# A Proposed Research Agenda for Investigating the Nature of Designerly Thinking in Action

Joseph Phelan
University of Limerick
joe.phelan@ul.ie

Jeffrey Buckley
KTH Royal Institute of Technology
jeffbuckley1992@gmail.com

Dr Donal Canty
University of Limerick
donal.canty@ul.ie

Dr Niall Seery
Athlone Institute of Technology
KTH Royal Institute of Technology
nseery@ait.ie

**Abstract**

The intent of this paper is to discuss the nature of Design and Technology (D&T) education and arising from that the potential contribution of cognitive psychology to further understanding of designerly thinking in action. D&T education is discussed in relation to its purpose and necessity as a discipline in education. A discussion pertaining to how D&T education develops technological capability in students highlights the need for a greater understanding of the nature of designerly thinking. This obligates the discussion for the potential of cognitive psychology to inform the investigation of designerly thinking and its utility in uncovering the nature of the cognitive processes of individuals.

The discipline of cognitive psychology is discussed with relevance to investigating designerly thinking in D&T education. The importance of ecological validity in study design is highlighted regarding cognitive psychology which highlights the difficulties which may be encountered in the application of cognitive psychology methodologies to the investigation of designerly thinking. Taking cognisance of these initial discussions, the warranty for a synthesis of the current body of knowledge surrounding the nature of designerly thinking in D&T education with an approach informed by cognitive psychology is proposed.

**Keywords:** *Design Education, Designerly Thinking, Modelling, Cognitive Psychology*

## Introduction

Design and Technology (D&T) education aims to develop students' competencies to effect change on the world (Roberts, 2013). The dualistic synergy potentiated by affording students the opportunity to cognitively and externally model when engaging in design tasks has long been identified (Kelly, Kimbell, Patterson, Saxton, & Stables, 1987; Kimbell & Stables, 2007; Roberts, Archer, & Baynes, 1992; Seery, 2013). D&T education fosters this synergy through tasks which promote the internal development of ideas with simultaneous external realisation. This sees D&T education as prioritising the development of the visionary and revisionary capacities of students as they engage in designerly thinking in response to a design task. Although recognised as integral to D&T education realising its aims, how designerly thinking is enacted requires further investigation (K. Baynes, E. Norman, & K. Stables, 2010). It is posited that investigating designerly thinking with consideration of the potential contribution of cognitive psychology is warranted. This paper proposes:

- the need for a research agenda to further our understanding of designerly thinking,
- the potential contribution of cognitive psychology in achieving this agenda, and,
- the importance of appropriately synthesising these disciplines.

## Design and Technology Education

Humans have transcended the evolutionary dependencies of other species for development to fill what has been theorised as the *cognitive niche* (Tooby & DeVore, 1987). This theory

proposes that humans' dominance in any ecosystem they inhabit is due to their unique ability to wilfully adapt to meet the needs of their environment in contrast to other species that have adapted through the process of evolution. Pinker (2010) describes the theory of the cognitive niche as being a useful explanation for three uniquely advanced but common traits of humans. These hyper developed traits include technological know-how, cooperation among nonkin and grammatical language. Technological know-how describes how we have and still "use and depend upon many kinds of tools, which involve multiple parts and complicated methods of fabrication" (Pinker, 2010, p. 8994). Without the acquisition of technological know-how surrounding the use and development of tools humans would be bound by their inherent physical capacities.

Technological know-how allows humans to augment their capacities to not only thrive within their environment but also to manipulate it to meet their identified needs. The recognition of technological know-how as a critical contribution to the emergence of a dominant humanity is pertinent to the aims of D&T as "the importance of design education has been fuelled by greater understanding of the propensity for humans to think and act in designerly ways" (Stables, 2008, p. 8). D&T education's inclusion as a discipline in curricula is justified by its anomalous means of fostering students' capability to effectuate purposeful change in the made world (Kimbell & Stables, 2007; Roberts, 2013). D&T education clearly aims to develop the trait of technological know-how with contemporary relevance. Educating students to be capable of identifying the need for change, appropriately conceptualising the means to meet that need, and then causing that change to happen in the made world has and still is acknowledged as critical to growth and prosperity of society whilst improving quality of life (European Design Leadership Board, 2012).

Advocating for the conceptualisation of purposeful change and its subsequent realisation establishes a complimentary dichotomy that "involves the active, purposeful deployment of understandings and skills – not just their passive demonstration" (Kimbell & Perry, 2001, p. 9). This highlights the synergy of simultaneously nurturing design and technological capability. Gibson (2008) posits the appropriate development of technological capability as cultivating students' skills, values and problem solving abilities encompassed by appropriate conceptual knowledge. The recognition of values as being central to capability concurs with the cultivation of the hyper developed trait of technological know-how to extend the capacities of humans as "the concept of improvement is essentially value-laden" (Kimbell & Perry, 2001, p. 5).

It is essential that visionary and revisionary capacities are developed through D&T so that the appropriate and necessary change is identified at the initiation of and throughout the enactment of design and technological capability. Schön (1983) outlines the reflective nature of designing as when engaging in design activity the individual is constantly engaged in a reflective dialogue with their solutions. D&T education's potential to develop students' capacity for employing a contemporary technological know-how is evident and manifests itself in the development of students' design and technological capability.

To fulfil its pragmatic aims D&T education is enacted through 'task-centred, goal-directed activity' (Kimbell, 1994). These tasks can vary in the level of autonomy they grant the student; closed tasks may seek to explicitly develop procedural skills and open tasks cultivate the

students' design and technological capability having acquired the procedural knowledge pertinent to engaging in the prescribed task (Kimbell, 1994). Roberts et al. (1992) highlight the necessity of *'*modelling*'* during designerly activity that "is chiefly concerned with 'ill-defined problems'" (p. 3). Seery (2017) describes the act of modelling as "a natural behaviour designed to support human enquiry into the unfamiliar" (p. 261), affording the representation of envisioned change and results in the construction of physical and/or cognitive models reflecting the proposed change (Roberts et al., 1992).

Designerly activity in tasks in D&T education is mediated through the act of modelling both inside and outside the head. Modelling inside the head may involve the cognitive conceptualisation and development of an idea or mental model whereas modelling outside the head involves the use of the individual's external environment to externally model concepts for development in the form of discussions, sketches and physical models etc. Kelly et al. (1987) illustrate the dichotomy of cognitive and external activity fostered during design tasks which demonstrates the synergistic result of this iterative relationship (Figure 1). Throughout designerly activity students engage in progressive visionary speculation of 'what could be' informed by their revisionary critique of 'what is'. This activity is at the core of developing design and technological capability in students. The benefit of affording a dialogue between he internal and the external is clearly communicated in the pertinent literature and the relevance of this in educating a student capable of implementing their conceived change is evident. What is not evidenced is the cognitive processes which underpin the enactment of designerly thinking as

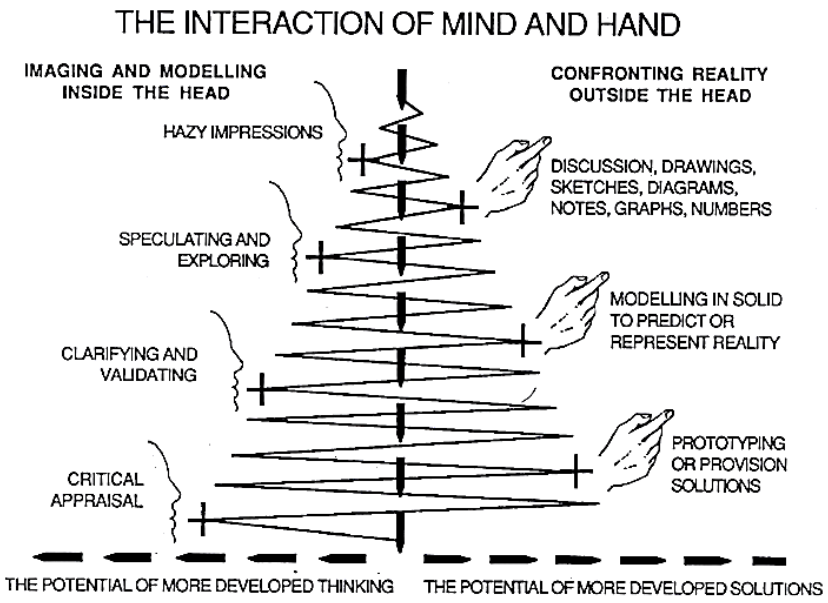


*Figure 1: APU model of the nature of activity in design tasks (Kelly et al. 1987)*

observed by Kelly et al. (1987) (Figure 1).

As a result of this Stables (2010) highlights the need for a better understanding "of how humans enact designerly thinking" (Ken Baynes, Eddie Norman, & Kay Stables, 2010, p. 8). It is posited that a greater understanding of the interplay between internal and external engagement in designing activity from a cognitive point of view is necessary. Why does the appropria te

synthesis of thinking and doing result in the observed activity? How can this be examined empirically? It is suggested that methodologies developed in cognitive psychology are of relevance in the context of investigating the nature of designerly thinking.

**Cognitive Psychology**

Cognitive psychology aims to understand human cognition and behaviour with the ultimate goal to "help people use cognition in real-life situations" (Sternberg & Sternberg, 2009, p. 23). To develop an understanding of cognition and behaviour cognitive psychologists predominantly employ rigorously controlled experiments in an experimental laboratory setting. A broad view of this process sees the participants' behaviour as an indicative result of their cognitive processes having perceived and interacted with certain stimuli. This approach has proven to be effective in shedding light on the way individuals think and behave. Roediger and Pyc (2012) highlight the benefits of applying cognitive psychology to educational practice due to its capacity to provide empirical evidence of techniques which optimise learning. The cases presented by Roediger and Pyc (2012) show the potential for cognitive psychology to assist in providing empirical evidence for the evidence-based practice advocated for in contemporary educational practice discourse (Slavin, 2002). It is evident that findings in cognitive psychology can function as a useful point of reference to inform practice but methodologies in cognitive psychology can provide just as rich a source to inform the investigation of cognition and behaviour in an educational context.

The approach taken in cognitive psychology to investigate cognition and behaviour has been criticised as lacking ecological validity as applying the results ascertained from an experimental laboratory setting to real life situations is a problematic juncture. Kingstone, Smilek, and Eastwood (2008) put forward the argument that the type of laboratory testing described above is problematic in finding real life applicable discoveries as the control and invariance in the experimental procedure may provide results which only arise in such a situation. Kingstone et al. (2008) propose a 'cognitive ethology approach' whereby hypotheses are developed based on the initial observation of real world situations and the subsequent laboratory experiments are designed with cognisance of those observations. It is suggested that such an approach of deriving the development of study design based on real life situations potentiates the heightening of their ecological validity. This movement towards more applicable findings acknowledges the possible situational effects on cognition.

The importance of viewing cognition as a situated process has recently gained significant recognition (Robbins & Aydede, 2009). The concept of situated cognition considers the effects the context of cognitive processes has on the nature of those processes. Robbins and Aydede (2009) select three theses as being particularly central to the concept of situated cognition, namely, cognition as embodied, embedded and extended. The concept of embodied cognition highlights the influence of the brain being situated in the body has on cognitive processes. An appropriate articulation of this happens when an individual engages physically with their task environment through their body. The concept of embedded cognition describes the way an individual can cognitively work within their environment. One explanation of this concept is the way individuals cognitively off-load onto their environment through "epistemic action" (Kirsh & Maglio, 1994). Gedenryd's (1998) view of cognition as extended subscribes to the situated view

of cognition in contrast to the view of cognition as “intramental” (p. 12) (Figure 2). This proposes a view of cognition as transcending the boundaries of the brain to exist as embodied in action and embedded in the environment. A situated view of cognition requires these to be considered in the cognitive processes of the individual from the outset of study design.

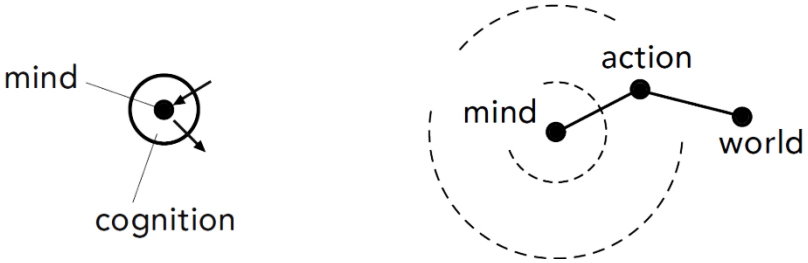


*Figure 2: Gedenryd’s (1998) juxtaposition of views of cognition as intramental and extended*

**Synthesis of Designerly Thinking Research and Cognitive Psychology**

There has recently been emphasis placed on the value of research which simultaneously contributes to theoretical understanding and pragmatic use (Smith, Schmidt, Edelen-Smith, & Cook, 2013). **Error! Reference source not found.** illustrates the model Stokes (1997) created as a means to position research in reference to its intent on furthering understanding and its consideration of practical application. This quadrant model gives exemplars of pure basic research as concurring to that carried out by Niels Bohr in his quest to understand atomic structure without practical implications of such an advancement. This is contrasted with the pure applied research carried out by Thomas Edison when discovering means of commercialising electrical lighting without the preoccupation of advancing understanding. Research which advances understanding and considers its potential to have pragmatic significance is the result of a commensurate synthesis of pure applied and pure basic research. This quadrant is labelled Pasteur’s quadrant due to his work in developing understanding of diseases to inform the development of vaccines to tackle them. Research aimed at advancing the understanding of a phenomenon such as designerly thinking in the context of the practically enacted discipline of D&T education must position itself in Pasteur’s quadrant to ensure practical consideration.

| | | Considerations of Use? | |
|---|---|---|---|
| | | No | Yes |
| Quest for fundamental understanding? | Yes | Pure Basic Research (Bohr) | Use-inspired basic research (Pasteur) |
| | No | | Pure applied research (Edison) |

Table 1: Quadrant Model of Scientific Research (Stokes, 1997)

Cash and Culley (2015) posit that the consideration of other disciplines in design research is beneficial to “the development of greater scientific rigour and the improvement of experimental methods and methodology” (p. 186). Implementing this proposal would enhance the means of developing a theoretical understanding which would complement the pragmatic considerations of “practice-based research that is common in design” (Wensveen & Matthews, 2015, p. 263). To approach the investigation of designerly thinking from a cognitive perspective it is therefore critical to consider the potential contribution of cognitive psychology. The appropriate synthesis of these disciplines is proposed to promote a use-inspired basic research approach to the proposed agenda.

Cash and Culley (2015) allude to the difficulty in executing such a multi-disciplinary synthesis, evidenced by Ball and Ormerod (2000) in reference to the appropriate yet ineffective employment of ethnography in the analysis of engineering design. Providing an example for what Ranulph (2015) describes as “the sometimes uncomfortable marriages of design and research” (p. 9). Coupling these concerns with those raised regarding the appropriateness of laboratory experiments used in cognitive psychology highlights the intricacy of such a synthesis.

As discussed previously, it is imperative that cognitive psychology research is cognisant of the importance of ecological validity. The cognitive ethology approach proposed by Kingstone et al. (2008) highlights how the current body of research into the nature of designerly thinking can inform the effective development of studies which aspire to provide a cognitive perspective. This consideration is posited to aid in the appropriate synthesis of research into designerly thinking with methodologies developed in cognitive psychology. Christensen and Ball (2015) emphasise the heightened ecological validity attained when design cognition is investigated based on observed practices. Within the context of D&T education there is a wealth of research into the nature of designerly thinking which will prove invaluable in informing the research implemented based on the discipline of cognitive psychology.

The acknowledgement of the possible difficulties presented by the proposed application of principles from cognitive psychology highlights some key considerations. One consideration is the need for an ecologically valid study which can uncover the real life means by which designerly thinking is enacted. Another consideration is the utility of the concept of ecological validity in relation to the effectiveness of use-inspired basic research. Use-inspired basic research aims to combine the quest for greater theoretical understanding with a practical use although it is necessary to note that research positioned within Pasteur’s quadrant does not necessarily automatically rate highly in terms of ecological validity because of that trait alone. Research positioned in Pasteur’s quadrant, in the context of the investigation of designerly thinking must ensure that the conditions it is carried out under are conducive to those in which designerly thinking is naturally enacted to further strengthen the applicability of its findings to practice.

**Conclusion**

Subsequently, discussion surrounding the proposed synthesis above substantiates the appropriateness of considering designerly thinking as a situated activity. The role of modelling

cognitively and physically during design tasks and the consequential progression through the process of designing this grants has been clearly outlined. The embodiment and embedded theories of cognition have clear relevance to the enactment of design thinking during design tasks in D&T education as modelling can occur cognitively and physically throughout this process. Models created during the design process such as discussions, sketches or physical models can be viewed as the outcome of the student's embodied and embedded cognitive interactions with their environment and through their bodies with their environment. The recognition of these theses as being particularly appropriate to the discourse surrounding designerly thinking is can serve to inform the design and analysis of research studies tasked with investigating designerly thinking in D&T education. The view of D&T education as being guided by task-centred activity must not be lost in the synthesis argued for here. The necessity of a research agenda which is; ecologically valid, informed by relevant disciplines, and, use-inspired has been identified.

**References**


Ball, L. J., & Ormerod, T. C. (2000). Applying ethnography in the analysis and support of expertise in engineering design. *Design Studies, 21*(4), 403-421. doi:https://doi.org/10.1016/S0142-694X(00)00009-0

Baynes, K., Norman, E., & Stables, K. (2010). *Design education: nurturing the designerly but at what cost.* Paper presented at the Paper presented via the Internet at the Technological Learning and Thinking Conference.

Baynes, K., Norman, E., & Stables, K. (2010). *Design education: nurturing the designerly but at what cost?* Paper presented at the Technological Learning and Thinking Conference, Vancouver.

Cash, P., & Culley, S. (2015). The role of experimental studies in design research *The Routledge Companion to Design Research*: Routledge.

Christensen, B. T., & Ball, L. J. (2015). Studying Design Cognition in the Real World Using the'In Vivo'Methodology *Routledge Companion To Design Research*: Routledge.

European Design Leadership Board. (2012). *Design for growth & prosperity: Report and recommendations of the European Design Leadership Board* (9279259466). Retrieved from Helsinki:

Gedenryd, H. (1998). *How designers work-making sense of authentic cognitive activities* (Vol. 75): Cognitive Science.

Gibson, K. (2008). Technology and technological knowledge: a challenge for school curricula. *Teachers and Teaching, 14*(1), 3-15. doi:10.1080/13540600701837582

Kelly, A., Kimbell, R., Patterson, V., Saxton, J., & Stables, K. (1987). *Design and technology: A framework for assessment.* Retrieved from London:

Kimbell, R. (1994). Tasks in technology. *International Journal of Technology and Design Education, 4*(3), 241-255. doi:10.1007/BF01212805

Kimbell, R., & Perry, D. (2001). Design and technology in a knowledge economy. *Journal of Design and Technology Education, 6*(1), 3-4.

Kimbell, R., & Stables, K. (2007). *Researching design learning: Issues and findings from two decades of research and development* (Vol. 34): Springer Science & Business Media.

Kingstone, A., Smilek, D., & Eastwood, J. D. (2008). Cognitive ethology: A new approach for studying human cognition. *British Journal of Psychology, 99*(3), 317-340.

Kirsh, D., & Maglio, P. (1994). On distinguishing epistemic from pragmatic action. *Cognitive Science, 18*(4), 513-549. doi:https://doi.org/10.1016/0364-0213(94)90007-8

Pinker, S. (2010). The cognitive niche: Coevolution of intelligence, sociality, and language. *Proceedings of the National Academy of Sciences, 107*(Supplement 2), 8993-8999. doi:10.1073/pnas.0914630107

Ranulph, G. (2015). The sometimes uncomfortable marriages of design and research *The Routledge Companion to Design Research*: Routledge.

Robbins, P., & Aydede, M. (2009). A short primer on situated cognition. In P. Robbins & M. Aydede (Eds.), *The Cambridge Handbook of Situated Cognition*. New York: Cambridge University Press.

Roberts, P. (2013). The aims of design education. In E. N. Ken Baynes (Ed.), *Design education: a vision for the future* (pp. 34-40). Leicestershire: Loughborough Design Press.

Roberts, P., Archer, B., & Baynes, K. (1992). Modelling: the language of designing. *Design: Occasional Paper No.1*. Loughborough: Loughborough University.

Roediger, H. L., & Pyc, M. A. (2012). Inexpensive techniques to improve education: Applying cognitive psychology to enhance educational practice. *Journal of Applied Research in Memory and Cognition, 1*(4), 242-248. doi:http://dx.doi.org/10.1016/j.jarmac.2012.09.002

Schön, D. A. (1983). *The reflective practitioner: how professionals think in action*. New York: Basic Books.

Seery, N. (2013). Design and making: natural enquiry. In K. Baynes & E. Norman (Eds.), *Design education: a vision for the future*. Leicestershire: Loughborough Design Press.

Seery, N. (2017). Modelling as a Form of Critique. In P. J. Williams & K. Stables (Eds.), *Critique in Design and Technology Education* (pp. 255-273). Singapore: Springer Singapore.

Slavin, R. E. (2002). Evidence-Based Education Policies: Transforming Educational Practice and Research. *Educational Researcher, 31*(7), 15-21. doi:10.3102/0013189X031007015

Smith, G. J., Schmidt, M. M., Edelen-Smith, P. J., & Cook, B. G. (2013). Pasteur's Quadrant as the Bridge Linking Rigor with Relevance. *Exceptional Children, 79*(2), 147-161. doi:10.1177/001440291307900202

Stables, K. (2008). Designing matters; designing minds: The importance of nurturing the designerly in young people. *Design and Technology Education: An International Journal, 13*(3), 8-18.

Sternberg, R., & Sternberg, K. (2009). *Cognitive Psychology* (6th ed.). Belmont: Wadsworth.

Stokes, D. E. (1997). *Pasteur's quadrant: Basic science and technological innovation*. Washington, D.C.: Brookings Institution Press.

Tooby, J., & DeVore, I. (1987). The reconstruction of hominid behavioral evolution through strategic modeling. *The Evolution of Human Behavior: Primate Models, edited by WG Kinzey*, 183-237.

Wensveen, S., & Matthews, B. (2015). Prototypes and prototyping in design research. In P. A. Rodgers & J. Yee (Eds.), *Routledge Companion to Design Research* (pp. 262-276). London: Routledge.