AC 2012-4391: A COMPARATIVE STUDY EXPLORING THE IMPACT OF ASSESSMENT CRITERIA ON ELICITING GRAPHICAL CAPABILITY

Dr. Niall Seery, University of Limerick
Dr. Diarmaid Lane, University of Limerick
Mr. Donal Canty, University of Limerick

Donal Canty is a lecturer at the University of Limerick, Ireland. His subject domain specialism is pedagogy and assessment in design based technical education.

A comparative study exploring the impact of assessment criteria on eliciting graphical capability

Much of formal educational provision correctly focuses on developing critical numeracy and literacy skills. Contemporary living in a digital image culture supports education now developing what Fish[1] describes as our visualizing instinct.

At second level the national graphics curriculum in _____ has moved from Technical Drawing (TD) to Design and Communication Graphics (DCG). The traditional vocational focus is now replaced with learning graphics through design driven activities, which encourage outcomes of innovation and creativity. While students still develop subject specific content knowledge, drafting skills and communication skills, the approach to learning is concerned with the design process as a vehicle for transferable learning.

Capturing the process of learning and not the product can be a challenge for conventional assessment methods. This paper explores the impact of determinist and non-determinist approaches to assessment on the nature and outcomes of the learning activity.

The method employed an off-set cohort analysis type study to explore the performance and output of two homogenous groups of initial teacher education students (stratified sample n=40). Group one were given defined assessment criteria, while the second group were expected to define the criteria based on their definition of graphical capability. The paper highlights the variance between groups in selecting, applying and executing appropriate graphical principles and medium, while solving an identical design brief.

The paper concludes by highlighting the importance of understanding the impact of assessment criteria on student performance. Students, who constructed not only their own meaning, but also the rationale for their meaning, demonstrated a higher level of graphical capability.

Keywords: Design Graphics, Assessment

Introduction

Efforts have begun to initiate a dialogue on developing graphicacy[2] as a broader conception of what is critical education. Graphicacy, best described as the intellectual process of acquiring and communicating meaning from visual images and forms, requires education to question the definition of current graphics based courses. What is it we teach when we teach graphics?

Developing graphicacy is less well accepted when compared to the cornerstones of literacy, numeracy and articulacy as critical aspects of educational provision. Defining graphical

capability and ultimately its relationship with visual literacy becomes essential when defending its position and purpose in formal education. The evolution of technology/engineering education from vocationalism to a design driven neo-vocationalism or even transferable education begins to blur the boundaries of the definition of a graphically capable person.

Specifically in engineering and technology education there is a growing need to develop transferable skill. Ritz[3] argues that educators and policy makers must "*look beyond the development of engineers, industrial technologists, or craft workers"* and outlines that we must take educators beyond the limits of specific professions. Moving towards a broader education agenda, the provision of technical skills must aligns with the global consensus that values problem solving, creativity, and design[4].

Technological Design Graphics

It is pertinent to debate the importance of identifying attributes, skills and knowledge appropriate to developing a knowledge economy. Dunbar[5] proposes that this is problematic in an Irish context where a lack of continuity between the formal and the implemented curriculum exists due to the lasting traditions of a vocational focus.

Balancing the technical skill acquisition and domain specific knowledge with the development of specific transferable skills is the challenge facing graphical educators. Culturally, there is often a difficulty in re-conceptualizing the role of graphical education, when its position in an industrial aged context held much esteem. Ferguson[6] highlights the importance of graphical competencies within a practical context.

> *'Certainly it is very difficult to transmit through the medium of natural language or scientific notation knowledge of certain sorts of dextrous skill or sensory discrimination, or to render into natural language adequate equivalents of, say, musical notation or engineer's orthographic drawings of mechanisms'.*[6]

Draker[7] describes the "hegemonic behaviorist cycle" as the prevailing model in technological education. This sees the learner as a passive object in the learning process, with the role of the instructor presenting expertise. Hansen[8] proposes that often much of the learning that takes place in schools is based on the students' interpretation of the teachers experience and knowledge. This model of didactic transposition is questioned by McGarr[9] who calls for a pedagogical strategy in graphical education that supports students becoming active constructor of meaning, while developing universal transferable skills.

Seery et al[10] presented a preliminary idea of the relationship between elements of graphical education with transferable (design driven) graphical competencies as a dependent variable. The need to develop technical language skills and analytical geometry skills is presented as a prerequisite to learning transferability and meta-cognitive processing.

Graphicacy presents a contemporary view of graphical education that looks beyond a standardized, product focused and declarative knowledge base and instead explores the value of harnessing the intellectual value of developing graphical skills. Focusing on the communicative function of graphics, this study looks at external and internal graphical dialogue. The idea of an external dialogue can be presented as the ability to create, manipulate and comprehend the technical language of standards, conventions and technical specifications and the ability to produce analytical solutions with deductive reasoning, and present data, ideas and concepts. The role of internal dialogue or dialectic is a more implicit concept that supports the development of an ability to synthesize ideas, see relationship and synergies and utilize external representations as a means of refining cognitive process. This dialectic approach supports students using graphics as a medium for innovation, evaluation, reflection and enquiry.

Assessment and learning

Assessment must capture a broader conception of understanding and tacit abilities while still being valid and reliable. To capture what counts as educational attainment becomes increasingly difficult when we change the nature or construct of what it is that we are trying to measure. Two difficulties with assessment compound this issue. Firstly, assessment reduces ambiguity by increasing standardisation[11] which increases the difficulty of trying to capture something that is not explicit. Secondly, Hanson[12] outlines that assessment instruments are representational with assessors tending to infer a specific performance and not ability. This is evident when you look at Davies[13] discussing *Art and Design* and Baynes[14] discussing *Design and Technology* where they agree that the focus of assessment tended to be on the artifact/product and not on the process of learning. This results in students being prevented from developing learning heuristics or constructing epistemological understanding of the discipline.

A predetermined or transitive route through a learning activity will have a significant impact on the student learning and the resultant measure of success or failure. Rather than guiding students through the learning activity they should be supported in the construct of value and meaning within the task domain, therefore leading to a true representation of their capabilities. This constructivist approach to teaching and learning must be complemented by a model of assessment that facilitates the student in their learning process. Pryor and Torrance [15] identify two distinct approaches of convergent and divergent assessment within the formative assessment paradigm. Convergent assessment is concerned with establishing if a student knows, understands or can do a predetermined thing. It is characterized by rigid planning and explicit methods of recording or quantifying the student activity. On the other hand divergent assessment emphasizes student understanding rather than the agenda of the assessor. The critical aspect of this approach is to establish what a student knows, understands or is able to do at the end of a learning task. It is characterized by more flexible forms of planning with open forms of recording or presentation of student work/learning, analyzing the interaction of the student and the curriculum from the point of view of the student.

The focus of assessment must develop an internal capacity to monitor and evaluate students own work if they are to improve and progress their learning[16]. For successful formative assessment students must think about criteria in a principled way and not just passively react to them as an extrinsic reward for effort in that area[15]. Rust et al[17] outlines that simply providing students with criteria or marking guides will not ensure a common informed understanding.

In an attempt to present the complexities of what is a broad area of study, the literature initially highlights the need to examine a broader conception of graphical education. The shift towards transferable skills requires further research into the richness of human capacity and ultimately valuing a more tacit knowledge. Developing what are often described as the 'softer skills' requires a more comprehensive understanding of student ability and questions the effect of current educational practices on student learning. Measuring and defining what constitutes effective learning in a less explicit paradigm, begins to uncover significant difficulties.

This paper looks at the part assessment plays in supporting effective learning and questions the wisdom of over defining outcomes. Instead explores the impact of assessment by focusing on the richness of outcomes when the student (being capable) defines evidence of capability.

Method

The study explores the impact of alternative assessment constructs on the performance of two homogenous off set cohorts of Initial Technology Teacher Education students. The study observes students development of a portfolio in response to a given design task. The initial group was required to produce their solutions in response to determined (see Table 1) assessment criteria (needs were determined by the teacher/expert), while the second group were required to solve the same brief by demonstrating their view of graphical capability with no explicit outcomes defined (develop their own epistemological understanding). For descriptive purposes these groups were labeled as '*Determinist'* and '*Non-Determinist*'.

The off-set cohort analysis type study was utilized to compare work from the two consecutive year three groups. A stratified sample was employed within each group to ensure that the variability within strata was minimized and comparisons were equitable. Work from the *Determinist* group (total n=122) included an equal distribution of portfolios from each of the performance quartiles (sample n= 20), and a comparable sample (n=20) was also taken from the 'Non-Determinist group (total n=127) across the same performance distribution.

In keeping with a thematic approach to technological design tasks, students were challenged to solve a socially contextualized brief (see Table 1).

Table 1 – Design Task and assessment criteria

Brief *Population pyramids for many developed countries highlight the reality of an aging population. The inevitability of growing older brings with it many challenges to everyday activities. This calls for new and innovative thinking to enrich the lives of our elderly and ensure facilitation of the emotional, physiological, and social needs that guarantee an independent, dynamic and stimulate life. Reinforcing the link between technology and society:* *Design and model a personal device/artifact that will enhance the quality of life for an elderly person.*	
Determinist Criteria	**Non-Determinist Criteria**
Instructor defined outcomes • *Analysis of brief* • *Research and investigation* • *Ideation sketches* • *Technical details* • *CAD model* • *Presentation of solution*	*Student defined outcome* *From a culmination of your knowledge and experience to date demonstrate evidence of graphical capability*

The design task was a significant element (25%) of the core graphics module (15 weeks in duration) studied by year three teachers, with a summative approach to assessment.

Findings

From general observations of the design portfolios, all pupils converged on solving a problem that had a personal meaning (problems tended to be contextualized by subjects close to the participant i.e. relatives or personal friends). It was apparent from the solutions to the brief that students from both groups identified problems that were observed and 'real'. This would suggest that the relevance of the brief was appropriate to both cohorts and each student had the capacity to personalize their own learning activity in response to the thematic brief. The lack of meaning that is often evident in technological briefs was for the most part was eliminated.

The quantitative analysis indicated that there was no significant difference in relation to the number of sheets produced by students from each group (mean no. of sheet for *Determinist* group was 13.8 and *Non – Determinist* group 13.75). However, while a low standard deviation (SD = 1.7) was recorded for the '*Non-Determinist*' group, students in the '*Determinist'* group tended to have more sheets in the top quartile and significantly less that the average for that group in the lowest quartile. This would suggest that the '*Non-Determinist*' students had a more coherent comprehension of what was expected despite not having explicit criteria, while students in the '*Determinist'* group at either end of the spectrum did not display a clear understanding of what was sufficient and appropriate to present as evidence of learning. This initial observation suggests that there is an epistemic uncertainty when students are prevented from constructing meaning and can result in a responsive and pre-determined approach to learning if the outcomes are over defined.

As must of design driven education is subjective in nature a qualitative approach to the analysis was taken. This analysis observed three primary categories that were apparent from the completed portfolios.

- The apparent difference in the design approach – Rigidity and fluidity.
- Students in the different groups tended to use graphical elements/media in different ways, highlighting the difference between the internal and external dialogue.
- The function of the portfolio and the presentation of the outcomes as evidence of capability and learning were different.

The evidence of the three categories is presented in the following sections.

Rigidity and Fluidity

Determinist portfolios produced in response to the six headings (or assessment criteria depending on your perspective) on average resulted in students producing an equal number of sheets for each of the headings. This even distribution of time, effort or focus was made irrespective of the requirements of their chosen design problem. It suggests that response to the guidance became the task as opposed to internalizing the activity and producing a solution that illustrated evidence of graphical capability. Alternatively, 'Non-Determinist' portfolios in general had a greater emphasis on the analysis of the problem and the evolution of the solution. For the most part the presentation of the finished product were confined to a single page and the nature of this presentation also differed as it tended to be in context, rather than an isometric within the CAD modeling software. Non-Determinist portfolios in general presented a clear and logical flow, as determined by the student, representing the narrative of their design evolution.

Internal and external dialogue

Apparent throughout the 'Non – Determinist' portfolios was the use of ideation sketching as a means of refining and exploring their ideas. Figure 1 illustrates the use of sketches to refine a 'duel function walking stick'. The sketches are not precious[18] in terms of communication, but instead give a clear insight into the thought process and refining of the concept. This aligns with Kimbells[19] dialectic design model presenting a conversation between the mind and hand as a means of cognitive refinement. The figure also includes rendered parametric CAD images to communicate the finished artifact. What is notable and consistent within this group is the evidence that students make appropriate decisions about the selection of graphical functions aligned with specific design stages. Instead of responding to predefined headings, these students made graphical decision based on an understanding of graphical capability.

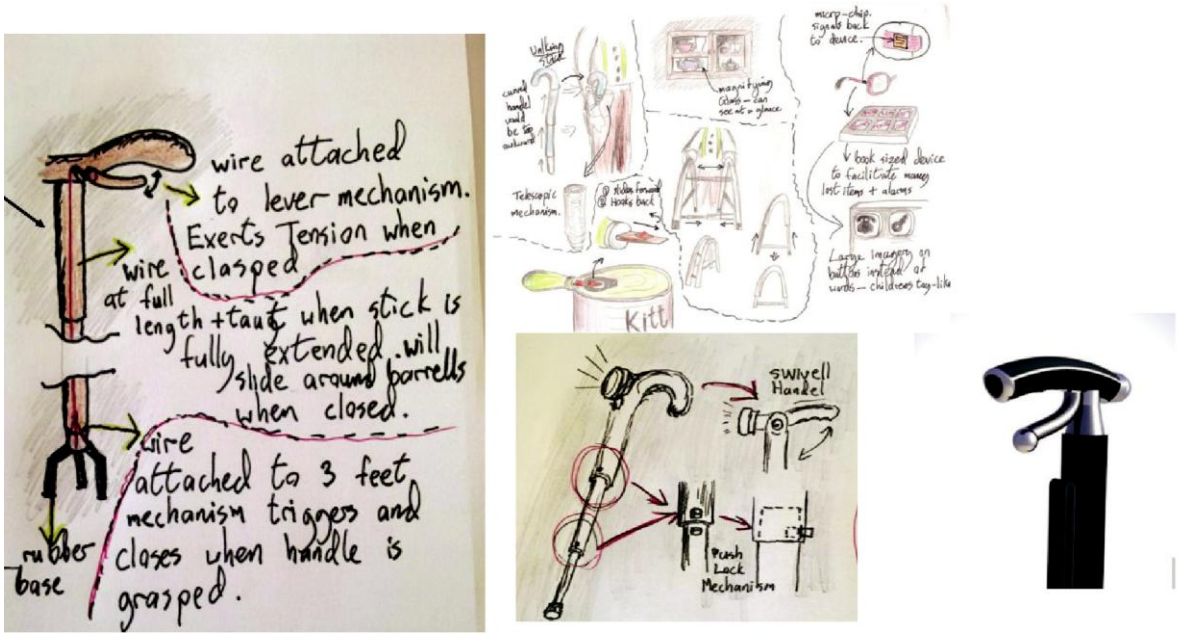

Figure 1 – Purposeful, non-precious ideation sketches

Alternatively, portfolios from the '*Determinist'* students were aligned responses to the given assessment criteria. Evidence from these portfolios illustrated a difference in relation to the purpose and function of the graphical elements. The manner of the response is interesting, when you consider the use of ideation sketching. Figure 2 illustrates evidence from two '*Determinist*' portfolios; the sketched ideas are absolute and communicative in nature, presenting a design solution and not an iterative process. From an assessment perspective the sketches (at least from the students' perspective) fulfill the criteria. However, there is no evidence in the work presented that either student used sketching as a means of reflection or refining cognitive process. Comparing the sketch and CAD model of the 'Skype phone' solution demonstrates a lack of understanding of the function of design stages and the function of graphics within these stages.

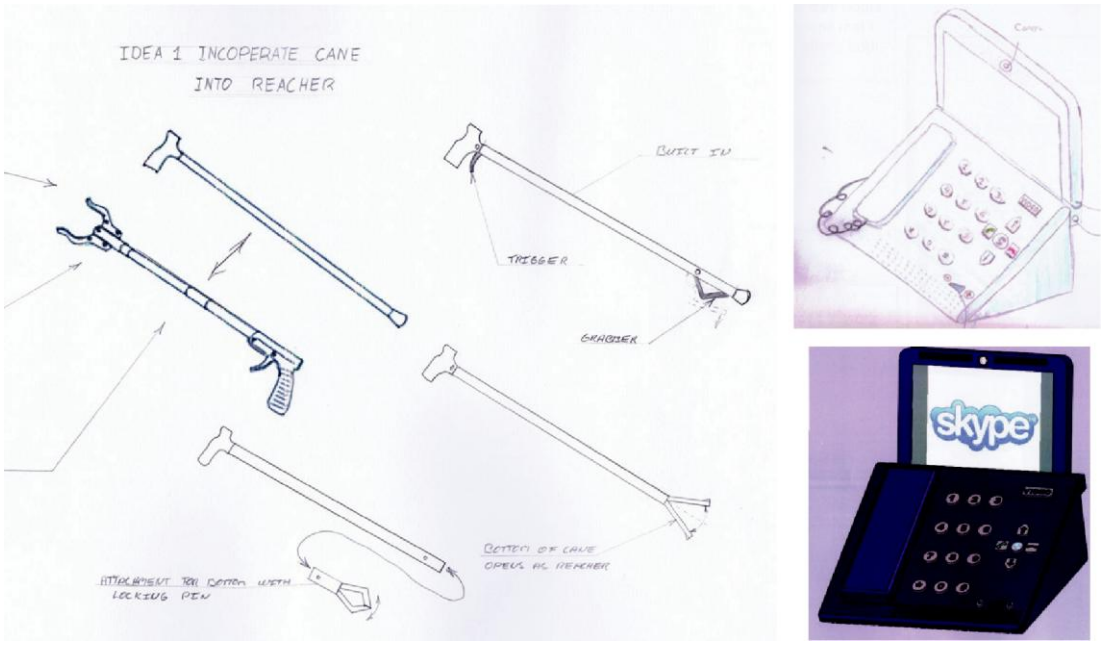

Figure 2 – Technical sketches to communicate a fixed solution

Aligned with the observation made by Lane et al[18], it was apparent from the majority of portfolios (and illustrated in Figure 2) that there was a precious nature to the technical sketches, and a clear intent to present representational drawings of their solution. This representation of the solution is also the objective of the CAD model, also demonstrating a lack of insight into the function of parametric modeling as a design tool.

Positivist and constructivist portfolios

Barrett and Carney[20] (2005) describe the purpose of a portfolio as a record of learning outcomes that can also serve assessment objectives. This study set out to question the construct validity of graphical education by exploring the impact of externally mandated criteria on student outcomes. As a result, analysis of the portfolios was conducted using a distinction proposed by Paulson and Paulson[21] where they described two different paradigms relating to portfolio construction *'Positivist and Constructivist'*. Positivist portfolios tended to be convergent in nature with an emphasis on the product, while the constructivist portfolios illustrated construction of meaning, clearly showing evidence of the learning process.

Without ambiguity, the retrospective analysis of the *Determinist* group identified the portfolios as conforming to a positivist definition. Portfolios presented by students in the '*Non-Determinist*' group (more so in quartile 1 and 2) produced portfolios aligned with demonstrating evidence of construction of meaning, decision making, refining and learning.

Discussion

Considering the approach taken by the '*Non-Determinist'* group (where the output was not made explicit), the consistence in the number of sheets produced in the portfolio is significant, especially with a large variance in the comparative group (who had defined outputs). This difference although not defendable or conclusive in determining an agreed epistemic stance, it is indicative of the epistemic certainties and uncertainties that mask the definition of graphical capability.

Using Argryis[22] double looped model of learning as a theory for investigating the difference in approach to the construction of the portfolios, is was apparent that students presented evidence of learning in different ways. It cannot be assumed that the difference manifested between groups was in relation to the assessment criteria, as both groups were focused on the module goals, but in the creation of the criteria in response to their interpretation of these goals. Much research has identified that epistemological beliefs can affect student's reasoning[23], judgment and motivation[24].

Students in the '*non-Determinist*' group not only presented evidence of capability but also were required to form an understanding of what it means to be capable. These students had a rationale for their response to those criteria, as they were purposeful and understood. This aligns with the work of Barlex and Trebell[24] who argue that competency develops with coherent thinking and not just as an accumulation of knowledge. The effect that externally mandated outcomes had on student's graphical capability encouraged a non-internalize response.

From the observations that categorized students work into internal and external dialogue, it would appear that there is a greater intellectual value associated with graphical education when you consider its capacity to support synthesis and refine cognitive process.

Conclusion

The findings indicate that the positivist portfolio resulted from a deterministic approach to the assessment of graphical capability. This limited the students in making decision about graphical media and application and hence presented a constrained view and development of the students' capability. Alternatively what resulted in a constructivist portfolio supported student engagement on a deeper and more holistic level and clearly demonstrated competencies such as ideation, cognitive modeling, use of graphical language, application of graphical systems, use of geometry as an analytical tool and effective communication skills. The study highlights the impact that externally mandated assessment criteria have on the expectation and level of engagement of students. However, it is not intended to present a cause and effect type argument, but instead question the construct of contemporary graphical education and consider the impact and potential of current practices.

Reference

1. Fish, J., Scrivener, S. (1990). Amplifying the Mind's Eye: Sketching and Visual Cognition. Leonardo, 23, 117-126.
2. Norman, E. and Seery, N. (Eds) (2010) IDATER Graphicacy and Modelling, Loughborough
3. Ritz, J. (2009). "A New Generation of Goals for Technology Education." Journal of Technology Education 20(2), 50 - 64.
4. Rasinen, A. (2003). "An Analysis of the Technology Education Curriculum of Six Countries." Journal of Technology Education 15(1): 31 - 47.
5. Dunbar, R., (2010) Informing Technology Teacher Education; Exploring the Effects of Contemporary Teaching and Learning, PhD Thesis , University of Limerick
6. Ferguson, Eugene S (1993) Engineering and the Mind's Eye, Cambridge Mass, MIT Press
7. Dakers, J. (2005) The Hegemonic Behaviorist Cycle, International Journal of Technology and Design Education, 15, 111-126
8. Hansen, R. (2010). Technological Learning and Thinking: A Statement on the Pedagogical Terrain. TL&T Conference, Vancouver, British Columbia June 17-21, 2010
9. McGarr, O. (2010) The elephant in the room: the influence of prevailing pedagogical practice on the integration of Design and Communication Graphics in the post-primary classroom. In: Norman, E. and Seery, N. (Eds) Graphicacy and Modelling, p. 121 – 129.
10. Seery, N., Lane, D., and D. Canty, (2010) Pedagogical Challenges Facing Design and Communication Proceeding of the 65th Engineering Design Graphics Division of the ASEE Mid Year Conference, Michigan
11. Wiliam, D. (2010) What Counts as Evidence of Educational Achievement? The Role of Constructs in the Pursuit of Equity in Assessment. Review of Research in Eduaction 34: 254
12. Hanson, F. A. (1993). Testing testing: Social consequences of the examined life. Berkeley:University of California Press.
13. Davies, A., (1996) Assessment and transferable skills in art and design. International Journal of Art and Design Education, 3, 327-331.
14. Baynes, K. (2010). "'Models of Change: The future of design education'." Design and Technology: An international Journal 15(3): 10 - 17.
15. Pryor, J. Torrence, H. (1998). Formative Assessment in the Classroom: Where Psychological Theory Meets Social Practice. Social Psychology of Education 2: 151–176,
16. Sadler, D. Royce (1989). Formative assessment and the design of instructional systems. Instructional Science, 18, 119–144.
17. Rust, C., O'Donovan, B., & Price, M., (2005): A social constructivist assessment process model: how the research literature shows us this could be best practice, Assessment & Evaluation in Higher Education, 30:3, 231-240
18. Lane, D., Seery, N., Gordon, S. (2010). A Paradigm for Promoting Visual Synthesis through Freehand Sketching. Design and Technology Education: An International Journal, 15(3), 23.
19. Kimbell, R., Stables, K., Wheeler, T., Wosniak, A., Kelly, V., (1991) 'The Assessment of Performance in Design and Technology', School Examinations and Assessment Council/Central Office of Information, London.
20. Barrett, H. and J. Carney, Conflicting Paradigms and Competing Purposes in Electronic Portfolio Development. Educational Assessment, 2005.
21. Paulson, F.L. and P.R. Paulson, Assessing Portfolios Using the Constructivist Paradigm. American Educational Research Association, 1994.
22. Argyris, C. (1991) Teaching Smart People how to Learn. Harvard Business Review,4, 2.
23. Sinatra, G., S. Southerland, et al. (2003). "Intentions and beliefs in students' understanding and acceptance of biological evolution." Journal of Research in Science Teaching 40(5): 510-528.
24. Paulsen, M. and K. Feldman (1999). "Student motivation and epistemological beliefs." New Directions for Teaching and Learning 1999(78): 17-25.
25. Barlex, D., Trebell, D., (2008) Design-without-make: challenging the conventional approach to teaching and learning in a design and technology classroom. International Journal of Technology Design Education, 119–138