who had entered the course without any foundations in computer-aided design. The projects were linked together in various ways to enable the students to revisit and reflect on their earlier work and the work of their peers. The use of direct and concrete exemplars in the Form and Function projects provided a smooth transition into digital media. This enabled the students to look beyond the seductive imagery of digital output by constraining them to physical entities that they were simulating. The concrete foundation of the first two projects enabled them to tackle the more complex tasks of modeling their designs with greater confidence and competence. The students were encouraged to play as a "team" in the laboratory, with the tutors working as peers to facilitate and direct discussion.
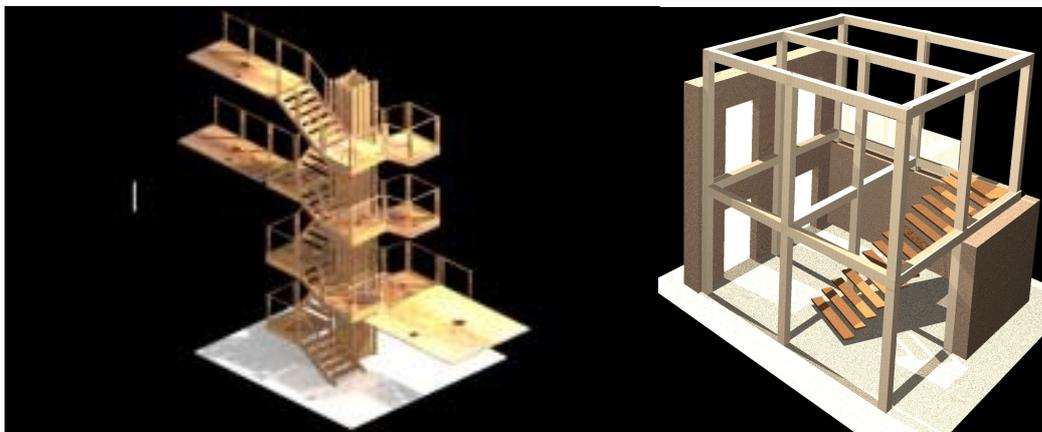

Figure 4. Modelling physical artefacts. Two examples from the *Function* exercise. The students simulate light, shadow, transparency and material using digital media.

Discussion

This section presents our learning from the use of the pedagogical template in the two courses. It draws out the successes and failures of the curriculum changes sponsored by the adoption of the critical framework applied to the problem of teaching higher-order reflective making to novitiate design students. The use of the template provides several insights into how the CUTSD project has sponsored changes to design curricula, the implementation of the TLMP of Deakin University and current approaches to the development of digital pedagogy, including the design, creation and delivery of learning objects. It also highlights the need for a critical stance in the adoption and assimilation of new media in traditional practice.

To investigate the fit between the design studio, centred on the traditional studio and the scope for using the computer as a constructive learning environment, we proposed an abstract re-useable pattern, called a *pedagogical template*. Firstly, when applied to traditional design studio learning, the template serves as a scaffold for incorporating digital media into the design studio. The students are able to take a reflective approach to their design, using the structure of the media as a scaffold. On the other hand, when the template is applied to teaching beginning design students digital skills, the template can be used to harness the students design knowledge as a scaffold for reflective making in the new media. The template provides beginning students of design with a concrete context through which to guide their tasks, a structured process for assimilating material, an instrument to seek out metaphorical

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[3] hosted at *http://www.ab.deakin.edu.au/dotcp/vGallery/SRC321/SRC321.html*

exemplars to further learning and a consideration of play in the task of learning. The template functions in much the same way as a window onto Alice's Wonderland. The metaphor of a lens (Datta and Woodbury, 2001) is an appropriate physical analogy for the critical stance taken in this paper. The template participates in the process of reflection, but does not interfere with making. In doing so, the template behaves in a transparent manner, filtering, reflecting, refracting the integrated learning of design and computing in a constructive environment.
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The new curricula arising out the study needs further development and refinement, including a comprehensive assessment of its potential and pitfalls from a student perspective. Initial work of summative and formative assessments have been undertaken under the aegis of CUTSD, but remain to be analysed and collated.

Conclusion

The limitations and opportunities of the pedagogical template need further clarification. It is necessarily a simplification of the complex process of creating learning material. However, such abstract simplifications will be necessary if the goal of reusable, interoperable digital learning objects are to be realised. We hope to extend our study of the use of template to a more formal footing in the future, particularly with reference to the creation of interoperable schemas. In keeping with this aim, we have felt that *Introspection* on the studio and laboratory output after the hand-in of their projects was lacking. We intend to develop deeper forms of *introspection*, enabling the students to write down their thoughts and ideas during the process of action. To enable this, sharing and collaboration on a digital bulletin board (Kvan 2001, Liu and Chien, 2001), shared by the students of the two courses will be investigated in the next semester. This will be further developed by extending the virtual collaborative to other institutions. The use of digital media to analyse, re-create and visualise architectural heritage is another way of developing cultural sensibilities and perceptions in students of architecture, engaging them in active cross-cultural collaboration and dialogue with other schools and practices, enabled by digital means.

The integration of digital media with an emphasis on craft and physical aspects of making create a supportive environment for learning in the traditional studio. The structures of computation provide a powerful new canvas for the exploration of architectural design. The traditional architectural design studio provides a powerful and tested setting for the exploration of digital media. Higher order reflective making is an effective tool for delivering design teaching in the early curriculum using an integration of design and computation. The use of a pedagogical template to implement a strategy for higher-order reflective making facilitates this integration. Further, it enables the integration of abstract, conceptual learning with concrete, case-based forms of learning without recourse to literal examples that can lead to design fixation. Finally, the template provides context, an immediate concreteness and urgency to design problems and can assist in the development of reflective making.

Acknowledgments

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