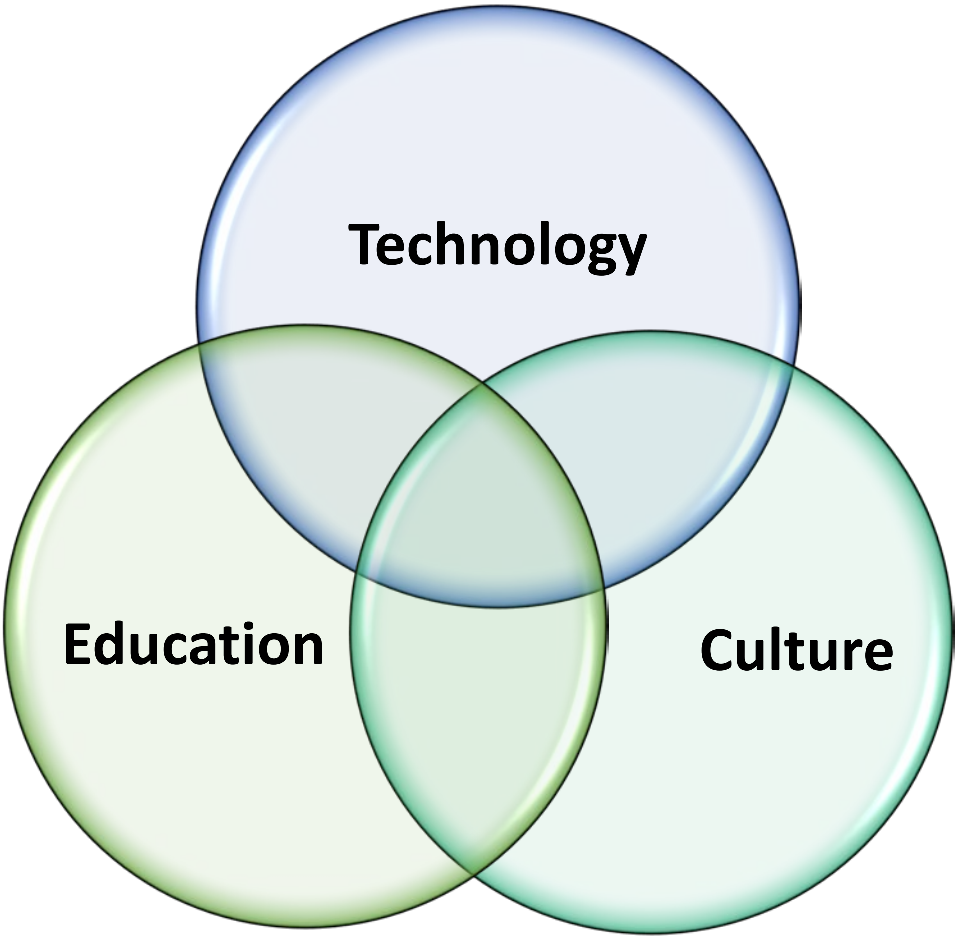
TENZ-ICTE CONFERENCE

Technology: An holistic approach to education



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Technology: An holistic approach to education

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About TENZ

Technology Education New Zealand

Technology Education New Zealand is a professional network, promoting and supporting technology education in New Zealand. This is achieved by fostering development of technology in the New Zealand Curriculum, and maintaining national and international links between those working in technology education and with the wider technological community.

It aims to:

- foster the development of Technology Education in New Zealand
- develop and maintain national and international links between those working in Technology Education and with the wider technological community
- support professional, curriculum, and resource development in Technology Education
- encourage and support research in Technology Education
- organise a national biennial Technology Education conference
- work closely with other subject associations for mutual benefit of technology education.

About ICTE Asia Pacific

International Conference on Technology Education (Asia Pacific)

The aim of this professional group is to promote communication and academic exchange in Technology Education amongst Asia-Pacific countries which have professional associations of Technology Educators. Current members of ICTE are Japan, New Zealand, Korea, Taiwan, Australia, USA and Hong Kong.

The first conference was held in Otsu, Japan in 1995. The next conference in Taipei, Taiwan in 1997 was when the ICTE organization was constituted. Conferences then were held in Canberra, Australia in 1999, Daejeon, Korea in 2001, Auckland, New Zealand in 2003, Hong Kong, China in 2006, San Antonio, USA in 2007, Taipei, Taiwan in 2009, Aichi, Japan in 2011, Nanjing, China in 2013 and Hong Kong in 2015.

About this Conference

TENZ / ICTE Conference

The opportunity arose for both these conferences to be held in New Zealand in 2017, and they have complemented each other well. The professional development focus of TENZ has resulted in many practice papers and practical workshops to be included in the conference program, and the academic papers of both TENZ and ICTE members have resulted in a well balanced conference program with something of interest to all professionals working in all areas of Technology Education.

The papers published in this proceedings have all undergone a peer review at the abstract stage, and then a blind double peer review of the full papers, to comply with the verification requirements for a conference publication – full written paper refereed.

Editor: John Williams
Proceedings Editor: Kerry Goodwin

Reviewers

The conference convenors woud like to thank the reviewers for their diligent work. This is one of the activities of academics that goes unrewarded, but is very important in maintaining standards of research practice.

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Advancing the Iteration Deficit Reduction Model

Anton Nemme
School of Design
University of Technology, Sydney
anton.nemme@uts.edu.au

Roderick Walden
School of Design University of Technology, Sydney
roderick.walden@uts.edu.au

Abstract

Through analysis of a case study from student design practice, this paper describes the refinement of an adaptable learning model designed to address the problem of 'iteration deficit'. We call this model the *Iteration Deficit Reduction Model* (IDR). 'Iteration deficit' is a term created by the authors, to describe a form of fixation in the practice of novice designers, where divergent thinking becomes suppressed by convergent thinking during a design project. Before application of the full-detail of the model to the learning context, here we examine the primary principles of the IDR model in practice, through an advanced-level student product design project at the University of Technology Sydney. The project reveals that a constructive design research methodology that incorporates experimentation through prototyping for each iterative learning cycle, correlates with key features of the adapted IDR model. A notable part of this correlation is that hypothesis-making in research-oriented product design practice is central to the iterative construction of prototypes as a means to advance the nature of the innovation in a knowledge-intensive way. Further, by positioning the construction of prototypes as the method for convergence-based learning in product design projects, we are better able to assign and schedule appropriate methods and support for divergent-based learning, identified as being critical to the development of innovation pathways in product design education.

Keywords: product design, iteration deficit, constructive design research, design education

Introduction

This paper seeks to build on previous work by the authors presented at the Technology Education Research Conference 2016. There the term 'iteration deficit' was introduced along with presentation of a teaching and learning model - the Iteration Deficit Reduction (IDR) Model. The IDR model was developed to mitigate the phenomenon of 'iteration deficit' in product design projects, particularly those that respond to ill-defined or ‘open’ briefs. We use the term 'iteration deficit' to describe a noticeable reduction in the number of iterative events evident during design development. The occurrence of 'iteration deficit' can be recognised when the designer locks onto a typology, interaction feature or form, obsessively, to the detriment of further exploration of the design outcome (a focus on convergence). The IDR model may serve as a prescriptive tool to support iteration through promotion of divergent thinking throughout the design process by pairing learning cycle stages with appropriate research methods. The importance of iteration cannot be overstated. Iteration is considered a base feature of the design process (Chusilp & Jin, 2006) and a key factor in successful design outcomes

(Cross, 2000). Berends and Reymen (2010) identified that iterations in the design process lead to rapid learning, adaptation, flexibility and short-term results which indicate that a more proactive approach to iteration in design studio may help negotiate the paradox of working through ill-defined problems and the significant time constraints of tertiary design programs. Through iterative practice - the act of progressively and repeatedly exploring and refining the concept (Lidwell, Holden, & Butler, 2003) - complexity in design is made ordered, and given form. In order to understand the application benefits of the IDR model, this paper aims to contextualise a case study from student design practice within the University of Technology Sydney, Integrated Product Design Honours program. The Honours program is knowledge intensive and driven by a practice-based research approach. Prototyping is the core research device driven by hypothesis-making within iterative cycles of design development. Hence, the paper explores how the conduct of an advanced level tertiary product design project maps over key elements of the IDR model and how this model design might be more widely implemented and applicable.

Literature Review

The notion of cycling through modes of thought and action has been addressed in a number of design models (Koskinen & Krogh, 2015; Stappers, 2007). Notably, the 'The APU design & technology model' or 'The Interaction of Mind and Hand' by Kimbell and Stables (2007), identifies that there are movements between imaging and modelling inside the head, and confronting reality outside the head (which relates to practice). Further, Kimbell and Stables note that these 'movements' cannot be prescribed in advance and that the iterative cycles of movement between thought and action must be "engaged responsively" (Kimbell & Stables, 2007, p. 16). This indicates that there is a form of 'hypothesis-making' at key stages in the process, necessary to direct each iteration. Research by Bang, Krogh, Ludvigsen and Markussen (2012) refer to hypothesis-making as part of a strategy for operationalising practice-based design research (particularly in product design or related fields). The structure of the IDR model is determined by the real-world constraints of a teaching program with the increased importance of managing and supporting iterative-design practice, particularly for complex, knowledge-intensive university product design courses. Yilmaz & Daly (2016) identify the need for supporting divergent thinking cycles throughout the design process and Daly, Yilmaz, Christian, Seifert and Gonzalez (2012) proposes that concept generation that leads to innovation is dependent on the development of multiple and diverse ideas. The model takes into account that an iterative process aids concept diversity and can be linked to innovation (Brophy, 2001; Liu, Bligh, & Chakrabarti, 2003). The management of iteration cycles is maintained by Kolb's four-staged Experiential Learning Theory (1984), comprising of concrete experience, reflective observation, abstract conceptualisation and active experimentation in that sequence and as continuous experiential learning loops (Kolb & Fry, 1975). Additionally, transitional learning-style phases are acknowledged in the IDR model (Kolb, 1985) as described by Kvan and Jia (2005) and McLoud (2013) in the form of converging (strong practical application of ideas), accommodating (reacting to immediate circumstances and reliance on people for information), diverging (generation of ideas and seeing multiple perspectives) and assimilating (creation of theoretical models into concise logical forms). The IDR model structures iterative learning cycles that intentionally 'grow' from a formative cycle to a summative cycle, inspired by the work of Dewey (1938/1969) that describes the importance of an in-build and linked series of cumulative experiences, noting that not all experiences are necessarily educative in nature. To gain a better understanding of how to assign methods to the IDR model, we attempt to map the conduct of a successful research-through-design by one of our Honours students over key elements of the model. This project was selected because it uses prototyping consistently as a central research device and innovates through socially significant research. The project features many attributes that we hope to develop in all our students at an advanced and well-articulated level.

Context

Advanced-level product design projects in the IPD course are conducted in the Honours Degree. An aptitude for prototyping of three-dimensional physical models has long been a feature of the UTS product design program. It aligns with the strategic goals of the Faculty particularly in connection with ‘technology-led thinking’ and ‘practice-oriented learning’ (Lie & Walden, 2015). The Honours Degree is where we can really test the connection between prototyping and design-iteration. The degree requires students to conduct research-through-design (Frayling, 1993), though the term we adopt and prefer is constructive design research (Koskinen, Zimmerman, Binder, Redström, & Wensveen, 2011) because of the importance it places on prototyping as a research device activated through clearly defined modalities of research. Constructive design research is defined as "design research in which construction - be it product, system, space, or media - takes center place and becomes the key means in constructing knowledge." (Koskinen et al., 2011, p 5). Consequently, the prototypes developed by students in the Honours Degree become a core means of building connections between fields of knowledge (Stappers, 2007) and as described by Overbeeke, Wensveen and Hummels (2006) a form of ‘physical hypotheses’, or hypotheses contextualised into physical form. By way of further defining the nature of prototyping in the course, we find definitions provided by Weensveen and Matthews (2015) to be useful, notably: *as physical embodiments of research concepts* for expository analysis, and *where the research contribution is tied to the process of crafting the artifacts* for case analysis. Additionally, investigation of the operationalisation of constructive design research was published by Bang et al. (2012). Their research demonstrates an iterative relationship between motivation, hypothesis-making and experiments that often manifest as prototypes in our degree.

Methodology

The research presented here is based on case study analysis involving both participant observation and critical review of documentary sources. Participant observation was conducted through reviewing the progress of the project each week and discussing the progress with both student and studio instructors. The documentary source is the research dissertation produced by the student at the conclusion of the project. Investigation of the source material motivates the research. The structure of the IPD Honours Degree requires the study of 48 credit points over two 12 week sessions. Session one consists of two interlinked studio subjects: ‘Research and Development (R&D) A’ and ‘Conceptualisation’ with a common lecture component. The deliverable for the ‘R&D A’ class is a preliminary research report and for the ‘Conceptualisation’ class, the production of multiple iterative prototypes are required. Session two consists of two interlinked subjects: ‘Research and Development (R&D) B’ and ‘Realisation’. ‘R&D B’ class requires the finalisation of the research report (the research dissertation) and ‘Realisation’ class requires the production and exhibition of a high quality artefact. These four subjects combine to form the capstone project for the IPD Honours degree. For the following case study, data collection was undertaken in R&D classes during individual studio consultations of 30 minutes per week with the respective student. The student would present information for discussion to the studio leader generated through a constructive design research methodology in the form of text, sketches, still images and video as well as iterative prototypes. The most intensive phase for iterative prototyping occurred throughout an 8 week period which would coincide with university timetabled weeks of 9 through to 16. It is important to note that the R&D classes provide the theoretical underpinning to drive experimentation and prototyping in both Conceptualisation and Realisation classes. The research dissertation is a comprehensive document that must demonstrate the way that the student has contextualised the entanglement of theory and practice to develop their product design outcome.

Data Analysis

The project described here is a capstone project developed in the IPD Honours Degree. Though the broader project developed a family of homeware products, for clarity we focus on the development of the ‘Beanz’ tray design. The motivation at the start of the project begins with a concern for improving product-consumer attachment in response to the unsustainable growth of consumerism. Formative stage literature research, helps to set a focus on the cultural connections with which we identify through materials, processes and experiences. Inspired by research from Jung, Bardzell, Blevis, Pierce and Stolterman (2011) and by Schifferstein and Zwartkruis-Pelgrim (2008) the first exploratory prototype of a serviette platter (Figure 1) investigates the hypothesis:

> that consumer-product attachment may increase through the deliberate introduction of an aesthetically crafted surprise element considered to improve aficionado-appeal with a rare product feature.

Figure 1: Serviette Platter

> The image above shows the scrap timber parts used to create the serviette platter. The joint was located in the final assembly according to the most efficient use of material, and not where it might be most ‘logical’ in the final design aesthetic. However, the joint is very precise and finely crafted to signal the mismatch of

the timber grain.

The serviette platter is made using two pieces of scrap timber that are shaped and formed to join precisely at an ‘illogical’ assembly point determined not by the function of the platter, but based on the most efficient use of the scrap material. Notably, the precision of the joint assembly combined with the seemly deliberate misalignment of the timber grain, generates a degree of surprise and encourages the user to query the motives of the designer in a way that may represent the starting-point for the deep narratives normally associated with kept and valued items. Learning from the serviette platter prototype and by accommodating new insights from the testing performed, the designer is supported in the direction they take to diverge away from the narrow focus of the project at this early stage. Another perspective on product-consumer attachment is framed around research that suggests that if we design products that are more culturally relevant, they will be more highly valued, kept and maintained. Extending further upon research by Schifferstein and Zwartkruis-Pelgrim (2008) the next hypothesis for the project (Figure 2) is:

> that there is a process for appropriating Australian material histories and by doing so, new meanings can be formed that forge a strong and culturally binding consumer-product attachment.

Figure 2: Storage Tray in recycled timber / European beech

> The images above are of two storage trays with exactly the same utility. The one on the left is made from a piece of recycled timber with the silvered and splintered surface exposed at the top. The one on the right from a new piece of European beech, finished in a modern way with smooth edges and surfaces. (Description from Walden & Koskinen, 2016)

Two timber trays for holding small items such as a wallet and keys, were made in exactly the same size and with the same form. One made from a piece of old, weathered timber, and the other from a new piece of European beech. The design using recycled timber was machined so that the top edge was left unfinished, exposing the 'silvered' and splintered weathering of the material. The version made with reused ‘silvered’ timber reveals a history of past-use through the material, and an appreciation of the fact that each version of the product would be slightly different because control over the behaviour of the material during processing is impossible. Learning from the performance of these prototypes, divergent-thinking was supported in the next iterative cycle by more deeply incorporating embedded memories and Australian material histories. Using an old timber weatherboard taken from a recently demolished house previously owned by a family member, a new tray was designed (not shown). The demolished house was very characteristic of Australian home design and construction from a particular point in Australian history. As with the previous prototype, selected surfaces were left unfinished, this time to ensure that the features of the original weatherboard piece were identifiable. Prototype evaluation both of the product concept and the processes used to define how the concept would be fabricated, contributed to the investigation of product-consumer attachment by permitting the user to provide the source material. Divergent-thinking in the next learning cycle, moved away from an entirely controlled process of material selection and appropriation, to one that is co-designed. Inspired by Mugge, Schoormans & Schifferstein (2009a), the hypothesis evolved to become

> that there is a co-design process for renewing personal product histories and by doing so, new meanings can be formed that forge a strong and culturally binding consumer-product attachment.

The designer conducted many experiments using different historical products and different materials, producing a series of outcomes, including moulded trays in leather that replicated features and forms from existing historical items (Figure 3). Both leather and felt were investigated for this purpose, though leather reproduced the original surface features of the historical products in greater definition. The transition from the ‘consumer’ to the ‘prosumer’ (Toffler, 1981) is identified as an appropriately workable concept in the context of this project and serves to extend the project beyond product innovation and toward process innovation. At this point the designer has a basis for challenging design conventions and contributing new ideas (possibly new knowledge) to the practice of product design in a contemporary context. We consider, for this subject, that to reach this point is to *transition* from the Formative stage to the Summative stage of the project.

Figure 3: 'Beanz' Tray

The enamel baking tray pictured above was used as the basis to explore the introduction of personal items in the design process. Modifying historical products by machining them was substituted for molding leather over the tray as a means to explore ways of giving the product renewed meaning. (Description from Walden & Koskinen, 2016)

The notion of the prosumer is expanded upon by Mugge, Schoormans and Schifferstein (2009b) by identifying that product personalisation stimulates emotional bonding with products as they become an expression of the owner's identity. The use of leather does not damage the original item but enables personalization and facilitates the accumulation of memories through the wear sustained through repeated uses of the product (Mugge, Schoormans & Schifferstein, 2005). The hypothesis was iteratively evolved in the next learning cycle to become:

> that there is a co-design process for renewing personal product histories through non-destructive replication of features to create new products with enriched meanings that forge a strong and culturally binding consumer-product attachment.

The next series of experiments produced prototypes that are made up of two (primary) parts: the original (historical) item and a new component made of leather or felt that is formed by moulding it over the original product. These included a frying basket with a felt tray-lid that was moulded using the frying basket itself. And a return to the Beanz[7] tray (Figure 4).

Figure 4: 'Beanz' Tray with Leather Lid

> Experimentation through prototyping, of the evolved hypothesis leads to the solution concept above that uses the existing beans tray product, but augments it with a leather moulded lid accessory. The leather moulding is essentially a 'tracing' of the original product. (Description from Walden & Koskinen, 2016)

Through a series of further iterations that produce more prototypes, the hypothesis develops to become:

[7] The ‘Beanz’ tray is a name given to the enamel baking dish used in the designer’s prototypes. According to the designer’s childhood memory, the baking dish was used by the designer’s grandmother as a tray for beans, hence the name.

> Tracing History is a co-design, co-production process for renewing personal product histories, through non-destructive replication of features, to create new products and product assemblies with enriched meanings that forge a strong and culturally binding consumer-product attachment.

The moulding method is a metaphor for ‘tracing history’ by reproducing the surface features of products through the making of a new component, that can then be combined with the original item to renew its meaning and extend the life of the product. The final stage of the project iteratively explores the function of the co-design process as a means to use the ‘tooling’ developed for the moulding technique, as a component of a new product assembly, that includes a final secondary leather moulding (Figure 5). The new product effectively ends the production cycle, since it uses the tooling, extending the concept of the value of rarity in product-consumer attachment to include *rarity of production*.

Figure 5: New Tray with Leather Lid made from 'Beanz' Tray tool.

> The 'timber loop' used to brace the original enamel tray is further machined and finely finished in American Walnut to act as a base in a new version of the design. The tool becomes the product ending the cycle for this series. (Description from Walden & Koskinen, 2016)

Discussion

The study of an (advanced-level) university product design project, that adopts a constructive design research methodology, serves to advance the development of the Iteration Deficit Reduction (IDR) Model, proposed by Nemme and Walden (2016), by providing clearer guidelines for managing design iteration in product design education. An adapted version of the IDR model is shown in figure 6. The case study described in the paper provides some verification that the process described by the IDR model is evident in the mentoring of constructive design research in product design. Further it indicates that prototype-centric iterations can be managed and supported in studio so that these prototypes function both as (using definitions provided by Matthews & Wensveen, 2015) *physical embodiments of research concepts* and *where the research contribution is tied to the crafting of the artifact.* We consider that by meeting these conditions the process can serve in achieving the Degree’s learning objectives, notably, the development of designs that innovate meanings and experiences, becoming accomplished at using prototyping methods as a central research device and to manage complex self-initiated design projects responsibly and professionally. It is possible to track this project by connections between hypothesis-making and prototypes constructed at key stages. By aligning the prototyping activity with *experimentation* (a terminological correlation made also by Bang et al. 2012) and the 'making of hypotheses' with *abstraction* in Kolb's learning cycle, we logically set-up the broad function of the other parts of the learning cycle as depicted in Figure 6. With reference to the model, It is important to describe the two functions of the design studio. Firstly, it must provide exercises that enable students to develop their design project according to the phase of the IDR model that has been reached, for that week. And secondly, it must set guidelines for the completion of work associated with the upcoming phases, so that every week, students complete a single learning cycle.

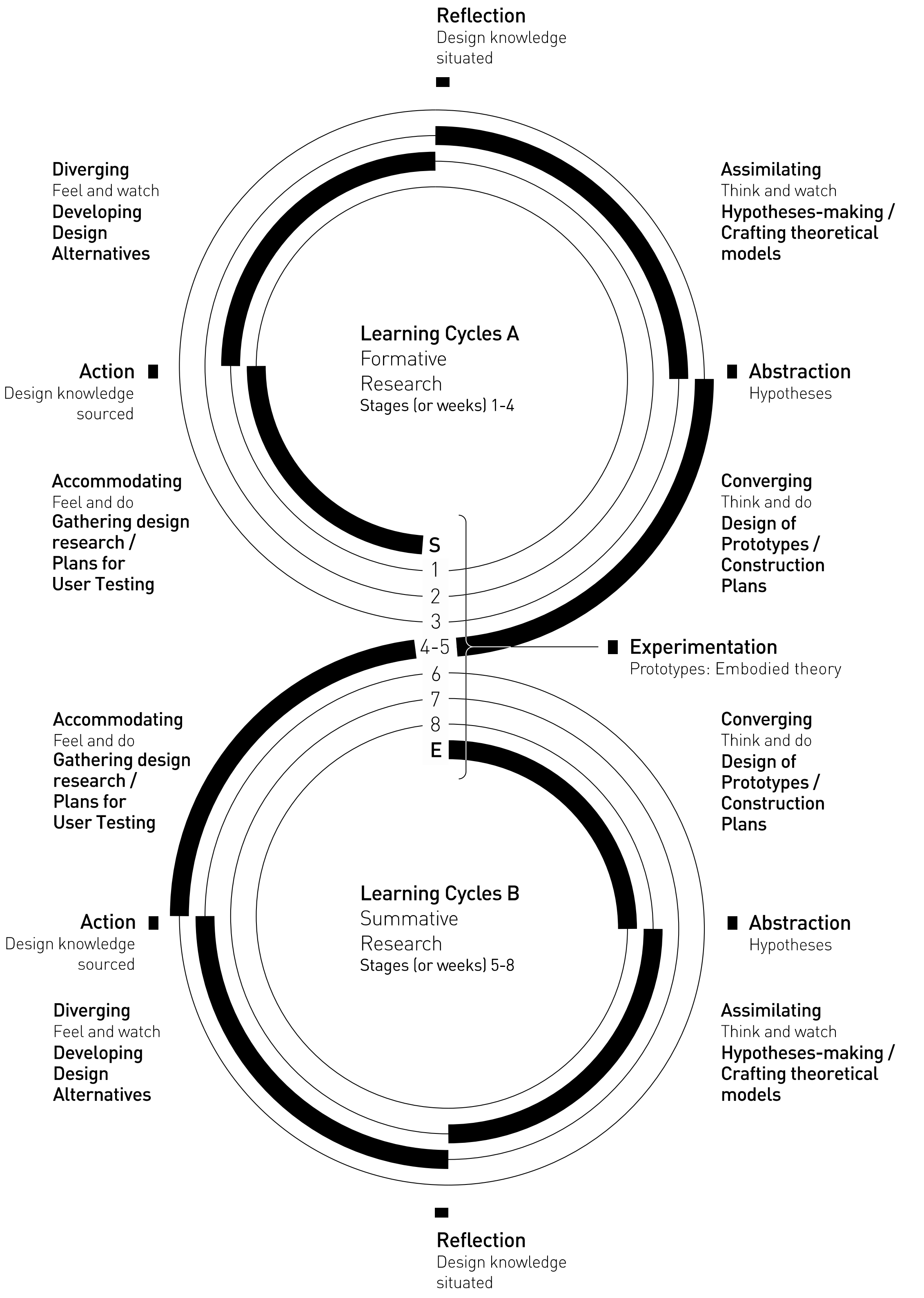

Figure 6: An adapted version of the IDR model (Nemme & Walden, 2016) where the learning styles described in Kolb's Experiential Learning Theory (Kolb, 1985; McLeod, 2013) are contextualised for

university-based constructive design research in product design. Hypothesis-making is assigned to the assimilation learning style in order to set-up prototyping for the experimentation phase. This correlation is supported by the case study presented in this paper and provides guidelines for the assignment of methods for other parts of the learning cycles, A and B.

Conclusion

With the goal of assisting students in moving towards a prudent iterative design process through use of learning device, the IDR model has been established. There is a necessity to support divergent thinking at every design stage in order to reach innovative outcomes. Although iteration itself is important, iterative practice remains an essential component of successful design projects and can be maintained through use of the IDR model. In the context of the IPD Honours Capstone Project, we can see connections between prototyping and design-iteration through each iterative cycle. The notion of cycling through modes of thought and action has been addressed by a number of design models (Stappers, 2007; Koskinen & Krogh, 2015; Kimbell & Stables, 2007), therefore it can be asserted that hypothesis-making and prototyping are essential to underpin the iterative process in pursuit of innovation. The development of hypotheses in the pursuit of knowledge was evident as a feature of Honours projects, and from a teaching perspective, providing a theoretical understanding of these concepts to our advanced level students is of notable concern. With reference to the IDR model, it can be concluded that the conduct of the capstone project discussed in this paper correlates with key features of the model, and this is evident in the way hypothesis-making aligns with the assimilation learning style, through interactions with the construction of prototypes, which aligns itself with the experimentation phase.

A future research pathway might be concerned with the tangible benefits for product design students. For undergraduate students with a less advanced aptitude (such as second year), key features and characteristics of the IDR model could be incorporated into the subject outline program. Here it would reside without graphic form, but could still engage students in the iterative process through the undertaking of a prescribed research method per cycle, albeit in a collective manner. For advanced students, the IDR model could be presented at the beginning of a project in order to visualise and guide the constructive design research process and enable responsible management of a student's individual iterative process. This might then enable students to find 'open', ill-defined and complex problems less intimidating. We can then observe if it inspires better, novel and more innovative design outcomes.

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