University of Limerick

The Impact of Holistic Assessment using Adaptive Comparative Judgement on Student Learning

A thesis submitted to the University of Limerick for the degree of

Doctor of Philosophy

by

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Declaration

I declare that this thesis has not been already accepted in substance for any degree and is not being submitted in candidature for any degree.

_________________________    _______________________
Student                        Supervisor

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Date                            Date

Statement

I affirm that the substance of this thesis is entirely the result of my own investigation and that due reference and acknowledgement is made where necessary to the work of other researchers.

_________________________    _______________________
Student                        Supervisor

_________________________    _______________________
Date                            Date
Dedication

This work is dedicated to Evelyn, Ava and Leah for their love and support throughout the completion of this study.
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Abstract

The shift in philosophy in Irish technology education has brought with it new challenges for practitioners, curriculum developers and awarding bodies. With the emphasis on technological capability the technology student must not only demonstrate the acquisition of knowledge, skills and problem solving abilities in context, but must also construct the meaning that defines a technologically capable person.

Traditionally in Technology Education, the over emphasis on product outcomes measured by summative criteria creates a dichotomy between the curriculum objectives and the inference drawn by assessment. Valuing the process of learning and the wide range of skills and experiences uniquely developed by the individual poses a significant challenge to the relevance of assessment constructs.

This study tracks the experiences and performance of 406 initial teacher education students as they develop a personal construct of technology capability and democratically converge on cluster qualities that support valid assessment. The research integrates assessment with learning by using holistic peer judgement facilitated by an Adaptive Comparative Judgement model of democratic assessment.

Independent of mandated assessment criteria, the student defined personal construct of capability determined the nature and quality of their peers work. Across the three years of this research, ACJ is presented as a valid, reliable and effective method of discriminating qualities of capability to generate a valid ‘measure’ of what to value in design driven education.

The study presents an empirical insight into the iterative, dialectical, non-linear nature of design based education and highlights the significance of appraisal skills in facilitating autonomy, diversity and personalised learning.
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1. INTRODUCTION
1.1 OVERVIEW

Defining the domain and nature of technology education has been a constant challenge for those that study, critique and/or acclaim its merits. The shifting nature of knowledge in technology education calls for a curriculum and pedagogy that empowers learners with the skills of acquiring and creating knowledge in the pursuit of solutions to problem based tasks. Malcolm Shirley in his forward in Kimbell and Perry (2001) outlines the contribution of Design and Technology in the English curriculum describing the subject as “a learning experience which is unbounded by fixed bodies of traditional knowledge, and transcends the academic/practical divide”.

As well as transcending the academic/vocational divide technology education is seen as a domain in which a broad body of knowledge and skills is combined across the arts, sciences and mathematics (McCormick 1997; Kimbell and Perry 2001; Ritz 2009). The constant state of flux of the technology education domain is highlighted by Kimbell et al. (1991), with variables that are ever changing as generations of learners pass through our education systems. “Technology education impacts on and is influenced by the political, economic, physical and social world in which we live and these influences create the climate in which some outcomes are seen as more desirable than others” (Kimbell et al. 1991)

As society evolves and changes, often as a result of technology, so too does the requirement for us to become capable in our environment. Being technologically capable requires the development of knowledge, skills and values in an inter-related context. As we move with this change so too must our education system, embracing and furthering all that is new, while valuing and building on that of value from the past. The teacher, student and curriculum must all be able to respond to the challenge that this poses.

It is recognised that technology education presents students with a learning environment that is not as rigid as other areas of the curriculum. Traditionally, academic subjects such as mathematics and science can (often unintentionally) promote convergent thinking that usually leads to one solution to a predefined problem (Johnstone and Al-Naeme 1995; Seery et al. 2010). The significance of
technological education is its support of divergent thinking, where the student is presented with a problem and can apply their own personal ideas and subject knowledge, (irrelevant of how) to solve the specific brief. The educational outcomes of creativity, autonomy, fulfilment and problem solving are essential elements of a broad and balanced curriculum and illustrate how technology based subjects are striving to adopt skills and aptitudes that our rapidly changing global society necessitate. The resultant challenge that faces participants in this matrix of activity is how to effectively achieve these outcomes in a meaningful way, and how, once achieved, the level of capability can be valued and rewarded.

1.2 THE IRISH CONTEXT

Technical education in Ireland developed in response to societal needs for a skilled workforce and is vocational in heritage. The development and progression of vocational education and training presented by Heraty et al. (2000) provides a clear description of the development and provision of practical education. Second level technical education traditionally focused on three distinct streams of study; construction, engineering and technical drafting. The discipline specific emphasis resulted in material biased subject areas where pupils participating in second level technical education chose subjects housed in Woodworking and/or Metalworking at Junior level (Years 1 to 3 of Second Level education) and Construction and/or Engineering as part of the Senior Cycle (Years 4 and 5 of Second level), (Technical or Mechanical Drawing was studied as an independent subject). The focus of these subjects was knowledge and skills development through the medium of prescribed project work and related theory. The subjects were vocationally focused in content, delivery and outcomes with goals of preparation for the workforce. In 1984 The Curriculum and Examinations Board (CEB) identified science and the new technologies as one of eight elements in a new framework proposed for the Junior Cycle Curriculum. The focus of this change was to balance the vocational and educational objectives and provide students with knowledge and understanding in a domain that would meet societal and economic needs. In 1986 the CEB reported that “Science and Technology must be seen as part of the general educational experience to which all students are exposed”. The progression and implementation of this vision was stifled by a lack of clarity in defining the subject domains; additionally
the potential threat perceived by subject teachers to the existing science and technical based subjects ceased progress. In 1987 the CEB was disbanded and replaced by the National Council for Curriculum and Assessment (NCCA).

This new body brought a different perspective to science and technology education where the two were separated into individual domains and resulted in the introduction of Technology as a standalone subject at Junior Cycle level in 1989. However, this progressive subject with a contemporary design based focus was now placed within the domain of the vocationally orientated technical subjects. A lack of in-service teacher training saw the subject struggle to create an identity within the strong vocationally focused teaching body which hampered its development at Junior Cycle (McGuinness 1997). A further proposal to amalgamate the four junior cycle technical/technology based subjects into one subject called Technology was met with a hostile reception with many practitioners from the technical subjects concerned that it would lead to “the relegation of craft abilities to a second-rate stratum” (TUI 1992). In 1992 consensus on the Junior Cycle technological based subjects was reached. Table 1.1 presents the technology subjects pre and post this period of review.

<table>
<thead>
<tr>
<th>Pre Review</th>
<th>Post Review</th>
<th>Year Implemented</th>
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<tbody>
<tr>
<td>Metalwork</td>
<td>Metalwork</td>
<td>1936</td>
</tr>
<tr>
<td>Woodwork</td>
<td>Materials Technology (Wood)</td>
<td>1992</td>
</tr>
<tr>
<td>Mechanical Drawing</td>
<td>Technical Graphics</td>
<td>1992</td>
</tr>
<tr>
<td></td>
<td>Technology (New)</td>
<td>1989</td>
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The revised subjects, in particular MTW (Materials Technology (Wood)) and Technology, integrate a design focused approach in the teaching and assessment of the curriculum. The lack of in-service training lead to an incoherent approach to teaching through design where teachers individually make the transition from the traditional process driven approach to the delivery a design approach. Carty and
Phelan (2006) categorised Irish technical education as a “craft-oriented approach” with a possible movement towards a “design approach” in some subjects. This statement shows that the strength of the vocationally orientated traditional craft based influence still prevailed almost 17 years after the initial inclusion of design as a methodology for teaching and learning.

In 2007 the philosophical shift to design based education was embraced at Senior Cycle\(^1\) where the design and implementation of new syllabi formed the basis of a sound approach to achieving the goals of contemporary technology based education. This new suite of subjects shows a significant change in the subject area philosophy, with the driving force now being technological awareness and design in all subjects at this level. The aims of the new syllabi changed the focus of technology education, aiming to provide students with the skills associated with design and realisation and the ability to apply these skills by thinking and acting imaginatively and creatively. However, defining a generic domain for technology based education is made difficult by the contextual setting and needs of individual curricula. Williams (2009) highlights this difficulty by outlining the struggle for technology education to find its place in the school curriculum. It is recognised that the contemporary technology subject has the potential to develop and deliver outcomes of autonomy, creativity, problem solving, self-actualization, critical reflection/appraisal and communication skills (Kimbell and Perry 2001; Barlex 2007; Williams 2009). These outcomes are a significant change from the vocational approach that focused value on declarative knowledge and the development of practical hand skills.

Historically, technology curricula have always faced the challenge of keeping up to date with new and emerging technologies, materials, practices, and societal needs. However, many international commentators and studies report on the significance of pedagogical practice, and teacher values and attitudes on embracing and implementing change. Owen-Jackson (2000) and Banks and Barlex (2002) comment

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\(^1\) Four syllabi were published, two of which were implemented in 2007 – Technology and Design and Communication Graphics.

The remaining two syllabi, Architectural Technology and Engineering Technology are pending implementation.
on how traditional pedagogic practices based on the transfer of knowledge are generally imposed on a new domain. These pedagogical practices are grounded on passive conformity rather than encouraging creativity and critique (McGarr 2010). The influence of this pedagogical strategy according to Drakers (2005) argues that:

“... learning in this narrow model is linear and instrumental and to all intents and purposes, not meaningful learning at all. It is more concerned with the assimilation of the young into an already established value system which has more to do with control than it has to do with liberation”. (p.113)

Dow (2006), reporting on a European Commission consultancy document looking at good practice in Maths, Science and Technology across Europe, highlighted the conflict between curriculum policy and practice and identified teachers’ reluctance to change as a significant problem. The study’s findings also proposed that the dominant model of teaching in the field of technology and science across Europe centred on a behaviourist transmission model dominated by whole class teaching and passive student participation.

With the new aim of technology education focusing on “… a balanced education, giving students a broad and challenging experience that will enable them to acquire a body of knowledge, understanding, cognitive and manipulative skills and competencies and so prepare them to be creative participants in a technological world” (NCCA 2004 p. 8), the challenge is to ensure that teachers are not only competent in their subject domain but also that their pedagogical practice and value system align with the new subject philosophy. This poses a challenge to Initial Teacher Education (ITE) providers to implement programmes of study that allow students to personally explore and define the role and value of technology education. Students must develop technical competency within the domain that are complemented by the development of a new pedagogical practice, embracing the new subject philosophy. Shifting from solely the provision of technical skills to a broader education agenda supports the global consensus that values problem solving, construction techniques, creativity, and design (Rasinen 2003).
1.3 SHIFT IN FOCUS

Balancing the provision of predefined craft education with the inclusion of design driven technological competencies now presents practical, philosophical, and pedagogical challenges for teachers and curriculum assessment. Identifying and understanding what to value is the primary challenge facing contemporary teaching, learning, and assessment. There is considerable debate, nationally and internationally, on the importance of identifying skills and attributes appropriate to developing a knowledge economy where curriculum and practice play a significant role. This is problematic in an Irish context where a lack of continuity between the formal and the implemented curriculum now exists due to lasting traditions of the vocational focus (Carty and Phelan 2006; Dunbar 2010). Ritz (Ritz 2009) makes a direct call for educators and policy makers to “look beyond the development of engineers, industrial technologists, or craft workers” and argues that we must take educators beyond the limits of specific professions. Recognising the need for a coherent approach to the core of technology education necessitates the identification of contemporary values and goals that underpin the new conception of technological education. Lewis (2009) claims that there are a variety of generative cognitive processes that are more likely to occur in technology education than elsewhere in the curriculum. To face this challenge will mean addressing the hegemonic culture ingrained in technology education that has hindered the growth and potential of the design based approach to date.

1.3.1 Challenge to Educators

The age old education discussion that questions the essence of teaching and learning and calls for a participative approach to education has never before been so important. Many commentators highlight the failing of current educational practices and identify its lack of flexibility in facilitating the learner in making meaning as critical. Lindeman (1926) - cited in (Hansen 2010) claims that “Too much of learning [in schools] consists of the vicarious substitution of someone else’s experience and knowledge.” Edwards et al (2002) supports this claim by arguing that the defined curriculum is often distinctly different from the student’s experiential
inherent knowledge and the knowledge that they require on completion of formal education. Edwards also argues that “that passive regurgitation is prized over a disposition to enquire; and that teachers are assessed on their ability to deliver knowledge rather than assure understanding and support children’s disposition to be learners”. Prashnig (2004) highlights the misguided emphasis been placed on “what people know”, and argues the importance of a paradigm shift from “knower to learner” placing value on “how people learn”. Therefore we need to question the entire structure of education and radically rethink our view of education (Robinson 2006).

1.3.2 Conformity in Sorting

With clear objectives for technological education and an understanding of the role of the subjects within the context of contemporary schooling, the focus shifts to assessing student competency. The importance of differentiating between the assessment of and for learning (Stiggins 2005) becomes central when focusing on the process. Kimbell (2010) adds a further level of complexity that highlights the conflict that may exist between curriculum policy and assessment policy, with the difficulties centring on standardisation and testing. This questions the validity of what it is we are actually measuring. Students conforming to the assessment criteria and aligning their outputs to address given criteria (regardless of meaning) facilitate the sorting nature of contemporary assessment. This assessment challenge is amplified within technological subjects as Kimbell et al. (1991) argue that the essence of the problem with design based educational activities lies in the transformation of active capabilities into passive products.

Assessment criteria that over-define the stages and functions of design can render the objective benign due to the exploration, experience and decision making that is central to learning being removed. True technological capability involves self-monitoring and awareness of how and when to use particular skills and knowledge. Barlex and Trebell (2008) argue that competency develops with coherent thinking and not just as an accumulation of knowledge. They outline that the value of design based activities lies in autonomy, the context and need to acquire relevant multi-
disciplinary knowledge, demonstration of capability, problem solving, communication, and synthesis.

The problem is trying to measure evidence of thinking while encouraging diversity within a system predicated on standardisation and weighted criteria. Kimbell (2007), reports that “Learners can be excellent in design and technology in dramatically different ways”. Therefore, the outcomes and solutions to design problems can often involve more variables than can be represented in a design sequence or loop (Williams 2000). Facilitating diversity in response to design must be supported; the difficulty lies in the inability of traditional criterion referenced assessment to accurately measure the process of the activity. So how do we help student manage uncertainty, to welcome ill-defined problems and take ownership of their own learning?

The measure beyond the artefact or finished product is critical to ensuring the sustainable value of design driven competencies. Measuring a complex iterative process requires a flexible model of assessment that can value evidence of learning in response to individual heuristics while supporting diversity and measuring capability.

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**1.4 RESEARCH QUESTIONS**

A number of inter-related areas have been identified that are central to the effective implementation of the goals and objectives of technology education. This study focused on two workshop-based courses, traditionally rooted in the development of craft based skills (i.e. wood and metal working), that are core to the development of technological capability in the technology based Initial Teacher Education programmes in the University of Limerick.

This study explores the shift in focus of technological education and the corresponding change by technology teacher education programmes. The study focuses on the Year 1 students of two concurrent undergraduate teacher education programmes, which were traditionally defined by a craft based heritage. The students of these programmes are the practitioners of the future and potential agents for change within the culture that currently exists.
Responding to the shift in focus from the acquisition of skills to the inclusion of designed based aptitudes, these modules necessitated a revision of teaching and learning activities. Broadening the educational experience and perspective of students within the constraints of traditional institutional structures demanded a clear aligning of educational approaches with learning outcomes. The research focused on the following research questions:

1.5 AIMS AND OBJECTIVES

This study aims to evaluate the impact that holistic assessment has on student performance and engagement in design based tasks and activities. Central to the study will be the focus on the development of technological capability defined by contemporary education. The study will also focus on the impact that this approach to assessment may have on teaching and learning in the area of technology education.

- Could the nature of assessment be changed to consider and value the development of meaning through students’ personal construct of capability?

- Can holistic assessment value student performance and capability in a design based educational setting.

- Is there a value in engaging students in peer assessment in initial teacher education development?

1.5.1 Objectives

The study will endeavour to:

1. To investigate the impact of integrating assessment as a vehicle for learning in design based technology education
2. To evaluate student capacity to develop a personal construct of capability in design based technology education.

3. To establish the construct validity of holistic peer (student) assessment derived from their individual personal construct of capability.

4. Evaluate the validity and reliability of peer assessment in discriminating quality of student performance in a design based learning task.
2 LITERATURE REVIEW
2.1 INTRODUCTION

Technology education, through its design based approach, has a significant role in the holistic education of the student for our modern times (Kimbell 2001; Ritz 2009; Williams 2009). The key elements in this area are the curriculum, the teacher and the student. Each have a significant role to play and can have considerable bearing, both positive and negative, on the outcome of the process.

Initially, the international consensus on the role and purpose of technology based education will be discussed. This will examine the factors influencing the nature and goals of the subject internationally and in the Irish context. Following this, an analysis of the approaches to learning in technology education will be examined. This will present the convergence on the design based approach as a methodology in delivery of the goals of contemporary education. With the goals and approach to contemporary education outlined, the next section will present what is internationally recognised as constituting capability within this subject domain. Once identified the critical issue of pedagogical practice and its impact on the learning and development of capability is presented. Evidencing and assigning value to these capabilities is then explored to identify an appropriate assessment mechanism that will complement the dynamic, fluid and personal nature of learning through a design based approach in technology education.

With the focus of evidencing learning and capability, the study must first establish the key elements that will affect the learning process. This section examines a number of relevant approaches to education with the focus on learning through design based activity.

2.2 INTERNATIONAL PERSPECTIVE

Gibson (2008), Jarvis and Rennie (1998), outline that a fundamental reason for the inclusion of technology education lies in governments’ awareness that this subject has the potential to enhance a country’s economic prosperity by, for example, developing the knowledge, understanding and skills of its citizens. The potential contribution of design based technology subjects to the knowledge economy is well documented by Kimbell and Perry (2001). Barlex (2000) argues that technology education can make a
significant contribution to the development of educational goals such as “greater autonomy, increased creativity, problem-solving, and the opportunity to engage in critical reflection, a truly impressive situation”. Atkinson (2000) outlines that design and technology based activities provide ideal opportunities to develop skills of problem solving, creative thinking, critical thinking and analytical thinking. Developing these skills require students to take risks, be flexible in their thinking and be motivated to deeply engage in a thinking process around the task (Atkinson 2000). Williams (2009) describes how technology education is struggling for relevance and definition in the current post modern era of globalization, taking on various forms in different countries. Rasinen (2003) identifies two distinct forms of technology education curricula, the lehrplan type documents and the standards type documents. The former provides very specific details of the domain content and how it should be taught with the latter concentrating on the curriculum goals to be met within the technology education domain. A shift toward the standards type approach to curriculum is identified with the onus being placed on personal development of pupils’ capabilities and thinking skills (Rasinen 2003). To achieve the contemporary goals of technology education Williams (2009) proposes that “a personal relevance type of curriculum design may be the most appropriate”. This is based on humanistic educational theory with its emphasis being on personal growth, integrity, autonomy and uniqueness. The goal of such a curriculum is to produce a self-actualizing, autonomous, authentic, healthy, happy person (Petrina 1992) through an integrated focus on the cognitive, affective and psychomotor areas of development (Williams 2009).

There is a long standing academic/vocational conflict with regard to the nature and role of technology education where it is argued, that technology is largely positioned within the vocational strand (Drakers 2005). With the roots of the vocational approach in the industrial revolution, its development was fuelled by the need to provide for the needs of industry. This is also backed by Ritz (2009) who comments that students (of technology based subjects) were engaged in activities designed to develop skills in using equipment to perform processes using a variety of materials and industry. Williams (1996) states that historically technology education has “…been more concerned with the development of in-depth manipulative competencies in a narrow range of technology areas than broad based, attitudinal and cognitive competencies.”
This results in a narrow restricted idea of technology education and does not align with constructivist theories of learning (Drakers 2004).

However, modern industry and societal needs question the industrial arts form of this approach in what has become a technologically, rather than an industrially mediated world (Drakers 2005). Wicklein (1997) describes a schizophrenic approach to curriculum design and educational practice within technology education outlining how old vocational models and philosophies were imposed on the newly developing curriculum with the effect of over-emphasis on the development of specific (and sometimes obscure) technical skills with other critical outcomes relegated to being by-products of the curriculum, only occurring in a haphazard and uncoordinated way. He highlights the polarisation of opinion within technology education on the types and degree of tool/practical craft skills that are to be developed within the domain. He suggests that a balanced approach to curriculum delivery could be achieved where tool/craft skills development are integrated with the development of design skills and capabilities and based on need rather than stand-alone isolated elements of the curriculum. The dualism that exists must be addressed if the goals of technological literacy and capability for future generations are to be realised. Much debate is generated on what constitutes the modern day technology subject but where there is consensus is that the hegemonic practices, methodologies and values grounded in the vocational approach still dominate the classroom learning environment (Dow 2006).

This is problematic as the international view of policy makers on technology education is that the subject provides the student with the opportunity to develop autonomy, understanding and creativity in an active, engaging environment for the learner (Barlex and Trebell 2008). Ritz (2009) concludes that early models of curriculum design for technology education are now inappropriate as today’s learner needs to be more active in developing transferable knowledge that can change and adapt to the evolving technological and societal needs. In simple terms, technology education is bridging the divide between the academic and vocational disciplines of the technology domain with the problem now being what to value and how our students should experience learning within this domain. Williams (2009) in his paper on technological literacy illustrates that many technology curricula of the past were recognised as addressing the development of personal and professional goals in a narrow vocational or industrial
manner, developing skills through practical workshop activities often serving as a career awareness, leading to vocational training in a specific domain. This method outlines the benefit of goals of technological multiliteracy with focus on a moral rather that vocational practice where students’ beliefs, opinions and decisions are valuable contributions to their development and learning.

Achieving the goals of technical education can only be examined and developed once it is clear what we want to achieve through education in this domain. Tensions within the domain of technical education have long existed as pointed out by Petrina (2000) where he outlines the criticisms of Dewey (1917) and Bonser (1928) on the model of industrial education at that time. Dewey & Dewey (1962) described “industrial intelligence” as critical insight or “discriminating inquiry” into material things and the world of work. They stated that “unless the mass of workers are to be blind cogs and pinions in the apparatus they employ, they must have some understanding of the physical and social facts behind and ahead of the material and appliances which they are dealing”. Yet, they point out that industrial educators were fostering an “undiscriminating gulping mental habit”, through a “systematic, almost deliberate, avoidance of the spirit of criticism in dealing with history, politics and economics” (p. 141). Bonser (1928) described discriminating inquiry as “selective judgement” and defined it as a practice of “affording experiences and materials through which learners may develop ability to choose among alternative courses of thought and action with that intelligence which includes a sense of social responsibility for the consequences of their choices”. It is clear that if technology education is to form part of general education it must relax its grip on past industrial or vocational principles and embrace a new philosophy in the interest of a holistic education for all.

2.2.1 Technological Literacy

As a curriculum goal, technological literacy is generally constituted of an ability/use dimension, a knowledge and understanding dimension and an awareness or appreciation of the relationships between technology, society and the environment (Williams 2009). The curricula expand on these goals outlining specific skills and abilities relating to these areas that on attainment will produce a technologically literate individual.
Williams (2009) points out that “there is no absolute definition of literacy: it will vary amongst individuals, societies, regions and nations, and also over time”. This illustrates the dynamic and ever evolving nature of the goals of technology education and presents the challenge to pedagogy, curriculum and assessment in their achievement. Williams (2009) also outlines that the “traditional competency based approach” to technology education was too narrow to be classified as a literacy, but with the integration of design based activities and the development and utilisation of a wide range of associated skills, technology education provides the basis that constitutes technological literacy. With the inclusions of design based competencies in the majority of Irish technology curricula it is imperative that a new approach to the delivery of these outcomes be established.

Technological literacy, as defined by the International Technology Education Association (ITEA) (1996), is ones’ ability to use, manage and understand technology and is seen as the intended outcome or end of technology education in the United States (Petrina 2000).

Gagel (1997p. 25) proposed the following four generalised categories that would encompass technological literacy:

(a) accommodate and cope with rapid and continuous technological change
(b) generate creative and innovative solutions for technological problems
(c) act through technological knowledge both effectively and efficiently
(d) assess technology and its involvement with the human life-world judiciously.

The ITEA (1996) outline five areas within the domain that are critical to being technologically literate. The areas are: the nature of technology, technology and society, design, abilities for a technological world, and the design world. Knowledge and skills are categorised by Prime (1998) as the key constituents of technological literacy. The knowledge domain is broad, ranging from technological solutions to problems to the social and cultural effects of technology, with the skills domain addressing cognitive, affective and psychomotor development.

What is clear from international discourse is that achieving the goals of technological literacy require active participation of the student not only in a practical manipulative
sense, but active in the decisions and critique directing their own learning within past, present and future contributions of the technology domain to society. With literacy as an overall goal, it is no longer valid to measure performance in technology domain activities by means that focus on knowledge and skill acquisition alone. We must now endeavour to gain an insight into what is happening in the minds of students and how their cognitive process is exercised to achieve the curriculum outcomes.

With this in mind, it becomes critical that ITE students now question the role of their subject and define for themselves the purpose of teaching in their domain. What they value will influence their teaching, establishing what is of value then becomes the most critical of goals for ITE providers. Values are critical to the formation of technological literacy and therefore students must be encouraged to challenge its educational value, not blindly follow a model of didactic transposition of domain specific content, without argument for its role or purpose. Petrina (2000) calls for the development of a critical literacy of the built world to help the individual to find their own way in the “powerful circuit of culture” that exists in technology education. In his paper he highlights the difficulty of many cultural influences on blurring the true educational purpose of this subject domain. Establishing what is of value requires the peeling back of past influences and experiences to provide a basis for the construction of a personal belief in the value of technology education.

2.2.2 The Irish Approach

Having examined the global consensus on the goals of technology education it is clear that new Irish curricula align with this approach. In their syllabus documents the NCCA outline the following statement:

Technology education is an essential component of the curriculum. In a world where encounters with a wide range of technologies are part of the daily life experience of all people at work or at leisure, students should be equipped to face these encounters with the confidence which comes from learning about, through, and with a range of technologies. It is equally important that they gain an appreciation and understanding of the complex interface between technology and society. As citizens they should have the capacity to enter discussion about,
and make personal judgements on, issues related to the impact of technology on their own lives, on society, and on the environment. Through technology education students grow in competence, grow in confidence, become more enterprising and are empowered in terms of their ability to control elements of the physical environment (NCCA 2007p.2).

In addition to that statement they also present the argument for the retention of some of the more vocational aptitudes of technology education:

Technology is a distinct form of creative activity where human beings interact with their environments, using appropriate materials and processes in response to needs, wants and opportunities. It integrates problem solving and practical skills in the production of useful artefacts and systems. More specifically, the value of technology education comes from the use of the wide variety of abilities required to produce a drawing or make an artefact, leading to a sense of competence and a feeling of personal empowerment. The acquisition of manipulative skills is an important component of this sense of competence and can help to give students a feeling of control of their physical environment. In a rapidly changing global society, students need to appreciate that technological capability is necessary and relevant for all aspects of living and working. Many subjects can contribute to the development of a technological capability. However, the technology subjects, which incorporate the principles of design and realisation in a creative manner, are central to this development. (NCCA 2007, p. 2)

It is clear, that in the Irish context, the practitioner must strive to achieve a balance in the delivery of the outcomes of this new approach. As discussed previously, this is a difficult task due to the hegemonic nature of the discipline practice and the common resistance to change experienced through the ages of curriculum implementation. Dow (2006) identifies the areas of pedagogy and assessment as being fundamental to successfully implementing change. She comments on how the implicit beliefs held by the teacher can act as a barrier to implementing change and places emphasis on the important role ITE programmes play in the development of such implicit beliefs. This is one of the key elements to breaking the hegemonic cycle and implementing change.
2.3 A DESIGN BASED APPROACH

Identifying the contemporary values and goals that underpin a new conception of technological education become important when contributing to the education of the student and the resultant assessment that assigns value to the learning and development. Shifting from the provision of technical skills to a broader education agenda supports the global consensus that values problem solving, construction techniques, creativity, and design (Rasinen, 2003). Achieving the educational outcomes of creativity, autonomy, and fulfilment are critical in adopting skills and aptitudes that our rapidly changing global society necessitates. Williams (2009) describes design as the prevailing pedagogical approach in technology education and the most appropriate in the achievement of the goals of literacy and capability. In their critique of literacy education, The New London Group proposed design as the meta-language of multiliteracies because of its richness and depth of meaning, and its felicitous ambiguity in identifying an organization or a product or a process (The New London Group, 1996). The group proposed three elements to design: Available Designs, Designing and the Redesigned in an attempt to emphasize the fact that ‘meaning making is an active and dynamic process, and not something governed by static rules’ (The New London Group, 1996 p74).

The teaching of the generic skills of design and creativity draw on teaching methods that are of a modern philosophy and use varying pedagogies in order to stimulate learners to achieve in these areas. Mawson (2003) outlines that the “design process” is well established as a structure for contemporary technology education, and says that progressing the implementation of technology education is dependent on teacher’s embracing pedagogies based on what we now understand about student technological practice. Mioducer & Dagan (2007) report that most curricular proposals focus on the design process of technological solutions as the central methodology in technology. In their study they questioned how the diversity in approaches to design instruction affected learning in the design activity. Their overall findings concluded that the contemporary functional approach towards design instruction was more effective than the more traditional structural approach, for supporting the construction of holistic, flexible, and effective mental models of the design process of technological solutions.
Even though the statements of intent of the technology subjects are to promote the skills and attributes outlined in section 2.2.2 the main driving motivation of the Irish second level pupil is success in a formal examination at the end of their course of study to obtain points for a national application system to third level institutes. Admittedly, it is recognised that within the junior and senior cycle technology subject areas there is an element of the assessment that offers an opportunity for pupils to display their design and creative capabilities through practical coursework. However, these activities are advised to be carried out under pre-defined models/approaches of design with a number of mandatory steps. This leads pupils and teachers alike, to adopt a cautious approach that treats the stages and functions of design as hierarchical steps that the pupils are to be directly assessed on, creating a linear approach to an activity that should be treated much more globally (Lewis 2009).

The paralysis of divergent thinking, fuelled by summative assessment driven pedagogy and the anxiety surrounding the acquisition of credit to achieve third level entry, undermine the inclusion of design and creativity. McCormick & Davidson (1996) state “The desire to ensure success prevents failure to produce outcomes, and reduces the risk in the process”. They report that teachers’ toleration of failure is generally in the making, rather than the ideas in the design, and propose that “teachers have to allow more risk and some degree of failure to produce outcomes”.

One of the main goals of technical education is the development of problem solving capabilities. It is accepted that the main pedagogical strategies for the attainment of this goal is student engagement in the process of designing to create solutions to real life needs. This can produce a conflict regarding the nature and merits of such a process. On the one hand, there is a creative, iterative, fluid process based on the application of a broad multi-disciplinary base of knowledge and skills, while on the other hand it has to meet requirements of assessment, time management, resources and the production of an artefact or product. Mioducer & Dagan (2007) identify two approaches to problem solving in technology education. The structural approach has an emphasis on the need for ordered learning of the stages of a design process while the functional approach emphasises the teaching and study of design functions rather than stages. Numerous structural models have been developed to aid in the teaching of design as a structured, organised and systematic process. These models generally have similar headings and
progression points along the design route. This structural approach is the one more commonly implemented in curricular material and many studies have raised doubts about students’ abilities to achieve a holistic view of the design process as a result. This approach is driven by the model selected and the teachers’ interpretation and implementation of its stages. The functions approach may require the problem solver to use several functions at any stage in the process requiring the contextualisation of functions during the solution generating process. This approach is based on the teaching of the different design functions so that students can use them in a way that best facilitates their problem, activity or style of working.

An important goal of design based education is the development of the problem solvers mental model of the process (Mioducer & Dagan 2007). This is a cognitive representation of the process that is engaged when formulating and realising the solution to a real world situation or problem. Expert problem solvers are assumed to possess powerful, dynamic and flexible mental models which adapt to different contexts and improve over time (Norman et al. 1995). Studies have shown (Mioducer & Dagan 2007), that students that possess an appropriate structural and functional mental model of a given system, used it for designing and planning effective solutions to problems related to the system’s functioning or operation and troubleshooting. It is claimed that in order to become skilled problem solvers, students have to construct their own technological problem solving mental models. This being the case, it would then be reasonable to expect that assessment of capability should somehow value this construct, once made explicit. Williams (2009) presents design based technology education as being embedded in the personal and social context of the student. Describing the role of knowledge in this process Williams (2009) notes that “The domain of knowledge as a separate entity is irrelevant; the relevance of knowledge is determined by its application to the technological issue at hand. So the skill does not lie in the recall and application of knowledge, but in the decisions about, and sourcing of, what knowledge is relevant” (Williams 2009). This view is supported by Norman (2010) citing Bruce Archer’s paper to the British Royal Society of Arts. Archer wrote that “Design is described as integrative to reflect the fact that a design has both to be complete and coherent internally, and to be well adapted to the environment in which it will be sold or used. A designer has the right and the duty to employ information drawn from any field of
knowledge that happens to be relevant to the case in hand. In this sense, the body of
knowledge in support of Design has to be regarded formally as unbounded”. Norman
highlights that Archers’ ideas are instrumental in the formation of the design education
movement in England and subsequently worldwide. Archer identifies two critical
procedures in design methodology that must be conducted with rigour as “the
procedures for determining the precise design requirements and the procedures for the
determining the validity of the design result” (Norman citing Bruce Archer Seminar 4
Orange series D&TE IJ 15.2 A silent D).

2.3.1 A Design Based Approach: Critical Issues

Challenging the hegemonic culture that exists with design and technology is of critical
importance. McCormick and Davidson (1996) suggest that teachers of Design and
Technology often see the product outcomes and associated skills as important in
themselves, and in the end these products tend to take precedence over the process of
design and problem solving. The vocational heritage of Irish Technology curricula may
now find teachers struggling to establish what to value in the design activity. Much of
the discussion within design and technology centres on the relationship between design
and make. Baynes (2010) makes the following two critical points about this
relationship:

1. There is a temptation to overvalue and hence to over assess the finished product.
2. There is often a miss-match between the pupil’s imaginative vision and the
   pupil’s ability to achieve it in reality.

Davies (1996) discussing *Art and Design* argues that the focus of assessment tended to
be on the artefact and not on the process of learning, resulting in students presenting
solutions to please the teacher instead of developing learning heuristics to solve the
design problem. Kimbell et al. (2004) identified that projects which tended to be
creative and innovative were generally based on and driven by ideas. In contrast they
highlighted that projects found to be competent or adequate (but not innovative) were
based on a conventional linear managed approach to the process of designing. Kimbell
et al. (2004) identified three elements to an assessment framework based on student
ideas within the design activity that are indicators of creative and innovative solutions as: *Having*, *Growing*, and *Proving* of ideas.

Promoting and developing creative and innovative endeavour as a critical feature of a design based approach requires a means by which assessment can value student ideas and capture their design evolution. When considering the role of assessment, educators must strike a balance between the impact of criteria in directing student engagement and its capacity to value innovation and creativity within the activity.

With the objective of assisting teachers and awarding bodies, many design process models have been developed. This gives a defined and standardised structure to engage with what is a complex, iterative process (Kimbell et al. 1991). Mawson (2003) reports on the adherence of technology teachers to a linear concept of the design process. Kimbell et al. (1991) also noted that although helpful guides to teachers, defined models were dangerous tools as they prescribed the stages that pupils needed to complete and tended to result in pedagogical practice. This holds true in the Irish context where the guide to reporting the design activities dominates the classroom approach and engagement in the process. Guilford (1950) expressed the view that it is difficult to develop design based attributes due to the conforming nature of schooling. The mismatch between the rhetoric about the importance of conceptual aptitudes and the value placed on creative talent raises concern about the coherence of educational strategy.

### 2.4 TECHNOCLOGICAL CAPABILITY

Kimbell (1991), through his work with the Assessment Performance Unit (APU), presented a dialectical model of designerly activity. He describes design activity as the interaction between the mind and the hand, - inside and outside the head. Figure 2.1 illustrates a schematic diagram of this model where it is clear that the interaction between the conceptual and the concrete is central to the process of designing. Kimbell contends that it is the inter-relationship between modelling ideas in the mind and modelling ideas in reality that is the cornerstone of capability in design and technology. He describes it as “*thought in action*” (Kimbell, 1991).
FIGURE 2.1 - APU MODEL OF INTERACTION BETWEEN HAND AND MIND

This model potentially holds the key to bridging of the academic/vocational divide that has been shown to exist in Irish technology education practice. Applying this model to practical craft based elements within the Irish design and technology subjects calls for an approach that utilises craft and processing skills as a medium for the expression of ideas rather than an outcome in itself. Without the interaction between skills and ideas, in this practical sense, the activity is either academic or vocational with neither outcome reflecting design capability. "Capability in design and technology involves the active, purposeful development of understanding and skills – not just their passive demonstration" (Kimbell (1991). The pursuit of craft skill acquisition must therefore be seen as developing a means of communication as well as an ability to manipulate materials and processes. It must also be recognised that craft skill development, in a design context, is a valid instrument for the stimulation and development of intellectual activity, a concept that is not generally recognised in educational circles. Recognising this potential, this study sets out to investigate if craft skill development for means of communication of intellectual thought will achieve the outcomes of capability in technology education.

Barlex (2007) identifies the process of design decision making as a key element of capability in design and technology. He identifies five domains of design decision
making that are all interlinked: conceptual, technical, aesthetic, constructional, and marketing (Figure 2.2). Though this model is outcomes based it does present how the stages and functions of design based educational activities are interdependent requiring a more holistic approach to developing meaningful practical solutions of educational value.

![Figure 2.2 - The Design Decision Pentagon (Barlex 2007)](image)

With decision making valued as a critical element of capability, provision must be made within the activity for students to make explicit their decision making process. Barlex (2007) calls for a minimally invasive approach to the assessment of capability where the assessment procedure will have as little impact as possible on the way the student engages in the process. He outlines that methods of capture and communication of this aspect of capability need to facilitate the student rather than dictate the outcome.

Gibson (2008) defines technological capability as "meaningful practical solutions to real problems framed within an appropriate set of values and underpinned by appropriate knowledge". He outlines that these relationships are based on a continuum and that varying degrees of interaction will take place depending on context. Figure 2.3 shows a schematic representation of this model and the potential outcomes as a result of these interactions.
To explore the interrelationship between elements of capability we must first examine them individually.

### 2.4.1 Skills

Gibson (2008) identifies three aspects of skills development in the context of technology education. These are intellectual, physical, and communication skills. Intellectual skills can be described as the making sense of new information through previous knowledge and experiences. This type of skill in the context of learning activity does not only rely on recall, but also on the ability to apply knowledge to instances not encountered during instruction. Common types of intellectual skills are making discriminations, forming concepts, applying rules, and solving problems. Physical skills enable students’ knowledge to be demonstrated in a tangible form by allowing the creation of quality products (Breckon, 1998; Donnelly, 1992; Mason & Houghton, 2002) cited in Gibson.
(2008). Physical skills are recognised by many as an aspect of procedural knowledge, with general consensus that there is close interaction between knowledge and skills. Gibson (2008), comments on the positive contribution of skills development and expression to psychological well-being and self-esteem. This is important in educational terms as motivation is such a critical aspect of meaningful engagement in any learning process. Therefore, it is important for any educational task to align the attainment of skill with the intellectual challenge to ensure that they can mutually support further development. Deficiency in skills will affect intellectual communication and potentially result in a lack of motivation to proceed. With this hypothesis, a methodology that focused on core skills development in support of intellectually challenging activities should be beneficial to the learning activity.

2.4.2 Values

Technology education is generally seen as different to most subjects as its existence is as a result of human activity and as a result is value dependent (Gibson 2008). Technology education devoid of attention to values and attitudes is little more that technical instruction which will not serve the needs of today’s learners (Martin 2002). Values indicate who we are and what we do. It is not just a matter of taste; it is much deeper than this. Values are implicit in the beliefs and constructs that we hold. Drakers (2005) argues that there is a certain ‘instrumental’ side in teaching values in technology education, which has been overlooked so often and systematically in the past that it serves to inculcate prescribed values ‘into’ pupil’s and students, thus leading to indoctrination. He proposes that for values to be informed they should be debated, in an open and democratic way. This individual construct of values should thus become clear or be made explicit through students’ thoughts and actions leading to the outcome(s) of the design task or learning activity. This reiterates the need for assessment to look at more than just the product outcomes of the task.

“Design is not just about change, it is about “improvement” and the concept of improvement is essentially value-laden. Good design practice therefore seeks to identify the stakeholders in any task and make their values explicit from the outset”.

(Kimbell and Perry 2001)
The embedded nature of values in technology education is highlighted by De Vries and Drakers (2005) where it is stated that to present the subject domain as value-free leads to a distorted view of technology education. Kimbell and Perry (2001) outline that any designed artefact or system is a “manifestation” of values and that this leads to diversity of solutions. The challenge they propose is for teachers to recognise the potential this holds for student development.

2.4.3 Knowledge

Kimbell (2001) declared that “the boundaries of knowledge and even what counts as knowledge are constantly shifting” Gibson (2008) outlines the difficulty in introducing technology based subjects to the curriculum because of the difficulty in achieving consensus on a definition of technology and knowledge within its domain. He identifies the dynamic and fluid nature of knowledge, with the inter-relationship of different forms of knowledge adding to its complexity (ibid.). In the context of this study, the focus on knowledge will be from a cognitive rather than a philosophical or epistemological view point as the study is primarily concerned with teaching and learning. The real issue for knowledge in technology education is that acquisition alone tends to have no purpose as the goals of the domain centre on active capabilities to control and shape the physical environment. Knowledge transfer within and beyond the domain is a central issue in this case with knowing what to do with knowledge, and why, becoming as important as knowledge itself. With development of understanding seen as forming links in students’ knowledge (McCormick 1997), the central role of knowledge in defining capability becomes apparent.

Alexander (1991) categorises knowledge in a conceptual framework identifying three elements of declarative, procedural and conditional knowledge. Declarative knowledge is based on factual information which would include domain specific content knowledge and is commonly referred to as “know-what” knowledge. Conceptual knowledge is an important subset in this area with the distinction of “know-why” based on understanding (Gibson 2008). McCormick (1997) describes conceptual knowledge as a form of “know-what” knowledge which allows situations to be explained in terms of “know-why”. Conceptual knowledge is concerned with identifying relationships
between items of knowledge in the pursuit of developing conceptual understanding. The distinction between declarative and conceptual knowledge is that conceptual knowledge is not simply factual but consists of ideas that give some power to thinking about technological activity (ibid.) In short the process of having ideas relates to the creation and development of conceptual understanding.

Procedural knowledge is often referred to as “know-how” knowledge. Stevenson (1994, in McCormick 1997) proposes three levels within procedural knowledge:

- First order: these are directed to known goals and are automatic, fluid, algorithmic, and include specific skills such as hammering in a nail.
- Second order: these achieve unfamiliar goals, and operate on specific procedures and include strategic skills such as problem solving.
- Third order: this switches cognition between the other two levels and hence it has a controlling function.

What is important, according to McCormick, is that when it comes to learning procedural knowledge, a balance must be struck between detailed procedures that support learners and abstract procedures that are impossible to use. Conceptual knowledge, it is proposed, is the key to the correct level (ibid.). Contextual problem solving is considered to be a high order procedural knowledge skill. However it is pointed out that approaches to problem solving should not be based on general purpose algorithmic procedures but rather on individual strategy that requires expertise in the context of its application (McCormick 1997). Thus, in the context of this study, it is critical to the development of knowledge, both conceptual and procedural (as the two are interlinked), that the process of problem solving, that is central to capability, is based on contextual and individual heuristics.

Conditional knowledge, also known as strategic knowledge, is a form of knowledge that in effect “controls” the procedural and declarative knowledge as a “how-to-decide-what-to-do-and when” knowledge (McCormick 1997). This type of knowledge is described as a heuristic strategy that is employed when the knowledge base for problem solving is inadequate. This kind of knowledge can be difficult to express (Norman 1998) as it is personal, subjective, and often immediate (Gibson 2008). Facilitating the
development of strategic knowledge is important in design based education, being able to see and value it is critical to both the student and assessor.

The key issue in the context of design based technological education is that knowledge within the domain often needs to be combined with other forms of knowledge in order to deal with a specific problem or situation (Norman 1998). Skills in knowledge transfer within and beyond the domain will rely on the level of understanding rather than recall to affect meaningful learning in the design based activity.

The interaction of knowledge, skills, problem solving, values and attitudes is central to the construct of capability in the technology education domain. The subject domain is defined by knowledge but this on its own does not constitute capability. To be technologically capable requires a demonstration of skills and problem solving ability guided by value related decisions informed by knowledge from the discipline domain. Implications for this study are summarised here.

The method employed must provide for the following:

- Support the acquisition of task specific knowledge
- Support the development of generic skills fundamental to the knowledge domain
- Learning environment supportive of individual learning heuristics
- Provide medium for the communication of cognitive and meta-cognitive process
- Stimulate debate on values in the domain
- Capture authentic designerly activity
- Encourage diversity and creativity
- Assign value to individual expressions of domain capability

Defining the knowledge domain of design based subjects is difficult as the contextual nature of the activity calls for an interpretation by the designer/learner of what is useful or valuable to their task at hand. Considering this, it then becomes important that those engaged in design based educational activities develop the skills of knowledge appropriation in order to progress their work or learning. Black and Harrison (1995) identify this as a key aspect of developing technological capability highlighting that this skill needs time for development. Activities with convergent learning and assessment goals would seem to be in conflict with this approach, inevitably leading to a narrow interpretation of the educational activity. Supporting creativity and autonomy as critical
learning outcomes would suggest that facilitating the individual construct of the value and nature of knowledge should be central to any design based learning task.

A key outcome of technology education in the Irish context is the development of processing and craft skills across a range of materials and equipment. The acquisition of these skills is grounded in the development and transfer of both declarative and procedural knowledge. Polanyi (1967) describes the tacit nature of much of this knowledge and skill development by individuals, which is often difficult to define and/or articulate. The development or passing on of such tacit capabilities is best achieved through social interaction and mentorship with expert practitioners over a period of time, in a setting that facilitates routine action of practice (Hakkareinen et al. 2004; Martin 2011). Achieving such outcomes in a classroom setting challenges the didactic contract (Hersant and Perrin-Glorian 2005) calling on teachers and students to establish suitable relationships that facilitate the co-construction of knowledge. Given the subjective nature of such competencies, a subjective judgement in the context of the activity would seem to be the more appropriate approach to assessing its value. Affording the learner the means and opportunity to present such attributes must then be facilitated.

Knowledge of qualities and concepts of capability are critical for students to be able to develop and monitor quality of their work (Sadler 2009). The nature of these being made explicit to the student are of critical importance with Sadler promoting the personal construct of knowledge over being explicitly told what to value. Such an approach has critical implications for the approach to learning in any activity.

2.5 VALUING CREATIVITY

Contemporary education places significant value on creativity and creative thinking by its participants (Robinson 1999; Cox 2005; Craft 2005). Sternberg (2005) outlines, that this is not alone for economic growth, but for the development of everyday life-skills. Reporting on the UK educational policy Cox (2005) and Roberts (2006) clearly indicate that not enough is being done to achieve the aims of nurturing creativity throughout the educational system (McLellan and Nicholl 2009). A similar argument is put forward by Keirl (2005) indicating the international consensus of the role and value placed on fostering creativity in our education systems. McLellan & Nicholl (2009) suggest that
Teachers may not fully comprehend the key role they play in the nurturing of creativity in schools. Their findings suggest that teachers often unwittingly, through their practice, contribute towards students generating fixated responses to tasks. With this in mind it should be fundamental to ITE that student teachers are afforded the opportunity to explore and learn in an environment and system of education that will allow them not only to express their creativity but also establish for themselves the value and influence of such an approach. From his studies testing the theory of successful intelligence, Sternberg reports that where teachers encourage their students to think creatively improvement in achievement is observed (Sternberg 2003). He also makes the point that some students may already do these things, but they are often undervalued by teachers or even punished by schools. He encourages the reconstruction of the classroom environment that rewards the student that decides to take a creative approach, thus unlocking a potential for greater achievement and development of abilities.

Robinson (1999) proposes that the general consensus among Western cultures is that creativity is “an imaginative activity fashioned so as to produce outcomes that are both original and of value”. The conceptualisation of creativity in terms of socio-cultural system is dependent on the inter-relationship between three factors (Csikszentmihalyi and Nakamura 1999). Csikszentmihalyi outlines that creativity can be observed where there is an inter-relationship/interaction between what are termed the Domain, the Field and the Individual as illustrated in Figure 2.4.

![The Systems Model of Creativity (Csikszentmihalyi & Wolfe)](image-url)

**FIGURE 2.4 - THE SYSTEMS MODEL OF CREATIVITY (CSIKSZENTMIKALYI & WOLFE)**
This systems model of creativity identifies three areas of critical importance where creativity is a key objective of the educational process. With nurturing of creativity as a key objective of contemporary education, it is important to establish the factors and structures that influence or impede students’ creative expression. The following section outlines the core elements of the systems model and its significance for this study.

2.5.1 The Domain

There is no absolute standard for what constitutes creative work (Sternberg 2003). The value of the same idea or product may vary within different environments or cultures. So being creative or recognising creativity is dependent on the domain in which one belongs or interacts. Understanding this domain, its limits and possibilities would then be important for the individual to create something that can be valued both personally and externally as creative. Nakamura and Csikszentmihalyi (2003) describe the evolution of domains as a stable process over time through generational exchange of learning. This occurs without change until individuals who try new things or methods that are valued or perceived as being better, are embraced and added to the domain. Csikszentmihalyi and Wolfe (2000) report that in order for a creative process to begin it is necessary that individuals become interested to assimilate the contents of a domain and for the contents of the domain to be transmitted to the person. They outline that access to a domain of suitable fit is essential for creativity and it is also clear that motivation to engage is central to an effective outcome. In the context of ITE and this study, it is important for students to explore and define their domain such that they can value or recognise creativity should they create or encounter it. Knowing what to value, instead of being told what to value, requires a deep understanding of the domain of which learning plays a significant part. In this study, the domain is design based technology education. A new pedagogical approach is outlined in the method that provides students with the appropriate structures and support to establish themselves within this domain. The following domain specific points are noted from the work of Csikszentmihalyi and Wolfe (2000) for the context of this study:

- How attractive is the information presented to the students. The information should be connected to interests and needs of the student or the task should
provide the opportunity for the students to create these links. The pedagogical strategy needs to provide structure and goals but afford the student some latitude in exploring and making decisions about the relevant acquisition of knowledge.

- How accessible is the information. Allow students to explore as many information sources as possible and at their own pace. Allow students to decide which knowledge sources are most appropriate to their needs while providing support for validating the knowledge selection and content.

- How integrated is the information. It is important for teachers to show how subjects are related to one another. Differentiation and integration are essential for complex learning with creative problems often arising at the interface of disciplines. It is advised that excessive compartmentalisation stifles genuinely new ideas.

- Are there opportunities for mentorships and apprenticeships? It is essential that the educational environment provide students with access to experts in the domain for education and mentorship which provide potential for new avenues of learning and development.

2.5.2 The Field

For new ideas to be included in the domain they need to recognised and validated by a group that are entitled to make decisions as to what should or should not be included in the domain. These gatekeepers are those whom Csikszentmihalyi (1996) refers to as “the field”. In the context of education, it refers to the social order of the domain with teachers, assessment bodies and curriculum development bodies involved in deciding what should or should not contribute to the domain. The question remains as to who is entitled to decide what is creative. Csikszentmihalyi and Wolfe’s (2000) argument that the amount of creativity there is at any given time is not determined just by how many original individuals are trying to change the domain, but also by how receptive the fields are to innovation. This has significant importance for ITE. They propose that to increase the frequency of creativity it may be more advantageous to work at the level of fields than the level of the individual. With the quest to challenge the traditional norms and practices that are rooted in our vocational heritage, and positively influence the hegemonic nature within the domain, this study will implement a unique approach that
integrates the learner into the system that has potential to influence the domain. Students will face critical judgements that will challenge and question their true understanding of their domain and that will be based on their own unique set of values developed as a result of their learning experience within that domain. Students must be allowed to develop a set of internalised criteria that will eventually allow them to make informed evaluations of their own ideas (Csikszentmihalyi and Wolfe’s (2000). This serves to benefit on three levels. Promote student exploration and understanding of the domain, identify and recognise creative contributions to the domain, and prompt students to critically reflect on their own work/performance based on their broadened perception from being part of the field.

In education, teachers constitute the field that judge and decide if student’s work is creative or not through tests, tasks, activities, portfolios etc., in their lessons and classrooms. When subjected to state examinations the field is bound by the fixed rules and criteria of assessment extracted from the domain. But the non-absolute nature of creativity outlined by Sternberg (2003) would question the application of pre-determined criteria to a task or activity that proposes to value creativity and instead would call for a model of assessment that is generated by the field of a specific domain in reaction to the work of the student. This now shines the light on assessment as well as pedagogy as having a key role in the nurturing of creative endeavour within education and thus will form a significant part of this thesis. The following points are noted by Csikszentmihalyi and Wolfe (2000) in relation to the field:

- Resources and funding. Schools that are better resourced and funded tend to provide better opportunity and support for creative work. Perceptions of creativity will vary depending on the field experience.
- Teacher openness to new ideas. Teachers that encourage students to go beyond the boundaries of conventional knowledge and skills acquisition are more likely to see novelty produced by their students.
- Teachers must stimulate students’ curiosity and interest. It is important that teachers stimulate students to find and create problems of their own, that they care about, building on the students interests and strengths.
• Distinguishing what is good and bad. Teachers must support students in their learning and help them to internalise standards and criteria for evaluation from the domain.

• Implementing student creativity. Must first recognise and value something that is creative but must then allow it to come to fruition. It is important to pass on the novelty to others through exhibitions, fairs, publications, plays etc., allowing the novelty to spread beyond the classroom.

2.5.3 The Individual

Having focused on the domain (subject knowledge and skills) and the field (teaching and assessment) the final element of the systems model is the individual or learner. Sternberg (1985) identifies the confluence of three intellectual skills that are of particular importance: (1) the synthetic skill to see problems in new ways and not be bound by conventional norms and practice, (2) the analytic skill to recognise which of your ideas are worth pursuing and which are not, and (3) the practical contextual skill to know how to persuade others of the value of your ideas. In simpler terms, to be creative, one must decide to generate new ideas, analyse these ideas, and sell these ideas to others (Sternberg 2003). In the study “Assessing Design Innovation”, commissioned by the UK Department for Education and Skills and the Qualifications and Curriculum Authority, Kimbell et al. (2004) identified that projects which tended to be creative and innovative were generally based on and driven by ideas. In contrast they highlighted that projects found to be competent or adequate (but not innovative) were based on a conventional linear managed approach to the process of designing. As previously mentioned Kimbell et al. (2004) identified three elements to an assessment framework based on student ideas within the design activity that are indicators of creative and innovative solutions as: Having, Growing, and Proving of ideas. This study was specifically conducted in the field of Design and Technology education and, when compared with Sternberg’s confluence of three intellectual skills, provides guidance on a set of overarching goals for student engagement in a creative design based activity. Csikszentmikalyi coined the term “flow” to describe the feeling people report when skills become second nature and everything one does seems to come naturally, and when concentration is so intense that one loses track of time. He argues that it is this
optimal feeling of flow that fuels the intrinsic motivation engine which propels creativity. Critical issues that relate to experiencing flow are the pitch of the challenge and the level of skill of the learner. A mismatch between the educational challenge and the level of skill of the student can on the one hand lead to anxiety or on the other apathy or boredom. Getting the balance right creates optimal conditions for flow. This has significance in the design of the pedagogical approach for this study to ensure that students are provided with the opportunity to achieve flow.

The following points are outlined by Csikszentmihalyi and Wolfe (2000) in relation to the learner:

- Students’ curiosity and interests are that main sources of potential creativity. The pedagogical strategy employed must not take these interests for granted or ignore them.
- Potential creativity is enhanced by intrinsic motivation and suppressed by excessive reliance on extrinsic rewards.
- Activities must be designed with the conditions necessary for flow in mind. They must be adaptable for each student’s ability and the goals must be clear and feedback not delayed.
- Learning to formulate problems should be part of the curriculum. Problem creation as well as problem solving is seen as being among the essential cognitive requirements for potentially creative thought.
- Respect creative personality traits. It is important for teachers to tolerate the idiosyncrasies of children who are otherwise curious and committed to learning.
- Promoting the internalisation of learning. A young person will be best prepared to introduce valuable novelty into a domain if he or she has identified themselves with the rules and contents of a given discipline, and developed internal criteria of excellence in it. It is more important to nurture these internal standards than to make sure that students are able to perform according to standards set externally, as when they take tests and examinations.

Understanding the nature of creativity and providing a teaching environment that nurtures its growth leaves the challenge of valuing its endeavour and outcomes. Aligning the model of assessment with the nature of creative activities challenges the
culture and perception of the role of assessment in education. In its quest to measure capability, assessment must have flexibility to value the diversity associated with creative endeavour. Ultimately, assessment is performed by the “field” of educational practitioners who will have the responsibility of both valuing and nurturing creativity in their classrooms. Ensuring the “field” embraces this objective will depend on their personal values and beliefs. This study will examine the potential that assessment may hold in kindling that creative spark.

2.6 CONTEMPORARY VIEW OF LEARNING

Having considered the aims of contemporary technology education and the educational framework that we have inherited, the resulting challenges are inherently teaching and learning focused. The way in which technological teachers approach technology education and the responsibility that they carry as the main agents of change is of critical importance and one that is amplified in this study as the cohort of students are undergraduate technology teacher education students. It is accepted that the structure and nature of education systems evolve with the demands of society, but evolution of the current system is only improving on a linear model that is proving elsewhere to be failing the needs of its participants by often dislocating them from their natural talents (Robinson 2010). Robinson argues that what is needed is a revolution in education that complements and caters for the organic nature of life, an education system that will not predict the outcomes but create the conditions in which natural talent can flourish. Robinson (2006) states that the human resources of talent are deep and we must go looking for them by creating the circumstances that let them show themselves. To achieve this reform and transformation, education must customise and personalise to the circumstances of the people that are being taught, where people can develop their own solutions with external support. The most recent shift is from the information to the conceptual age. Current and future citizens must develop skill sets and aptitudes that will allow them to thrive in this new era (Pink 2006). Pink describes six contemporary aptitudes required to thrive in the conceptual age. Right brain dominant or conceptual aptitudes that become integral when the learning is personalised facilitate the ability of structured educational systems to develop aptitudes like Design, Story, Symphony, Empty, Play, and Meaning. Pink describes these as fundamental human attributes that
have been underdeveloped and undervalued by education in the past. The value of creativity and design capabilities cannot be over stated when striving for a fast functioning knowledge economy. Although, it is possible to stimulate creative growth within the constraints of current educational structures, progress is needed to explore a fundamental rethink of what we value. Prashnig (2004) highlights the misguided emphasis been placed on “what people know”, and argues the importance of a paradigm shift from “knower to learner” placing value on “how people learn”. Emotional intelligence or soft skills are becoming much sought after as organisations begin to recognise the positive contribution they can have on their success. This is particularly so in professions where people deal in face-to-face interactions in their working life. Soft skills are behavioural competencies also known as Interpersonal Skills, or people skills. They include the skills of communication, conflict resolution and negotiation, personal effectiveness, creative problem solving, strategic thinking, team building, influencing skills, selling skills, and many more. To embrace and facilitate these existing but under-valued skills and aptitudes calls us to question the entire structure of education and radically rethink our views (Robinson, 2006).

Current educational discourse places value on thinking creatively and thinking critically to solve problems, with consensus that this methodology should be embedded in any subject across the curriculum. The ability to develop cross-curricular skills where students source and manage knowledge and skills should be facilitated. The nature of the design based approach that integrates the contexts of personal, social, economic and environmental issues into the learning activity places the technology education domain in a strong position to deliver these outcomes. Participants must take personal responsibility for their own learning, manage their time, set targets and goals, and to track their own progress. This will prepare students to take on a more knowledge and content based curriculum, be more motivated to learn and to have more positive attitudes to succeed. Activity based learning will put students in touch with their multiple intelligences; this is moving away from the traditional narrow academic focus. It has potential to help students gain knowledge about themselves (see their strengths weaknesses, likes and dislikes in terms of their learning). The approach requires students to learn how to use knowledge appropriately in a context that is relevant to the task.
Teachers are living in the present having learned from the past and preparing people for the future. They are not just responsible for giving students knowledge but are now facilitators, to provide opportunity. Students must learn to take control of their learning as a more valuable education is one grounded in the development of both knowledge and skills and not founded on the acquisition of knowledge alone. This approach is most effective with active, engaged and participative learners.

The previous section identified pedagogy and assessment as critical influences on any learning activity. It was seen that to maximise the potential of any learning strategy it is important to consider what it is that should be assessed and the factors that influence student engagement and performance in the educational activity. This section will map out the nature of learning with focus on methodologies and models that align with the objectives of technology education and of this study. One of the over-arching aims of technology education is to educate students through the medium of design based tasks and activities. This requires the student to source and create knowledge and understanding across a range of disciplines, establishing a context for decision making, and applying skills and abilities to solve and communicate problems created and encountered during the learning process. To begin, an analysis of how people learn is presented.

2.7 CONSTRUCTIVISM

Three schools of psychology, cognitivist, behaviourist and humanistic contribute to the theory of learning. Dow (2005) makes the following statement that highlights the significance of the constructivist approach in contemporary teaching and learning:

The holistic nature of education is one that is increasingly being recognised and the current focus on communities of learners is paralleled by a growing shift of interest away from the reductionism of behaviourist theories of learning in which learning is regarded as passive, unidirectional, sequential and hierarchical, towards a more holistic, social constructivist view which sees learning as an active and essentially socially and culturally mediated activity (Dow, 2005 p. 7).
The constructivist view sees the student as an active participant rather than a passive recipient in the learning process. The emphasis on active engagement aligns the constructivist model with the goals and approach of design based technology education. The following section presents the key aspects of the constructivist approach.

Constructivism is a theory that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. Constructivism is not a specific pedagogy; it is a theory describing how learning happens. Jean Piaget's theory of constructivist learning has had wide ranging impact on learning theories and teaching methodologies in education. The constructivist approach suggests that learners construct knowledge out of their experiences through processes of accommodation and assimilation. Snowman and Biehler (1997) state that meaningful learning involves the active creation of knowledge structures such as concepts, rules, hypothesis or associations in an effort to interpret new information in the environment. Prawat (1992) in his paper on teachers’ beliefs on teaching and learning called for change in the focus of teaching placing the student at the centre of the learning activity in an effort to encourage deep and meaningful learning. Petty (2004) outlined the universal acceptance of the constructivist approach by experts in the field to thinking and learning. The general consensus is “that learning occurs when students construct their own meanings, usually out of their prior learning and experience, and of course out of their instructional experience” (Petty 2004, p.4).

Turnbull and Snape (2011) outline how the constructivist approach to teaching and learning successfully leads to the development of student teachers understandings of technology education and technological practice. Key elements to the success of the approach were collaborative engagement in meaningful tasks with integrated peer and self-reflection throughout the activity. The positive influence of social interaction and the development of community in learning are presented by Brophy (2002). Key benefits of the approach are the development of a supportive classroom environment enabling students to take risk and developing a sense of ownership of their learning. Social interaction in the construction of knowledge is central to the writings of Vigotsky (1978). This approach with its emphasis on personal interactions is known as social-constructivism.
2.7.1 Social Constructivism

The social-constructivist view of learning is holistic in nature focusing not only on the construction of knowledge but also on aspects of attitude, emotions, values and actions (Breck and Kosnik 2006). The approach encourages the development of relationships between teachers, students and peers creating an environment or community supportive of personal and academic development. Effective communities of learning are ones that are inclusive and equitable with a common sense of purpose and a real need to know what each other knows (Beck and Kosnik, 2006). Webb and Palinscar (1996) describe the potential of collaborative learning to improve achievement and increase levels of motivation, leading to increased self-esteem and sense of achievement. Learning through collaborative practice may occur through giving and receiving help, sharing knowledge and resolving contradictions between a student’s own and other’s perspectives (Webb and Mastergeorge 2003). The issue of positive interdependence is presented by Dow (2005) as being important to the development of communities of learners. This stimulates students to purposefully engage with peers for mutual benefit. Price (2005) underlines the need for community of practice for the effective development and sharing of standards for the purpose of assessment.

This personal construct approach is also supported by the ideas of Claxton (2010). He proposes a move away for learning as a process and suggests a type of ‘Epistemic Apprenticeship’ (pg. 55). This proposal supports a broader conception of learning where students develop relevant skills that are embedded in the actions and behaviours of their culture. He supports the idea of a type of learning by osmosis. Collaboration proposed in this study serves to expand the experiences of the students during the learning activity, giving a broad base on which to establish their personal construct of capability.

2.8 INITIAL TEACHER EDUCATION

The Teaching Council of Ireland is a statutory body charged with the development and monitoring of the professional standards for teaching. In their policy document they outline the following:
“…the time is now right for a thorough and fresh look at teacher education to ensure that tomorrow’s teachers are competent to meet the challenges that they face and are life-long learners, continually adapting over the course of their careers to enable them to support their students’ learning.” (The Teaching Council 2011 p.6)

In a further statement the Teaching Council outlines that:

“The Council is also mindful of the evolving and dynamic context for teaching whereby new understandings and insights have emerged in a range of areas including pedagogy, curriculum, assessment, human learning, early childhood education and teacher education”. (Teaching Council, 2011, p. 6)

It is clear that there is a significant challenge to ITE providers to nurture and develop knowledge and skills that will see future practitioners play a central role in this dynamic environment. In their continuum for teacher education, the Teaching Council highlight the importance of student teachers understanding the value and role of their subjects in the broader context of the curriculum and society. The first step on this continuum is exploring the subject domain, developing a personal understanding of its value and potential for learning. This highlights the critical need for students on Initial Teacher Education programmes to develop their conceptual understanding of their subject domain as well as the acquisition of declarative and procedural knowledge and related skills. This is a particular challenge in the domain of technology teacher education because of the ever-evolving and rapidly changing nature of technology (Barlex, 2005). For ITE students, newly developed concepts of technology education must be well established by to face the challenge of achieving the goals of curriculum and broadening the education of their future students. A lack of confidence by the teacher in their conception of the domain can lead to a fragile and transient understanding of the purpose and value of their subject area (Jones 1997; Jarvis and Rennie 1998).

Banks et al. (2004) present a framework for conceptualising teacher professional knowledge and identify three critical elements that contribute to the development of a personal subject construct. They present the general application but outline that its origin and development were in the technology education domain. The three interrelated elements of the model are presented in Figure 2.5.
Banks et al. (2004) outline the importance of reflective practice in teacher education programmes but caution about its effectiveness when rigidly structured and completed with insufficient breadth of knowledge and experience. They strongly encourage that students experiment with reflection on their practice to help them internalise the purpose and role of their subject domain. Developing a construct of teacher professional knowledge requires active interaction between subject knowledge, school knowledge and pedagogical knowledge. The overlap between the three elements is where the personal construct of the subject by the teacher is revealed. The following outlines the nature of the construct presented by Banks et al.:

Lying at the heart of this dynamic process are the ‘personal constructs’ of the teacher, a complex amalgam of their past experiences of learning, a personal view of what constitutes ‘good’ teaching and a personal belief in the purposes of the subject (Banks et al. 2004, p. 144).

In the context of this study the focus is on the third element of beliefs and purpose of the subject. Banks et al. outline in this study that student teachers must question their personal beliefs about their subject and why they want to teach it as they work out an approach for their classroom behaviours. This is critical to the development of the student teacher creating a solid foundation for the continuum of professional development.
The medium of technological practice presents an ideal setting for the students’ development of their personal construct. Through participation in an authentic technology task, students will explore, evaluate and establish value in the subject domain.

2.9 PEDAGOGICAL FOCUS

The teaching of the generic skills of design and creativity draw on teaching methods that are of a modern philosophy and use varying pedagogies in order to stimulate learners to achieve in these areas. Peterson (2002) comments on how playfulness and humour in the classroom can contribute to the flow of ideas. The intrinsic motivation required to promote creative thinking in pupils was increased through introducing pedagogical factors such as challenge and freedom (Isaksen, in Peterson 2002). However, the nature of schooling can often hinder this type of approach. Guilford (1950) expressed the view that the development of creativity can be encouraged in schools but is inhibited by the conforming nature of schooling. The mismatch between the rhetoric about the importance of conceptual aptitudes and the value placed on creative talent raises concern about the coherence of educational strategy. Education systems valuing educational managerial and administrative style skills over creativity in teaching highlights the misalignment between the direction and the objective of technological education. Sir Ken Robinson (2006) questioning if schools kill creativity states:

I believe our only hope for the future is to adopt a new conception of human ecology, one in which we start to reconstitute our conception of the richness of human capacity.

The primary purpose of this study focuses on the development of student capability through a design based learning task. How students experience their educational development will have a significant influence on what they will learn and value at the end of the process. Though not specifically addressing the issue of pedagogical strategy with the student teachers in this study, it is recognised that the pedagogical strategy employed will have implications for student attainment, engagement, motivation,
understanding of and value for, the learning process. Dow (2006) indicates that teachers pedagogical approach is critically influenced by their ITE experience and also their encounters on school based practice with the latter often dominating as novices struggle to find their feet as practitioners. To help overcome this issue it is important that ITE students are afforded the opportunity to establish their own values and beliefs for the role of their subject and not just passively conform to that dictated by tradition and pressures of assessment outcomes.

When concerned with development of capability (the end) among students, where the value of what it is to be capable is seen as being equally as important as its demonstration, the pedagogical strategy (means) employed must consider the development of this personal construct of capability. To facilitate such an approach, both the constructivist and humanistic paradigms of education offer a framework for action. With the design approach generally accepted as the most effective methodology for technology education we must look deeper into how it is implemented to ensure successful outcomes for the goals of this study. Williams (2009) makes the following point in relation to the design approach as a pedagogy for technology education:

Many technology education teachers have an understanding of the virtues of design as a pedagogy for technology: it is ill-structured and ill-defined, learner centred, interdisciplinary, collaborative, iterative, creative and purposeful. (Williams 2009, p. 249)

In a further statement the approach is described as providing:

…students with a tool kit of relevant knowledge, critical skills and multiple processes through which to shape the world in which they live. Through designing, students critique technologies that are relevant to them. As an outcome of their critique, they develop skills to represent their new ideas in three dimensional forms. They engage locally and globally … to both inform their critique and to disseminate and consequently refine their ideas through iteration (Williams 2009, p. 250).

Mawson (2003), Kimbell (2007) and Barlex (2007), have all identified the negative impact that rigid structured approaches to design activities have on learning and outcomes of design based education. They encourage a more flexible functional
approach, valuing individuality over conformity, where the student and their decision making processes are at the centre of the activity. The importance of critique and inquiry are clear and must be central to the learning activity.

Learners must be set free to explore and question all aspects of their work, while being supported through the provision of relevant experiences and guidance on how to make the decisions that are central to their learning. The task, pedagogic approach and assessment mechanism have critical roles to play if such outcomes are to be supported.

2.10 ASSESSMENT IN TECHNOLOGY EDUCATION

The issue of assessment consistently presented itself as being influential and problematic in the domain of technology education. It is clear that assessment can have a significant impact on teaching and learning where generally it is accepted that alignment of pedagogical strategy with the attainment of assessment outcomes impacts negatively on the achievement of the broader curriculum goals. Kimbell (2004) describes the situation with regard to assessment practice in the British design and technology curriculum as “widely regarded as having become formulaic, routinised and predictable”. It is also accepted that assessment can be stressful and the cause of much anxiety among the student body. Are students lacking confidence in their abilities? A general conversation with any young adolescent would generally seem to suggest no. Or is it that they are unsure of what they need to know and why they need to know it? Could understanding of domain specific competencies and skills lead to a more active participation in response to the call of assessment? Could it really be possible to enjoy assessment? Looking at the field of sport it is easy to draw parallels with many forms of assessment. Norms or criterion referenced, ipsative or comparative but to mention a few all boil down to competition and performance and a demonstration of ability at some stage in the process. And yet sports people thrive and crave this environment. Why? Is it because they are provided with a platform to display their talents? Once that bell sounds or the whistle blows the responsibility becomes theirs. Their goals are clear but their path to success is uncertain. They utilise their skills and strategy in reaction to their environment with the confidence that they will get just reward for their effort. Might it be possible that the same could happen in education? If so we must establish how we might help students to manage this uncertainty, to welcome ill-defined
problems and take ownership of their own learning? When it’s not all about winning how does one value the taking part?

2.10.1 An Approach to Assessment

With clear objectives for technological education and an understanding of the role of the subjects within the context of contemporary schooling, the focus shifts to assessing student competency. The importance of differentiating between the assessment of and for learning (Stiggins 2005) becomes central when focusing on the process. Kimbell (2010) adds a further level of complexity that highlights the conflict that may exist between curriculum policy and assessment policy, with the difficulties centring on standardisation and testing. This questions the validity of what it is we are actually measuring. Students conforming to the assessment criteria and aligning their outputs to address given criteria (regardless of meaning) facilitate the sorting nature of contemporary assessment. This assessment challenge is amplified within technological subjects as Kimbell et al. (1991) argue that the essence of the problem with design based educational activities lies in the transformation of active capabilities into passive products. Assessment criteria that over-define the stages and functions of design can render the objective benign due to the exploration, experience and decision making that is central to learning being removed. True technological capability involves self-monitoring and awareness of how and when to use particular skills and knowledge. Barlex and Trebell (2008) argue that competency develops with coherent thinking and not just as an accumulation of knowledge. The value of design based activities lies in autonomy, the context and need to acquire relevant multi-disciplinary knowledge, demonstration of capability, problem solving, communication, and synthesis.

The problem is trying to “measure” evidence of thinking while encouraging diversity within a system predicated on standardisation and weighted criteria. Kimbell (2007), reports that “Learners can be excellent in design and technology in dramatically different ways”. Therefore, the outcomes and solutions to design problems can often involve more variables than can be represented in a sequence or loop model of designerly activity (Williams 2000). This also presents a challenge to criterion referenced assessment that dominates assessment practice (Sadler 2009). Current
discourse on technology education recognises the benefits of fostering diversity and creativity in student’s responses to design tasks. It is recognised that students must be supported in this process that will be unique and individual to each and every learner. Valuing such traits in educational terms is problematic if learning activities are rigidly aligned to assessment requirements that inadvertently predetermine the outcome of the activity to some extent. With the importance of designerly activity outlined as a key element of capability (Kimbell 1991), the difficulty lies, not only in the inability of traditional criterion referenced assessment to accurately measure the process, but also in its ability to have a negative impact on the learning activity itself. If an authentic measure of a creative, diverse, individual, personalised, conceptual and concrete outcomes is what we need, it becomes obvious that the student and their learning must become central to the educational process with assessment almost taking on the role of an inspirational pedagogical tool driving and motivating both students and teachers.

The measure beyond the artefact or finished product is critical to ensuring the sustainable value of design driven competencies. Measuring a complex iterative process requires a flexible model of assessment that can value evidence of learning in response to individual heuristics while supporting diversity and measuring capability.

Kimbell (2007) outlines the difficult nature of judging student work against abstract criteria, but when compared with an exemplar of capability the task becomes much more meaningful when normalised for the assessor. Project e-scape (Kimbell et al. 2005, 2007 and 2009) outlined a new and innovative approach to the assessment of performance portfolios. The e-scape methodology was adapted from an assessment model developed by Alistair Pollitt based on the Law of Comparative Judgement (Thurstone 1927). The approach, based on the comparison of students work, relies on a holistic judgement where overarching criteria are used to guide the assessor to make a professional judgement. This requires the judge to have an understanding of what is better or worse in terms of the required capability while eliminating the varying standards that may exist across a group of assessors. This approach has particular significance when introducing a group of student teachers to the field of assessment as they can focus on evidence of capability without the worry of levels of attainment, and make professional judgements based on both their own capabilities and that of their peers. Peer assessment has the potential to increase thinking, learning and confidence,
helping the student to establish the role and purpose of assessment (McDowell and Sambell 1999)

2.10.2 Models of Assessment

Let us first look at an overview of common assessment procedures identifying issues of relevance to this study. Assessment is a process of documenting capabilities and characteristics of skills, knowledge, values and attitudes. First they must be displayed and or captured/recorded, then they must be assigned a value. Assigning this value must be both valid and reliable, two key issues in any assessment discourse.

"Validity ... is built into the test from the outset rather than being limited to the last stages of test development, as in traditional criterion-related validation."

(Anastasi 1986 p.2)

This is also proposed by Kimbell et al. (1991) where he outlines the importance of building assessment models that are domain specific and integrate all aspects of capability on which judgments can be made. The approach to assessment will impact on what can be established about students’ ability or what they know. Convergent assessment is concerned with finding out if the learner knows, understands or can perform a predetermined concept. Torrance and Pryor (2001) characterise it as a method that entails detailed planning and is generally accomplished by closed or pseudo-open questioning and tasks. In this method the interaction of the learner with the curriculum is seen from the point of view of the curriculum. The theoretical origins of such an approach would appear at least implicitly to be behaviourist, deriving from mastery-learning models and involving assessment of the learner by the teacher. Divergent assessment emphasises the learner’s understanding rather than the agenda of the assessor. In this form of assessment, the important thing is to discover what the learner knows, understands, and can do. It is characterised by less detailed planning, where open questions and tasks are of more relevance to the learner. The implications of divergent teacher assessment are that a constructivist view of learning is adopted. As a result, assessment is seen as accomplished jointly by the teacher and the student, and oriented more towards future development rather than measurement of past or current achievement (Torrance & Pryor, 2001). Dow (2005) outlines that students learn best
when they are actively engaged in formative, as opposed to summative, assessment. This approach provides feedback giving indication of action to affect improvement developing skills of appraisal and critical reflection. This suggests that for effective learning we must employ effective and appropriate assessment. Many approaches and models are utilized to assign value to student work all of which have merit if applied in the right context. The following section will investigate the elements of assessment relevant to this study and present how they impact on teaching and learning.

### 2.10.3 Formative Assessment and Learning

When embracing a constructivist approach to learning, formative assessment becomes a central issue. As students work within their zone of proximal development (Vygotsky, 1978) their guidance and support from a more skilled person, is informed by assessment of their progress. Black and Wiliam (1998) outline the positive influence of formative feedback on student learning. Yorke (2003) details the formal and informal nature of formative assessment and presents the potential of formative assessment in promoting self-regulation in students. This presents students developing an appreciation of the standards expected of them. Black and Wiliam (1998) report, that the effectiveness of formative assessment is dependent on the quality of feedback and the interaction between student and assessor. Yorke (2003), Orsmond et al. (2000) and Sadler (1998; Sadler 2009), Black and Wiliam (1998) present the teacher, peers and the student themselves as potential contributors to the formative assessment process and outline the importance of strategic planning for the integration of formative assessment into any learning activity. Sadler (2009) highlights the benefits of formative assessment but strongly advocates that students be inducted into the assessment process to help them make sense of the formative comments in a way that can progress their learning.

Formative assessment is concerned with educational attainment through learning for understanding. The term assessment *for* learning is commonly used to describe formative assessment. Stiggins (2005) called for a radical rethink in relation to how we assess students, calling for models that integrate assessment for learning at their core. Sadler (1998, 2009) and Orsmond (2000) indicate the complexity of integrating formative feedback into learning and assessment activities. They highlight the need for
students having knowledge of fundamental concepts and principles to facilitate them in being able to internalise and value formative feedback. Sadler (1989) also identifies a key feature to the development of learning is to provide students with significant appraisal experience as part of the pedagogical design of a learning activity, to enable the student to internalise the context, nature and value of formative assessment. Sadler (2009) proposes the use of holistic assessment for the development of the skills of appraisal. The role of appraisal in holistic judgement is outlined by Kimbell et al. (1991) and indicates the potential benefits of integrating holistic student judgement as a central facet of the learning approach. The need for students to be able to identify levels of quality in contextually related work is seen as being critical to students monitoring the quality of their own work while its being developed (Sadler 2009). This requires students to develop a set of values on which to base their judgement, which leads to the question of what should they value. Establishing value on the elements of capability in the task can principally be achieved in two ways. Students can align their values with those presented externally or they can endeavour to try and work it out for themselves. Formative assessment will aid students in internalising such criteria but, if the former approach is taken, the process gets limited to telling which rarely satisfies the conditions for learning (Sadler 2009). Either way the establishment of criteria is necessary and critical to the learning activity.

The critical point of note is that formative assessment is an integral part of learning but developing students’ ability to process assessment information is also of significant importance.

2.11 ASSESSMENT CRITERIA AND STANDARDS

All assessment is based on the inference of an assessor on qualities that are relevant to the task or performance in question. Criteria, in terms of assessment, are described as a distinguished property or characteristic of work that can be used to judge or estimate its quality (Sadler 1987; Orsmond et al. 2000). Criteria-referenced assessment measures student competencies, establishing to what level they can or cannot do something. This method requires definite statements of outcomes and levels of attainment or quality. Judgement in assessment, whether made analytically or holistically, need reference to
Sadler (2005) presents the argument for using criterion-referenced assessment by identifying two distinct educational and ethical benefits. The first is that students are graded on the basis of the quality of their own work without normative reference to others that engaged in the assessment activity. The second benefit is that students can be provided with the criteria at the beginning of the task, allowing them to develop their work in line with what will be valued by assessment. However Sadler (2009) describes many uses of criterion-referenced assessment as sub-optimal, limiting both the teacher and student in the learning and assessment process. This is supported by Kimbell (2007) where the suitability of analytical criterion-referenced assessment is called into question when faced with diverse and creative work. To cope with this variety, Kimbell outlines that criteria or attainment levels have to be either very vague, or numerous or both often leading to a formulaic approach educational achievement. Orsmond et al. (2000) describe assessment as shaping every part of the student learning experience often defining what the student regards as important. With this study focused on the development of student values in the subject domain the issue of assessment and its integration into the learning activity have paramount importance. Orsmond et al. (2000), in a study that examined the co-construction of assessment criteria by teachers and peers, presents that students developing a sense of ownership of the assessment criteria leads to greater understanding of their meaning and value in terms of marks to be awarded. The ability of students to identify and quantify criteria based on the quality of peer work is presented by Orsmond et al. (2000). Their findings indicate that developing an appreciation of the criteria has a significant impact on student learning and the quality of the assessment practice.

O’Donovan et al. (2004) outlines the impact of the emphasis on reliability and transparency in higher level education resulting in significant emphasis being placed on precise articulation of standards and assessment requirements. Sadler (1987) and O’Donovan et al. (2004) argue that despite best efforts that articulation of standards in assessment are difficult to capture, often fuzzy in nature, open to interpretation and context. The critical finding from their work was that providing explicit descriptors of assessment criteria and standards alone did not ensure meaningful transfer of knowledge.
of the assessment criteria and standards to the students. O’Donovan et al. (2004) outline that there is both an explicit and tacit nature to the development of standard and criteria and students must be exposed to both for effective learning and assessment. Sadler (1987) describes academic standards as being “essentially in unarticulated form inside the heads of assessors, and are normally transferred expert to novice by joint participation in evaluative activity”. For a teacher to make judgements about the quality or standard of work they must have a reasonable idea or feel for the standards they intend to apply (Sadler 2005). Sadler also identifies two critical elements that dominate judging of quality of students’ work as teachers’ personal expectations, and how other students have performed in the assessment task. Kimbell (2007) echoes this where he highlights the difficult of making judgements on work against abstract criteria. With the introduction of exemplars for comparison, Kimbell communicates how the assessor can begin to “make sense” of the criteria and quality. This is presented as normalising the criteria to make them meaningful and highlights the unavoidable relationship between normative and criterion-referenced assessment.

For effective assessment students must play their part. Student must be inducted into the assessment process to develop an understanding of its nature and purpose. This requires the development of skills of appraisal and judgement which will help the student in reflecting and establishing value on their own work and the work of others. Inducting student into the assessment process needs careful planning and support to ensure that it is meaningful and beneficial. It is recognised from the literature that standards and criteria are critical elements of the assessment process. Prescribing the criteria can lead to convergent outcomes devoid of meaning for the student. The benefit of engaging students in the development of the assessment process and the establishment of standards and criteria can have a positive impact on their learning. To further explore the issue of student integration into the assessment process a review of the practice of peer and self-assessment was completed to identify key issues that impact on students’ ability to engage with assessment.

2.12 PEER LEARNING AND ASSESSMENT

Boud (1999) outlines four key benefits of integrating peer learning into programmes in higher education. The first is developing skills of collaboration, planning, teamwork and
the development of communities of learning. The second is the potential for students to
explore and develop ideas within the security of the relationships with their peers,
outside of the authority of the teacher. The third benefit is that students will develop
their communicative skills through the externalisation of ideas and concepts to peers
who may have a similar level of knowledge or capability. The fourth benefit is the
assumption of responsibility by the group, deciding on their needs and planning a
strategy to address them. The qualities outlined are central to the holistic education of
the student which strengthens the argument for integrating the approach in learning
activities. Trends show an increase in the integration of peer assessment into learning
activities but the nature of conventional assessment de-emphasises the collaborative
nature of peer assisted learning (Boud, 1999). In the same paper Boud outlines that
assessment can actually foster peer learning but only with strategic planning from the
outset of the design of the learning task. If teacher supplied instruction and feedback is
to give way to peer learning and assessment, then some of what the teacher brings to the
learning task must in itself become part of the curriculum for the student and not an
accidental or inconsequential adjunct to it (Sadler 1998). Students need to be inducted
into the role of teacher or assessor through inbuilt strategies and supports in the learning
environment.

Looking at the issue of peer and self-assessment Orsmond et al. (2000) identify their
potential to develop a better understanding and clearer interpretation of formative
feedback between teacher and student. This results from the need to clearly identify and
understand the learning outcomes through meaningful dialogue for the purpose of
developing a strategy to complete the task (Orsmond et al 2000). The success and value
of peer and self-assessment relates back to the issue of criteria and standards. Two
critical issues are identified in the literature that are of significance to this study. The
first is that there is a need to internalise criteria and standards in order to have
meaningful engagement and return from the peer or self-assessment activity. This
internalisation process leads to deep knowledge of the functioning of criteria and their
relationship with quality and standards (Sadler, 2009). Having to develop the criteria is
preferred to having them externally imposed as establishing what to value leads to
complex appraisal and reflection on the knowledge and skills at the core of the task
domain. The second issue is that the process of peer and self-assessment should focus
on the learning and development of the individual student rather than any numeric or otherwise outcome generated by their assessment activity. The lack of validity in student assessments relates to their under developed understanding of criteria and standards (1999). Orsmond et al. (1997) believe that the success of peer or self-assessment should not be judged solely on the correlation between student and teacher assessment. They also highlight that the success of peer or self-assessment as a formative assessment tool is not just dependent on the students’ ability to mark according to criteria. The success of peer or self-assessment should be judged on the basis of the learning and development of the student as a result of engagement in the assessment practice.

The practice of peer or self-assessment requires the student to engage with standards and criteria to form their judgements. This cannot be left to chance and students must be inducted into the process of learning orientated assessment to ensure that is purposeful in the student development (Sadler, 2009). Proper implementation requires the teacher to engage the students in activity that develops a deep understanding of how the assessment criteria function in making complex appraisals that lead to the formation of judgements on the quality of the work being assessed (Sadler, 2009). Sadler identifies the development of skills in appraisal and judgement as critical for students developing and progressing their own learning. The development of such skills is accepted as complex. This is exemplified by Sadler where it is presented that teachers’ conceptions of quality are largely in tacit unarticulated form inside their heads. “It is difficult for teachers to describe exactly what they are looking for, although they may have little difficulty in recognising a fine performance when it occurs” (Sadler 1989).

Orsmond et al. (2000) found that student assessors had difficulty in judging more abstract criteria in peer-assessments despite having demonstrated the capability in that criterion in the task themselves. This highlights the need for assessment induction if peer and self-assessment are to be integrated parts of the learning activity.

Developing an appreciation of assessment criteria is highlighted as potentially enhancing the quality of the assessment practice and having a major impact on student learning (Orsmond et al. 2000). Their study looking at the use of student derived marking criteria in peer and self-assessment found that students developed a sense of ownership of the criteria in total and may not have been able to clearly discriminate
between them when marking. This highlights the need for students to explore and determine the nature and value of criteria for the formation of their judgements. The study was based on students assigning marks to work based on criteria that were consensually derived by the teacher and student groups. However, marking of the criteria (on any scale) raises the issue of standards, marker reliability and marker error. Sadler (1983) states that students need to develop a conceptualisation of what constitutes quality or standards if they are to achieve consistently high levels of performance. To develop this conceptualisation Sadler promotes the use of student evaluation “without necessarily being bound by tightly specified criteria” mimicking the way that experienced teachers make multi-criterion judgement of student work and ability (Sadler, 2009). Sadler rejects the use of explicit assessment criteria favouring an approach that provides students with experience of what is termed the latent-to-manifest translation process. A student’s pool of criteria is developed over time on an individual basis and through engagement and interaction with peers and teachers. These are stored in the mind of the assessor and brought to the fore as a working set of manifest criteria when making judgements. When works exhibit something noteworthy, latent criteria get temporarily added to the set of manifest criteria to inform the assessor’s judgement. Such flexibility is critical to the students’ conceptualisation of quality where value and meaning is created and built through students’ experience and engagement in assessment related activity (Sadler, 2009). To aid the student in this process, it is recommending the use of relevant or guiding criteria in the induction process highlighting that properly implemented they act as enablers for appraisal of the substance of the work (Sadler 2009).

Boud (2005) outlined that a necessary feature of peer learning is that it is reciprocal in nature where peers can and do learn from each other. A significant observation for this study will be to establish if peer learning is initiated and valued with the introduction of comparative pairs peer assessment.

2.13 HOLISTIC ASSESSMENT

Hager and Butler (1996) argued that innovations and initiatives in education such as problem-based learning, education for capability and portfolio-based performance assessment are most suited to a judgemental model of assessment. Holistic assessment
is the judgement or measure of value of “the whole” rather than the sum of a set of individual components of a task or assessment. Kimbell et al. (1991) reported that when their models of assessment of capability were compared, a much greater reliability was found when using holistic judgements. Their work led them to the belief that due to the complex and integrated nature of the aspects of design based activities, a model of assessment (holistic) that takes account of these interactions was the most effective in assessing overall capability of students. Sadler (2009) characterises holistic assessment as impressionistic or intuitive. The judgement of the work is based on the appraisal of qualities that relate to appropriate criteria (Kimbell et al. 1991; Sadler, 2009). The flexibility in this approach allows the assessor with flexibility to call on more evidence where necessary to make a value judgement rather than being bound by fixed and predetermined criteria (Hager and Butler, 1996). Sadler (2009) outlines two problems with traditional criterion referenced assessment. The first is that the sum of the parts may not always reflect the intuitive or holistic mark of the teacher and the second is that there may be criteria missing from an assessment rubric that are important or set the particular work aside as exemplarily. The difficulty with these anomalies is that they are structural and cannot be addressed by making assessment rubrics more explicit or elaborate. Sadler presents holistic judgement as an appropriate assessment for work with open and divergent responses using skilled judgement based on multiple criteria. Such responses are determined as demonstrating sophisticated cognitive abilities, integration of knowledge, complex problem solving, critical reasoning, original thinking, and innovation (Sadler 2009). The judgement cannot be reduced to a set of individual measurements to be reconstructed to arrive at the correct appraisal, but rather is based on holistic recognition based on the intellectual processing of the relationship between qualities observed as a whole Sadler (2009). These qualities must be internally processed by the judge, based to personally set criteria and standards. Integrating holistic assessment into the learning activity serves the purpose of exercising students’ skills of appraisal, inducting them into the world of assessment. It is therefore critical for the integration of holistic assessment that students must have a sound basis for their judgement, which must be developed in a context and genre similar to the work being assessed. The holistic model also presents the possibility of assessment becoming a dialogue between the student and assessor, with the student being able to make their
case through the content that they perceive to be of value. This is supported by Hager and Butler (1996) where they propose that such dialogue leads to a more integrated approach to learning and assessment. To facilitate such dialogue, this study gave students the authority and freedom to construct the nature and content of the electronic portfolio with the intention of leading the assessor in the virtual dialogue on their conception of capability in their work. Sadler (2009) outlines factors that may become obstacles to the integration of holistic judgement in peer learning and assessment. Three of these obstacles that have relevance to this study are presented:

- “Student and teacher positions reinforce each other, setting up a credit accumulation economy. The development of evaluative expertise requires production, peer appraisal and peer feedback in a context where there is neither credit nor penalty for trial and error, experimentation, or risk taking. If these are to become normalised as legitimate processes in learning, ways have to be found to subvert the credit accumulation economy”.
- “Students’ perceptions of themselves. They may feel ill-equipped to grade the works of peers. This is true initially, of course, but changing both the actuality and the self-perception are two of the course goals”.
- “Students’ fear of exposure, loss of face or impending sense of humiliation among their peers. This may be because they lack experience, status or skill. These feelings are personal, about themselves and about how confident they are. Unless students are already familiar with engaging in peer assessment, they may appear to accept the logic behind a transition to a different pedagogy, but retain their reservations and reluctance. Such students need reassurance that just starting on this path is likely to be the hardest part. Once they become accustomed to it, they typically find it highly rewarding, and their learning improves”.

(Sadler, 2009)

Kimbell et al. (1991) developed a model of the holistic judging process that aids judges in formulating their judgement on a piece of work being assessed. The model presented in Figure 2.6 identifies three stages in the process.
The process outlines the identification of qualities, then grouping of qualities into clusters and establishing the relationships between the cluster qualities. Critical for this study is that the work of Kimbell et al. (1991) used holistic marking to assess capability in design based technology tasks. The study identifies reflective and active abilities at the heart of capability that are iteratively linked by appraisal. Three clusters were developed from these qualities as the focus for the judge when making their holistic judgment. The three elements are presented in Table 2.1.

### TABLE 2.1 - HOLISTIC ASSESSMENT CLUSTERS (KIMBELL ET AL. 1991)

<table>
<thead>
<tr>
<th>Issues</th>
<th>Proposals</th>
<th>Appraisals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflective Quality</td>
<td>Active Quality</td>
<td>Linking Quality</td>
</tr>
<tr>
<td>A range of qualities enabling the consideration of many dimensions of a task that might have a bearing on how good a solution is.</td>
<td>A range of qualities facilitating the foundation of design ideas and proposals.</td>
<td>A range of qualities allowing pupils to push their ideas forward by bringing together their proposals with their understanding of issues.</td>
</tr>
</tbody>
</table>

The relationships between the clusters of qualities are presented by the model in Figure 2.7 showing integrated design and technological capability at the centre of the overlapping elements.
The use of the model aligns with the use of relevant or guiding criteria (Sadler 2009) for the induction and analysis of student judging activities in the study.

2.13.1 Evaluating Quality

Sadler (2009) makes five propositions for the induction of students into the development of evaluative expertise in their subject domain. The development of a conceptualisation of quality is key to consistency in high achievement. The following is a synopsis of the propositions with regard to the context of this study.

Proposition 1

Students must monitor the quality of their work as it progresses. This requires enough evaluative skill to compare, with considerable detachment, the quality of what the producer is creating with what would be needed for it to be of high quality. The study must ensure the students are provided with the opportunity, through experience in the learning activity, to develop a basis for reflection and evaluation of qualities of capability.
Proposition 2

Students can develop evaluative expertise in much the same way as they develop other knowledge and skills, including the substantive content of a course. Skilled appraisal is core to this expertise. The study must provide opportunity for students to engage in learning activities where the focus is on appraisal skill development rather than the outcome of its implementation.

Proposition 3

Students’ direct evaluative experience should be relevant to their current context, not translated from another. The focus for their experience must therefore be works of a genre that is substantially similar to the one in which they are producing. The study must ensure that the context of the student assessment activities is housed in the domain of their learning task.

Proposition 4

The pedagogical design must function not only effectively but also efficiently for both teachers and students. The learning activities must pre-plan the integration of assessment such that it is meaningful and manageable within the structures of the learning activity.

Proposition 5

Students in higher education contexts should learn how to make judgments about the quality of emerging and finished works holistically rather than using analytic schemes. This requires the development of structures that facilitate the students in making holistic judgements on work created during the learning task. This requires a medium for the communication of capability that facilitates the nature of the holistic judging process.
2.14 VALIDITY AND RELIABILITY

2.14.1 Assessment Validity

Validity in assessment is when you measure what you intended to measure. It is important that the test instrument is specifically designed to appropriately observe or document the knowledge, skills or performance in question. Pollitt (2011) makes the following comment in relation to validity in assessment:

“Valid assessment requires the design of good test activities and good evaluation of students’ responses using good criteria. The traditional concept of construct validity requires that we are clear about what we want to measure, that the teachers and students also are clear what that is, and that our assessment does indeed reward students for showing evidence of what we wanted to measure and them to develop or learn”.

Martin (1997) highlights the importance of validity in assessment and how the selection of the assessment instrument is critical in ensuring the valid outcome. Validity is concerned with the assessment instrument measuring what it sets out to measure. Along with the validity of the assessment instrument, the validity of what it is that is being measured is of critical importance. This is the first aspect that should be decided upon and then within that context the validity of the instrument to assess those desirable qualities should be discussed (Martin, 1997). Hager and Butler (1996) recommend that a judgemental approach to assessment be employed where the objective of assessment is to capture innovations and initiatives including problem-based learning, education for capability and portfolio-based performance. This approach is supported by Kimbell (2007), Sadler (2009) and Orsmond et al (2000) for the assessment of performance based capabilities. Central to the judgement model of assessment is providing the evidence of learning or capability on which to draw inference for the assessment. To validly assess the desirable competencies and skills students must be provided with appropriate means for their demonstration or communication for the assessment to be deemed valid. Meeus et al. (2009) state that to validly capture authentic performance and learning students must be given the freedom to decide for themselves what to present as evidence of their capability.
2.14.2 Construct Validity and Assessment

Wiliam (2010) states, that validity in assessment should be based on the inference that can be drawn from the outcome of the assessment activity. In this paper, Wiliam outlines that to ensure that assessment is valid the focus should begin with the construct of interest and not on the assessment itself. Clarifying the construct of interest leads to better understanding of the qualities that should be measured. The construct of interest to be assessed is a philosophical issue relating to what is of value in the domain rather than a technical issue about how it will be measured. Having defined the construct of interest the focus turns on the instrument that will provide us with the information on which to draw our inference about the construct of interest. Two key challenges to the validity of assessment are construct underrepresentation and construct irrelevant variance. The method of assessment must provide sufficient evidence of qualities from across the construct domain to be valid. In the case where the assessment may not fully represent the whole of the construct of interest, the qualities that are assessed may function as an adequate proxy for those aspects of the construct that are not assessed (Wiliam 2010) which highlights the complex nature of validity. An assessment that is too narrow to support the construct of interest can lead to bias within the qualities of the construct leading to invalid inference being drawn from its outcomes. Construct irrelevant variance is when extraneous information in the assessment affects the inference drawn from the assessment. To address construct irrelevant variance the assessor must be able to look beyond the irrelevant and focus on the construct of interest. A key issue for this study is that the method of assessment must have the flexibility to cater for the personal construct development of the individual students. Therefore, for the study to be able to evaluate valid personal constructs, the identification and communication of construct relevant qualities must not be influenced by the means of communication. This means that the content and mode of communication must be drawn from the students’ personal construct and not the instrument for assessment. These issues must be considered when selecting a model of assessment to validly represent the construct of interest.

Wiliam (2010) states, that assessment’s operationalize constructs. In other words assessment breaks up the construct into manageable parts or qualities for the purpose of
assigning value or measurement. With the emphasis on the student derived personal construct at the core of this research study, it is of critical importance that the method of assessment does not impose values on students through the operationalization of the construct. Holistic assessment with flexible assessment criteria as presented by Wiliam (2010) and Sadler (2009) offers a valid solution to this threat to construct validity. The challenge for the model of assessment in this study is to be able to respond to the student defined construct in the context of the construct of interest. A valid instrument for the study needs to validly assess the construct of interest while accounting for the development of the personal construct by the student.

2.14.3 Assessment Reliability

Reliability in assessment relates to the consistency of the instrument to yield the same result under the same conditions. Two significant factors that impact on reliability are internal consistency of the test and the assessor judgements. However, over-emphasis on developing scientific methods that are highly reliable and reproducible can lead to devaluation of curriculum content that is core to the validity of the assessment (Norman et al. 1991; Hager and Butler 1996). Martin (1997) outlines that reliability in terms of the judgemental approach to assessment is concerned with the dependability of the decisions made about a piece of work and that the reliability can be increased by the quality of data collected and the opinion of additional experts. In a study, looking at the use of student portfolios in assessment, Meeus et al. (2009) highlight how standardised assessment tools can reduce the assessment error by providing the assessor little or no margin for interpretation, thus increasing the reliability of the instrument. However, they present that the standardisation of portfolios for assessment is in direct contradiction to the aim of portfolio based assessment of capturing authentic learning. The challenge of assessment reliability is highlighted by Luken (2004) where it is suggested that not everything that is of value in education can be measured with complete reliability. Meeus et al (2009) present a range of issues that can positively influence the reliability of portfolio based assessment. Among their proposals are the use of holistic marking, assessor training, appropriate criteria and using a range of different assessors. They report that portfolio assessment is more reliable when done by a number of assessors with varying opinions help in the moderation process.
When considering the assessment instrument for the capture of performance and capability, a balance between validity and reliability must be achieved. The significant factors for consideration are capturing authentic learning through a portfolio based medium and holistic assessment of quality by a range of opinions or judgements.

2.15 TESTING DOMAIN SPECIFIC CAPABILITY

Kimbell et al. (1991) deemed isolated tests of knowledge and skills as being inappropriate measures of capability in design and technology, as this discipline involves the active, purposeful development of understanding and skills not just their passive demonstration (Kimbell 1991). Individual tests of these elements may be valid in their own right but they are not valid for a design based activity. The work of the APU laid out a blueprint for the holistic assessment of active capability in design based activities which will now be outlined.

Tests for performance based capability need to be developed that will give a window through which the process in action can be observed. Tests should be designed that give the opportunity to observe the three critical elements of capability:

- Conceptual understanding (inside the head)
- Communicative/modelling facility (outside the head)
- Their interaction through the process in the activity  

(Kimbell 1991)

![Diagram of processes of design and technology]

**FIGURE 2.8 - DIMENSIONS OF CAPABILITY (KIMBELL 1991)**

Kimbell et al. (1991) also make a critical point that “... it is as important for the student to be aware of what they need to know as it is for them to actually know it. Assessing
new knowledge and skills in response to the demands in the task is a fundamental characteristic of capability in design and technology” (Kimbell 1991). This requires an assessment model that allows the student to make explicit something that may be both complex and abstract and often difficult to communicate. The key to a valid measure of capability in this process is for the student to be the driver in communicating what is of value through media that best support their needs. Presenting what is relevant and of value can really only be decided by the student that has developed a construct of capability within their domain. Prescribing the stages of communication of capability by providing a structured approach to the project portfolio may lead to a pre-determined and inaccurate reflection of designerly activity and thus capability. What is required is a model that challenges the student to reflect on their cognitive activities and to place value on the elements that have influenced their thinking. Kimbell (1991) outlines that the difficulty in assessing intellectual processes (inside the head) is that they cannot be seen. He acknowledges that inference can be drawn from student behaviour but that for validity, assessors’ interpretation must align with that of the student intent. This attempt to gain insight into the cognitive and meta-cognitive process of the student is critical and without it, Kimbell comments that assessment becomes little more than guesswork which is not acceptable. This approach places a lot of responsibility on the student not only to engage in the task for the purpose of solving the proposed problem, but also to establish what is of value in terms of learning during the process. With this responsibility comes risk, which is identified as a critical characteristic of creative endeavour (Robinson 1999; Sternberg et al. 2005; Norman 2010). Helping students cope and manage in such an environment requires significant learning environment support as well as confidence that the value of their expressions both mental and physical can be fairly interpreted and assessed.

As outlined earlier, assessment that values the product over the process can have a negative impact (Pollitt 2004) on pedagogy and student learning. The influence of assessment criteria aligning with linear or rigid models of design processes, influences pedagogical approaches to ensure successful product outcomes. What gets lost in the process is the focus on learning which is central to the curriculum goals, as the purpose of technology education is not to produce designers or products, but to provide a medium that will allow students to learn and develop. Removing the framework of
criteria allows the student to explore and create in a manner that is personal and guided by their learning and experience. Through this unique and individual process students will ultimately generate the criteria by which they want to be assessed, requiring the assessor(s) to be able to respond to this need. This requires an assessor that has an understanding of, and can judge, what it is to be capable in this domain rather than score individual predetermined elements in a summative form.

Kimbell (1991) found that teachers were good judges of student performance and capability but the issue of assigning a value arises when making decisions on the quality of students’ work.

“As we develop a better understanding of the way in which individual qualities combined, we began to see patterns or groupings which made the process of overall judgement more manageable. Holding a view of the value of many discrete components and how they affect each other is a difficult, if not impossible task. This is because the finer components will not be distributed evenly across all the work and may not even be evident at all in some of it. If you can group features together into related clusters it becomes much easier to see how these clusters interact”. (Kimbell 1991 P154)

The APU trials found that assessors were helped to make more reliable holistic judgements when asked to focus on these clusters or qualities or over-arching criteria. Even though fine detail may not be consistent across student work, assessors could search for enough evidence to make a reliable judgement. They found that overall judgements were made easier based on how well these clusters worked together (Kimbell 1991).

In his paper “e-assessment in project e-scape”, Kimbell (2007) describes the struggle when assessors are faced with judging the quality of student work if all they have are a set of abstract criteria. To help with this issue awarding bodies introduce exemplars of levels of quality of work. Now the assessor can make a judgement on whether the work is better, worse or on a similar ranking with the exemplar. “The criterion - on its own – does not help. The comparator makes sense of it” (Kimbell 2007). This normalisation of the criteria prompts Kimbell to propose the idea of a comparative model of assessment. In project e-scape he utilised an assessment model based on Louis
Thurstone’s *Law of Comparative Judgement* (Thurstone 1927), developed by Alistair Pollitt who at the time was the director of assessment research at the University of Cambridge. Pollitt proposed an alternative to summative forms of assessment:

“The alternative approach to summative assessment that I would like to propose is based on the psychophysical research of Louis L. Thurstone, and specifically on his Law of Comparative Judgement (Thurstone, 1927)... The essential point will be familiar to anyone grounded in the principles of Rasch models: when a judge compares two performances (using their own personal ‘standard’ or internalised criteria) the judge’s standard cancels out... a similar effect occurs in sport: when two contestants or teams meet, the ‘better’ team is likely to win, whatever the absolute standard of the competition and irrespective of the expectations of any judge who might be involved”. (Pollitt 2004 p.6)

Pollitt outlined that assessment inevitably reduced to comparing one student’s work with another through the use of criteria and exemplars and so posed the question why we don’t just compare students’ work directly (Pollitt in Kimbell 2007). The system devised for the e-scape project sees judges compare two portfolios of students’ work. Their assessment decision or judgement is which one is better (norms based assessment). The basis for this decision would be based on their understanding and value of capabilities within the subject domain. To aid judges in the decision making process they would be given a set of shared domain specific features of capability. These would act as a set of criteria that are not marked as with conventional assessment, but rather a holistic judgement is made on which piece of work is better as a whole. On completion of a number of judgements on a range of student work, a rank order of quality is generated for the student work. The final stage in the process is identifying the standards and assigning grade boundaries. The following section will outline the mechanism for assessment utilised in project e-scape identifying key features that will align with the goals of this study.

### 2.15.1 Adaptive Comparative Judgement (ACJ)

Pollitt (2011) describes a brief history of educational assessment summarising the role of professional judgement. He outlines how two central issues of manageability (time
and resources) and professional bias were problematic with this model which ultimately led to the invention of marking. With the recognition that performance based disciplines are more suited to judgement as a whole, the need still existed for judgement based assessment. In the light of software and web based services development in recent times, the possibility of developing a model of judgement based on the work of Louis Thurstone from 1925 to 1935 now became a feasible and manageable alternative. Thurstone developed a model known as the “Law of Comparative Judgement” for use in the measurement of psychological rather than physical phenomena. His assumption was that a person perceiving some phenomenon will assign it an instantaneous “value”, which may vary with time and context, and when asked to choose the better of the two of these phenomena, will pick out the better based on the comparison of these assigned values (Pollitt 2011). With computational developments it became possible to write computer programs that apply the method of Thurstone’s comparative judgement based on a Rasch distribution model (Pollitt 2011).

The model is based on the probability of any piece of work (object) being better than another in a group of tests. The comparisons of the individual objects generate a set of probability parameters for each object. This parameter value is not a direct measurement of the quality of the work but is rather an indicator as to where the work would lie on a scale of the comparisons of all the work in an assessment. The difference in parameter value will give an indication of the “distance” between objects in terms of quality. The method ensures that every object is compared with a number of other suitable objects generating a reliable probability parameter for each object in the assessment group. Through experimentation it has been shown that every possible combination of comparison for a test group is not necessary, with approximately 10 comparisons per object with other suitable objects generating very reliable results (Pollitt 2011). After an initial rough sort where the Rasch values are assigned the system is able to “chain” comparisons. Chaining means that after every comparison one of the objects or portfolios from the previous comparison will be used in the next comparison. This means that the judge has only one new object or portfolio rather than two to navigate which has significant implications for time saving when comparing complex pieces of work. This also means that the same portfolio will be compared twice by the same judge possibly using differing criteria depending on the paring. This
is discussed in greater detail in section 3.4.5. Again, this indicates the significance of judges needing a deep understanding of the overarching criteria of the assessment model and the need for flexibility in their application to their judgements. The system will run generating object parameters for each estimation round until a stabilised set of parameters with low standard errors is achieved generating a rank order of object values.

A key requirement for the judging process is that judges are able to form a holistic evaluative judgement of the object against a notional scale that is a shared consensus of all the judges. The model is based on the assumptions that judges are equally good at their ability to discriminate between objects, that each object is equally “discriminable”, and that each judgement is independent of all other judgements (Pollitt 2011). The power in the system is that each of these elements can be checked through analysis of the system statistics generated for judge misfit, object misfit and bias respectively. These statistics have significance for providing feedback to both awarding bodies and individual judges on the validity and consensus within the process. Of particular interest to this study is the potential of the portfolio and judge misfit statistics to indicate to module leaders the need for dialogue or intervention with outlier students, with the view to engaging in formative discussion on their judging or portfolio of work.

In a summary of the relevant statistics generated by the Rasch analysis (Pollitt 2011) the following are of interest to this study.

**Object Parameter:** indicates the position of the object on the rank order. This is represented by a numeric value ranging between (-10) and (10), the higher value indicating the higher the quality of the work as perceived by the judging cohort.

**Weighted mean Square (WMnSq):** Used as an indicator of judge or portfolio in-fit or out-fit. Judges or portfolios whose WMnSq values are seen to exceed the mean plus two standard deviations are deemed as having misfit and may require further analysis or intervention. In this document the term misfit statistic relates to the calculation of the in-fit/out-fit statistic.

**Reliability Coefficient:** This relates to the precision of measurement in the system. It is an equivalent to Cronbach’s alpha coefficient which is a traditional reliability statistic.
Further points of note relating to the reliability of ACJ are in the nature of the judging process. In conventional assessment, markers can go wrong in three different ways (Kimbell 2007; Bramley 2010; Pollitt 2011). Firstly, markers may have different standards which introduces the notion of a “hard” or a “soft” marker. Secondly, markers may award the same average marks in terms of standard but may discriminate differently between the very good and poor work rewarding or penalising on differing scales. The third aspect is where markers may value different aspects of the overall quality of the work produce. With the ACJ model the first two causes of reliability error are cancelled out as an absolute decision without assignment of a numeric value by the assessor is all that is required. This cancellation, coupled with the multiple judgements carried out on each portfolio by a large number of judges, make a significant contribution to the high levels of reliability recorded in testing to date (Pollitt 2011).

The final issue relating to this assessment model is generating grade awards from the ACJ defined rank order. Pollitt (in Kimbell 2009) outlines that a suitable linear transformation that preserves the interval scale of the portfolio parameter generated by the rank order is valid for this purpose. This requires the setting of two appropriate performance thresholds to guide the grade distribution.

2.16 PROJECT E-SCAPE

Holistic assessment of performance capabilities is in its infancy in the domain of design based technology education. Much of the work to date has been initiated or inspired by the work of the research team in TERU, Goldsmiths, University of London. The team at TERU led by Professor Richard Kimbell, have a long history of research publications in the field of assessing performance in design and technology education. The study of most significance for this thesis is called project “e-scape” an acronym for e-Solutions for Creative Assessment in Portfolio Environments. The overriding ambition of project e-scape which was conducted in TERU between 2004 and 2010 was to enrich learning and teaching environments (Kimbell 2011).

Principally the e-scape methodology utilises modern technologies to capture and assess student performance in an examination based setting. With the central goal of assessing student capability, project e-scape was equally concerned with valuing how this
capability came about. It centres on the live construct of an electronic portfolio using hand held portable technologies during the active engagement in the formation of a solution to a design based task. Multi-modal capture of the student performance is facilitated by hand held devices which have a live connection to a web based portfolio where the student communicates their intent and progression in the electronic portfolio. Audio, video, picture, text and sketching facilities are available to students to communicate their thinking, ideas and solutions. The live capture ensures the authenticity of the capture of the student’s performance and active capabilities. The system also provides the opportunity for peer to peer interaction at the initial ideas generating stage of the task. This is included to stimulate critique and evaluation of their own and peers ideas in an attempt to broaden their perceptions of the task, encouraging creative expression. With the emphasis on capturing the unique and personal capability of each student a holistic assessment model is employed to evaluate the process as well as the product outcome of the activity. The holistic judgements are used with an Adaptive Comparative Judgement (ACJ) assessment tool to generate a rank order of performance capability. No marks are awarded at any stage; the only decision a judge (assessor) has to make is which piece of work is better when two are compared. For example, marks were not awarded for the “quality” of the portfolio. If the portfolio was effective in its key function of communicating the students thinking and capability, this would contribute to the formation of the judges’ opinion of the quality of the work. Communication is not scored on its own, but rather is integrated, like all other aspects of capability, forming a web of indicators of student ability.

2.16.1 The Evolution of e-scape

In 2003 TERU launched a research project “assessing design innovation”. In its report in 2004 Kimbell et al. commented on the positive impact of the paper based portfolio system implemented in the study on student engagement and activity. With the concurrent discourse on assessment for learning at the time, the research team in TERU set about exploring the potential use of digital systems in aiding teachers in the management of the large amounts of personalised learning data collected for the assessment of their students. The group also saw potential in combining the digital
portfolio with the portfolio assessment system from the “assessing design innovation” study to create a system where students’ performance could be digitally assessed.

Kimbell (2011) outlines the importance of defining the nature of the portfolio in the context of this design and technology performance based activity. He describes the portfolio as a combination of an assessment portfolio, a learning portfolio and a working portfolio. Aware of the issues surrounding portfolio creation and content Kimbell and his team set about creating a system that was integral in the classroom activity, evolving and growing with student learning and experiences. He describes the portfolio as a “dialogue” by the student “with themselves” in the context of their learning activity and proposed that this form of portfolio is akin to looking inside the head of the learner, revealing what they are thinking, feeling and experiencing during their endeavours in their design task (Kimbell 2011). The portfolio is populated live which removes the problematic issue of retrofitting a sanitised post-activity account of the student work (Kimbell 2009). He makes it very explicit that these portfolios are not only repository’s for student work but are a trail of the students journey, experience and learning which cannot be pre-determined but through working on the portfolio are shaped and developed in pursuit of their solution. The issue of portfolio management by teachers for purposes of assessment is also highlighted and questions that validity of the criterion referenced teacher managed portfolios in assessing design capabilities of students.

Central to the implementation of the e-scape strategy was the use of technologies that would facilitate the capture and recording of the student learning and experience. It was important that the technology be accessible to and compatible with the industrious and sometimes hectic and messy nature of the technology classroom environment. Furthermore, it was critical that the technology was perceived as a learning tool or aide that would encourage students to engage with it rather than perceive it as a chore or secondary outcome of the task. For this reason, individual hand held portable devices that facilitated capture and management of student work were selected as the technology of choice for the activity as they are less intrusive in the flow of the classroom learning activities.

Project e-scape was implemented over three phases. Phase one concentrated on proof of concept with focus on technologies for assessment, pedagogic support, classroom
manageability and validity and reliability of such a tool in performance based assessment in design and technology. The proof of concept was accepted by DfES, QCA and the awarding bodies leading to the second phase of building a working prototype of the e-scape system.

Phase 2 was concerned with the development of a system that would facilitate design based activities in the classroom using peripheral digital technologies that allowed for the real time tracking of learners’ work for assessment by awarding bodies. The system was tested in 14 schools in a national pilot in 2006 and a published report (Kimbell, 2007) highlights the critical findings of the study. One of the critical features of this phase was the development of a system that allowed for the real time upload of student work to a web based portfolio that evolved with the student’s engagement in the activity. The hand held devices had drawing and writing devices as well as a built in camera providing all the functions from phase 1 in a single device. A significant addition to phase 2 however was the use of a speech recording tool also integrated in the device allowing for the capture of the real voice of the learner as they progressed through the activity. In terms of assessment, the use of electronic portfolios opened the possibility of using a “comparative pairs” judgement (Thurstone 1927, Pollitt 2004) as the basis for the holistic assessment of the students work. In the phase 2 report the four categories of research questions from phase 1 of technological, pedagogical, manageability and functionality were addressed and proven to be successfully answered. This led to the third phase of the e-scape project which focused on moving the system from a research based context to the context of national assessment for awarding bodies.

Phase 3 had two key areas of concern which were investigating the transferability across other subjects in the curriculum and the scalability of the system such that it could be managed by practitioners in their classroom environments for learning and assessment. The findings from phase 3 of the study report unequivocal consensus that the system had the capacity, compatibility and robustness to facilitate national implementation (Kimbell et al. 2009). In particular the validity and reliability of the comparative judgement model of assessment coupled with its positive influence on student engagement and teacher pedagogy present significant potential for this model to be adapted in the context of this study housed in initial teacher education.
The following section outlines a study that implemented the e-scape approach for high stakes assessment in a second level education setting.

2.16.2 Digital Forms of Assessment

Williams (2011) describes a three year study that was conducted in Western Australia between 2008 and 2010 that investigated the use of digital forms of assessment of performance in engineering. The study focused on developing a model of assessment that would validly assess practical performance in a manner that was manageable both in terms of school implementation and cost. The key questions of the study centred on the suitability of digital portfolios to support summative assessment of performance, the impact on teaching and learning, and if the comparative judgement model of assessment could deliver reliable results in performance based engineering tasks. The framework for the study combined students’ digitally recorded material with a digital repository for access by examiners for both standards based and paired comparison forms of assessment. The study found that the use of the digital portfolio and portable evidence capturing devices had a positive influence on the students toward completing the examination. In assessment terms the summative standards referenced assessment was completed by two external assessors, while the pairs comparison assessment was completed by ten judges each completing 473 judgements. There was a moderate and significant correlation ($r=0.46$ $p<0.01$) between both assessment models with the comparative pairs method indicating greater reliability (Williams 2011). Problematic issues identified from the study generally centred on the manageability of the communication between the data capturing devices and the web based repository where it was found that failure or glitches in the technology tended to distract students from the task at hand. The pre structured stimulus response methodology employed in guiding the iterative generation of the portfolio served to stimulate student ideas and thinking. However, some students found this repetitive and teachers felt that the task could have been a little more “strenuous” to develop higher order thinking (Williams 2011). All students in the study indicated that they preferred the task to the traditional paper based exam.
2.16.3  Summary of the e-scape Approach

At this point it is important to summarise the key attributes of the e-scape methodology and also to document any concerns for its direct application in the context of this study. From the review of the e-scape story to date, it is clear that it has had a significant impact on a number of key issues that are pertinent in educational discourse at the present time. It provides for authentic capture of student performance, in real time, providing a structured but flexible environment where students engage and record their thinking and learning experiences. It provides multimodal means for communication of ideas and solutions that are integrated into the learning environment, encouraging reflective practice and the synthesis of formative feedback from both teachers and peers. It has had a positive impact on practitioners encouraging spontaneous and holistic reflective practice of both student learning and pedagogical practice and in doing so has helped teachers advance their methodologies in reaction to curriculum goals rather than assessment criteria. The use of comparative judgements in the assessment of students learning facilitates the assessor in seeking out what is of value in terms of literacy and capability allowing flexibility for the assessment of diverse and creative solutions. However when placed in the context of the goals of this study the e-scape methodology may not provide the optimum model for achievement. The original e-scape model was only concerned with the capture and assessment of performance in a design based activity. This was completed over a period of six hours where the focus was capturing the authentic capabilities of the student for later judgement. The focus was on assessment and not on teaching and learning. Subtle elements of its structure encouraged thought and action and it became clear that learning was taking place during the process of assessment which was having a significant impact on student engagement. However, when situated in the context of initial teacher education, it is important that the student teacher is subjected to the positive impact of the experiences of both teacher and learner outlined above. The activity must cater for the balanced development of a range of vocational and transferrable skills to meet the goals of the new curriculum. With curriculum goals of developing technological literacy and capability, it is not enough for an ITE student to merely display these characteristics. These students must develop an understanding of what constitutes literacy and
capability in this domain, recognise it, display it, communicate it and evaluate it. ITE students must reach a point in their understanding of their subject domain where they have internalised the concepts of literacy and capability to an extent where they can generate their own criteria for its evaluation and assessment. Providing explicit assessment criteria or a structured format to the task execution and portfolio could have a significant impact (positive and negative depending on what you value) on this process. To facilitate the generation of an internalised concept of capability, the task activity must encourage exploration within the domain and be supported by a pedagogical and assessment strategy that will assist the student in their quest for truth. There is significant risk involved in this strategy for the student and therefore confidence in the assessment mechanism that will value their learning, failures, development and attainment of the characteristics and skills of literacy and capability is paramount. This study will explore a duality in the role of assessment where the model not only evaluates the outcomes of the learning activity but concurrently facilitates the generation of the criteria that will evaluate attainment from a personal construct of domain capability. Ensuring validity of this assessment will be a critical element of the work.

The study will also investigate the impact of democratic peer assessment on the learning and assessment activities. This is made possible by the use of ACJ and its high reliability as discussed earlier. Essentially the portfolio and judging statistics will give an indication of consensus among the group of assessors. The question of interest is whether this consensus of judgement aligns with quality of performance.

The British scientist Francis Galton (1822 – 1911) stumbled across the power of democratic judgement and the intelligence of groups phenomena. His initial experience of the power of group intelligence came in 1906 when he analysed the results from a competition at a county fair where the public were asked to guess the weight of an ox. What he found is that when he averaged the weights from all the guesses the result was the exact weight of the ox. This drew him to conclude that as groups we make judgements that are much more reliable than that of individuals. In his book “The Wisdom of Crowds”, James Surowiecki identifies four criteria that characterise effective crowds:
1. Diversity of opinion: Each person should have some information (possibly values) that is theirs (this could even be a poor or inaccurate interpretation of known facts)

2. Independence: A person’s opinion should not be influence by the people around them. Each person should act independently

3. Decentralisation: People should be allowed to specialise independent of the group and exercise this specialist knowledge (even if perceived irrelevant to the task at hand)

4. Aggregation: Having a reliable mechanism to take the individual decision/opinions and derive a collective decision.

(Surowiecki 2004)

He comments that it is a mathematical truism, that if you ask a large enough group that are diverse and independent the average of their estimates will result in the errors of each estimate cancelling each other out. With this in mind any attempt at democratic peer assessment must try to ensure that the construct the “group” aligns with these criteria. It is noted that the first three criteria can and will be influenced by the methodology of approach in the teaching and learning activities of this study.

Kimbell (2009) in his reflection describes the use of holistic assessment as “very powerful” as it focuses the assessor (teacher) on the domain capability as opposed to a box ticking exercise. He firmly believes that all teachers have an intuitive sense of what amounts to excellence in students work. Ensuring this intuitive sense is nurtured and grown has to be a critical element of ITE programmes and is a compelling reason for the selection of holistic assessment based on the ACJ model from project e-scape is the chosen methodology for assessment in this study.

2.16.4 Summary

The review of the literature indicated the potential of design driven technology education in achieving the desired goals for contemporary education. Central to their achievement is pedagogical strategy and assessment. With the potential negative influences of assessment activities on pedagogical practice and learning outlined, this study focuses on the potential of, a constructivist pedagogical strategy and Adaptive
Comparative Judgement model of assessment, to enhance learning and the development of capability. This study sets out a methodology that supports students in developing an understanding of, and value for, domain specific capabilities, with the goal of using this as a platform for the expression, communication and judgement of their personal capability through design based activities.
3 METHODOLOGY
3.1 PREFACE

This section is a preface to the methodology, presenting an analysis of the methodological considerations that formed the basis for the chosen research approach. The challenge and complexities of developing an appropriate methodology are highlighted by Kimbell et al. (1991):

There is no single, all-embracing approach to research in education. There are many approaches – indeed new approaches are constantly emerging as researchers tackle different kinds of problems and devise strategies to suit them. And so it is necessary not only to select the approach that is most suitable for any particular research undertaking, but also to demonstrate why it is more suitable than other approaches that might have been chosen.

(Kimbell et al. 1991)

With particular consideration for the research questions, the following section presents an analysis of research techniques, highlighting the limitations of the considered method and presents the decision and characteristics of selected methods (or elements of) that merit inclusion in the study.

3.1.1 Identification of a personal Construct

When investigating personal constructs the objective is to establish the basic units or elements that are used by individuals to interpret and make sense of their environment and thus extend their experience of the world (Kelly 1955). He also presents that people have a limited number of constructs that can be used as a means of evaluating the phenomena that constitutes their environment. Constructs that are created by individuals are the features that are used to conceptualise aspects of their world. These differ among individuals in their interpretation and construction from events. Being able to capture or infer the development of a personal construct has the potential to capture the value and meaning that underpins learning. Considering a method to capture this personal construct as it develops required a research method that is minimally invasive and unbiased.
Analysis of considered research techniques

The repertory grid technique is a common technique presented for eliciting constructs of individuals. Repertory grids have two essential features that of constructs – what a person uses in the conceptualising of their world - and elements – the stimulus objects that people evaluate in terms of the construct that they employ (Cohen et al. 2007). Kelly (1955) also presents the idea that constructs that are employed when evaluating, may be thought of as bipolar and capable of being defined in terms of polar adjectives i.e. good or bad aligned or not aligned. The design of repertory grids can take two formats, that of elicited or provided constructs. In their analysis of approaches to repertory grid techniques Cohen et al. (2007) present that the nomination of constructs and elements by the subject themselves is central to the personal construct theory. Implementing a method that provides the construct and elements will serve to evaluate how students align with a predetermined construct of capability and not elicit the impact of the personal construct as a whole on the assessment process. The elicited approach requires students to establish relationships or differences between elements.

Strengths and limitations of Repertory Grid Technique

The critical element for consideration is how to elicit the personal construct of capability that each student employed during a peer assessment. Implementing the existing methods of repertory grid techniques require the elements and constructs of interest to be made explicit to students. This potentially becomes problematic if students perceive capability to be aligned with the rubric presented. The repertory grid technique does however present the key elements that must be considered when establishing a personal construct. This presents the study with the need to employ a method that allows the students to use their own criteria for assessment based on their personal construct of capability and present the elements that they value based on their construct. This requires the elements of capability drawn out through the analysis of student work to be documented and codified for analysis.

Reflections and decisions

The decision not to implement a repertory grid technique is also supported by the need to authentically capture the student perceptions of what to value as capability. This was also based on the presumption that the prescription of explicit criteria may restrict the
students exercising their personal construct while assessing. The challenge is then to create and implement a method that would support and capture the personally derived elements that are central to the analysis of personal constructs. What is required is a method that allows students to formulate an evaluation, while actualizing their personal construct of capability and identifying the critical elements that inform their judging. The characteristics of the method must capture the critical elements of the construct and present them in a bipolar form such that it is possible to make determinations from the data.

### 3.1.2 Holistic Assessment Valuing Capability

The use of criterion reference assessment is presented by Sadler (2009) as being limiting on students and teachers in terms of learning and assessment. The suitability of criterion referenced assessment when evaluation diverse and creative work is also called into question by Kimbell (2007). Orsmond (2000) presents assessment as shaping every aspect of the students learning experience, impacting on what the student values as important. Sadler (2005) presents the importance of assessors in having a feel for the standards they intend to apply in any assessment of student work. This becomes a significant challenge in assessment where the interpretation of criteria and standards is presented as a significant contributor to marker error and low reliability in terms of the assessment. The use of comparison of student work is presented by Kimbell (2007) and Sadler (2009) as being critical in the judgement of quality, while Hager and Butler (1996) indicate that a holistic judgemental approach to assessing capability through portfolio based performance is considered to be most effective.

The method must consider an assessment technique that provides assessors with the flexibility to exercise holistic judgements without the restriction or imposition of externally mandated criteria, which may or may not relate to elements and qualities being assessed. With this study focusing on the ability of students to value capability through the development of their personal construct, the methodological approach must consider holistic assessment combined with non-explicit assessment criteria.
Analysis of research techniques

From experience, summative assessment based on explicit weighted criteria can result in a routine and mechanistic approach to project based learning. This questions the efficacy of using a project based approach as the emphasis on reliability outweighs the validity of student capability.

The use of rated scales in the holistic assessment of capability is presented by Kimbell et al. (1991). However this type of exercise requires the assessor to have a notional concept of the quality of the scale on which to place their mark. Coupled with the holistic value of quality, Kimbell et al. (1991) conducted an analysis of the student work for relationships between clusters of qualities central to defining capability in the design and technology domain. This gave an insight into the important qualities presented by students through their performance in a design based technology task.

The method was further developed by Kimbell et al. (2009) where they utilised a holistic assessment method based on the direct comparison of two pieces of student work. The judging decision is binary where the work is either better or worse than the work it is compared to. For this study this approach eliminates the need for the interpretation and implementation of a scale of quality thus reducing the potential error in the assessments.

The evolution of pair-wise comparison method and its development within the e-scape projects (Kimbell et al. 2005; 2007; 2009) makes this approach feasible, a method could now be considered to facilitate holistic assessment by the definition of individuals’ personal construct.

Strengths and limitations

Sadler (2009) presents the act of completing holistic judgements on work as being central to the development of the concept of quality. This method has the potential to facilitate emerging concepts of quality as they developed through the judgement of considered work. The strength of the ACJ method of holistic assessment is that it eliminates two of the three issues relating to error in assessment (Pollitt 2011). This has significance as the error in assessment will be concentrated on the valuing of overall quality of work which is the focus of this study. An added strength of the ACJ
approach are the misfit statistics generated for both the judges and the portfolios which will indicate if the judgements align in terms of what is valued by a group of assessors.

The limitation of the approach is that it does not provide an explicit reason for the judgement of quality and therefore the approach must also employ a triangulated method. This must analyse student outcomes as agreed by consensus and by comparison to established benchmarks and qualities of capability.

**Reflections and decisions**

The potential of holistic assessment to develop a broader understanding of a subject discipline is conceivable in two ways. Initially, students are expected to determine capability based on their perception of capability through their developing personal construct. Secondly, exposure through comparison to their peers work that they presented as capability. Similar to the approach taken by Kimbell et al. (1991) and the e-scape project (Kimbell et al. 2005, 2007 and 2009) the approach must be an authentic design based activity. The method should couple the students’ presentation of their personal capability with the holistic assessment of their peers’ definition of capability in an attempt to elicit the value of holistic assessment.

### 3.1.3 Value of Peer Assessment

Defending the position of technology education on the national curriculum is difficult without a clear consensus on its definition. Questioning what it means to be technologically capable is the initial position to establish a new era of technology education. Initially teacher education must encourage its students to question what it means to develop capabilities within the subject domain. This must not be entirely defined by prior experience of the subject domain from the perspective of a pupil but instead must be internalised and defined by value. Considering the social-constructivist paradigm the study must consider a method to encourage a community of learners that are scaffolded through the act of creating meaning.

**Analysis of research techniques**

The research method must capture the social meanings of students in their naturally occurring settings. The researcher must ensure not to impose any of their bias on the
data. The considered approach to elicit the value of peer assessment within ITE is to take an ethnographic approach in an attempt to understand the impact of interventions on cultural change. Ethnographic research gives a framework to cater for a broad range of research techniques while focusing on the specific knowledge, skills and attitudes of a cultural group. The capacity to apply a tailored mixed methods approach that supports qualitative and quantitative methodologies is required.

**Strengths and limitations**

The core strength of ethnographic research is to look at a homogenous group in their natural learning environment completing an authentic design based activity. This allows for the authentic capture of data through observation, survey, performance measures, formal and informal discussions while still facilitating speculative inferences while still maintaining the ability to conduct domain specific analysis in situ.

There are a number of considerations when taking a naturalistic approach to research that may affect the validity and reliability of the research. Initially, Cohen et al. (2007) describes as the definition of the situation where students deliberately distort information due to being ‘falsely conscious’ – unaware of the real situation. There is also a potential for the research to be skewed due to the Hawthorne effect depending on their reaction to the presence of the researcher.

**Reflections and decisions**

Within the confines of the module structure in the University the methodological approach must balance the research objectives with the core attainment objectives of the modules of study. The research approach requires the capacity to capture authentic indicators with minimal commitment from the students in addition to regular learning and assessment activities. The decision to conduct an action research study supports the initial research question and is applicable to the ethnographic approach. To elicit the sustained effect both by comparison and retrospectively an offset longitudinal cohort analysis type study gives an opportunity to track the value of peer assessment both in term of validity and development of personal construct.
3.2 APPROACH

The hypothesis at the centre of this study is that the development of active capabilities can lead to meaningful learning within a technology domain or discipline. Capturing meaningful learning and evidencing domain specific capabilities are critical to the validity of any results or findings. Establishing the relationship between the learning activity and development of capability is of key interest in the light of the call for a re-evaluation of pedagogical practice for delivery of the goals of contemporary technology education in Ireland. With the goal of developing a framework for implementation at national level in second level design based curricula, this study took the form of an action based research study at the University of Limerick with three groups of first year Initial Teacher Education (ITE) students over a period of three years. The participant groups were all studying to become teachers of the technology based subjects in the Irish second level curriculum. The study is presented as the first phase of the framework development which focuses on proof of concept, manageability and functionality. With this parameter, the methodology for the study is designed for implementation in a third level setting where the core activity is concerned with the development of domain specific capabilities in preparation for teaching at second level. An experimental learning activity was developed for the evidence based educational research approach with the overall aim of developing student capability. The review of literature identified three critical areas relevant to the development of the research instrument. These areas are pedagogical approach, student learning, evidencing capability and student evaluation and assessment. With the nature of teaching, learning and assessment being individually complex and inherently intertwined, detailed consideration of a suitable research approach was required. A mixed methods research approach was chosen for the study as the nature of the analysis focused on both qualitative and quantitative data. These were concerned with the measurement of student performance and their educational experiences as a result of teaching, learning and assessment interventions. The aspects of the study under analysis are complex due to the organic and diverse nature of the learning activities and the idiosyncratic nature of the individual learner within the educational process. As a result it was important that data generated on key aspects of the study be complemented
by other research methods that would strengthen the validity of the research findings. Figure 3.1 outlines the main types of qualitative and quantitative methods that were combined in the mixed methods approach of compiling and analysing the research data.

The nature of teaching and learning is complex and subjective. Denzin and Lincoln (1994) define qualitative research as “studying things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of meanings people bring to them”. With the goals of establishing the impact of assessment on student learning, it is therefore important that the study employs qualitative measures to ensure that the research is informed by the participants’ situational interpretations of their learning experience. The dependability (Miles and Huberman 1994) of the method will be heightened by the fact that the research participants are informed groups in the area of teaching and learning, being students of initial teacher education programmes. The quantitative methods of data collection in this study have been previously tested for validity and reliability and are discussed in detail in section 3.4.
3.2.1 Action Based Approach

The action based approach serves to benefit the outcomes of this study in two significant ways. Firstly the method is identified as having application in areas such as teaching methods, learning strategies, evaluative procedures and attitudes and values (Cohen et al. 2007). The potential for an action based approach, as outlined by Cohen et al. (2007), to inform and shape educational practice, aligns with the goal of technology based educational research at the University of Limerick (TERG 2010). With the issue of the hegemonic cycle of practice in schools outlined in section 2.2 it is critical to this research that the method employed provides the potential for participants to establish a personal construct of what constitutes domain capability and its inherent value in educational terms. Kemmis and McTaggart (in Cohen et. al 2007) suggest that:

“Action research is concerned equally with changing individuals, on the one hand, and, on the other, the culture of the groups, institutions and societies to which they belong. The culture of a group can be defined in terms of the characteristic, substance and forms of the language and discourses, activities and practices, and social relationships and organisation which constitute the interactions of the group”.

(Kemmis and McTaggart in Cohen et al. 2007 p.298)

While this statement specifically relates to the practitioners involved in the implementation of the research, it is clear that the central role of the teacher in the activity, being part of the decision making process and determining what is of value, is instrumental in influencing their behaviour and beliefs. A further point on action based research is highlighted by Oja and Smulyan (1989) where they suggest that teachers are more likely to change their behaviours and attitudes if they have been involved in research that demonstrates not only the need for such change, but also that it can be done (Cohen et al. 2007). These potential outcomes could see ITE students become important agents of change in the implementation of the new curriculum philosophy. With this potential identified, this study implemented an approach that required students to take an active role in not only providing evidence of capability, but also in determining, through active participation, what constitutes capability in the subject
domain. This is a new challenge for pedagogical practice, one that requires significant support and input from both teacher and student. Establishing an instrument that facilitates student learning and assessment will be presented in this section.

The second point of note with this approach is that it provides researchers the opportunity to observe, elicit and evaluate the cause and effect of the outcomes of the research methodology as they manifest in the practical classroom environment. This is critical to this study as many of the potential outcomes and effects of the method may not be attainable by other means. This section presents a rubric of indicators that provide clear evidence of causality and effect of the experimental programme. Cohen et al. (2007) citing FitzGibbon (1997) suggests that:

“evidence based approaches are necessary in order to challenge the imposition of unproven practices, solve problems and avoid harmful procedures, and create improvement that leads to more effective learning”.

This has clear alignment with the goals of this study. An evolutionary design methodology was adapted for this study where the emergence of critical observations and findings were used to validate and inform the approach to the analysis of the learning task in subsequent years. This approach provides the study with flexibility to adjust its focus where appropriate to analyse the impact of the same method implemented over the three year period.

### 3.2.2 Participants

The study examined the performance and reaction of three groups of undergraduate students participating in technology based modules in their second semester of their first year of studies. The participants in this study were undergraduate Initial Teacher Education students from the Materials and Engineering Technology (Metal) and the Materials and Construction Technology (Wood) degree programmes at the University of Limerick. Table 3.1 shows the implementation dates and group size for each year of the study.
TABLE 3.1 – PARTICIPANT GROUP DATA

<table>
<thead>
<tr>
<th>Year</th>
<th>Implementation Period</th>
<th>Group Size (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>Jan - April (13 Weeks)</td>
<td>137</td>
</tr>
<tr>
<td>2010</td>
<td>Jan - April (13 Weeks)</td>
<td>133</td>
</tr>
<tr>
<td>2011</td>
<td>Jan - April (13 Weeks)</td>
<td>136</td>
</tr>
</tbody>
</table>

Students ranged in age from 17 to 32 with a mean age of 19.13 and a standard deviation of 2.97. Table 3.2 shows the homogeneity of both groups.

TABLE 3.2 - HOMOGENEITY OF THE SUBGROUPS BY YEAR

<table>
<thead>
<tr>
<th>Year</th>
<th>Course (N)</th>
<th>Male</th>
<th>Female</th>
<th>CAO Entry*</th>
<th>Mature Entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>M&amp;ET (Metal) 64 (47%)</td>
<td>64</td>
<td>0</td>
<td>62</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>M&amp;AT (Wood) 73 (53%)</td>
<td>72</td>
<td>1</td>
<td>66</td>
<td>7</td>
</tr>
<tr>
<td>2010</td>
<td>M&amp;ET (Metal) 51 (38%)</td>
<td>48</td>
<td>3</td>
<td>47</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>M&amp;AT (Wood) 82 (62%)</td>
<td>79</td>
<td>3</td>
<td>74</td>
<td>8</td>
</tr>
<tr>
<td>2011</td>
<td>M&amp;ET (Metal) 55 (40%)</td>
<td>55</td>
<td>0</td>
<td>48</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>M&amp;AT (Wood) 81 (60%)</td>
<td>77</td>
<td>4</td>
<td>72</td>
<td>9</td>
</tr>
</tbody>
</table>

* CAO Entry – Refers to the standard entry route to third level education. Second level pupils apply to the Central Applications Office and are awarded entry based on performance in the Leaving Certificate Examinations (Performance calculated on the best six grades achieved).

The sample is representative of the demographic of annual intake of the ITE programmes of study in technology education over the past 10 years at the University of Limerick. It is also important to note that the University of Limerick is the only provider of ITE programmes across the full range of second level technology based subjects in Ireland. This has significance in addressing the material bias in existence in the subject domain and also in the development of a coherent approach to educating through design based activity with capability and learning at its core. All CAO entry students in the study studied a minimum of one technology based subject at Leaving Certificate with 74% of the participants studying two or more technology based subjects at Leaving Certificate level. 82% of mature student participants studied one or more
technology based subjects to Leaving Certificate level with the remaining 18% not completing the Leaving Certificate examination. All mature student participants had either a trade (level 6) or degree (level 7 or level 8) qualification on entry to their programme of study. Students from both programmes (LM094 and LM095) studied 4 common modules and one subject specialist module each in the first semester.

3.2.3 Defining the Subject Domain

For the purpose of clarity and analysis it is necessary to define the area within the technology domain that is the focus of this study. The study is housed in the attainment of the goals of two practical, craft skill development modules delivered to both ITE cohorts of students. Traditionally these modules were individually concerned with the development of decorative wood craft skills (Module WT4302 Wood Technology 2) and decorative metal craft skills (Module PN4102 Process Technology 1(Ed)) as well as domain specific knowledge relating to material processing, tools and equipment. Both modules explored the nature of capability with emphasis on mastery of practical skills.

With the need for change outlined in the literature review, the method adopted in the delivery of these modules combined the knowledge and skills from both module disciplines to engage in generating a solution to a design based task that had the common goals of evidencing capability and learning. The modules were run over a twelve week period with one lecture contact hour and four laboratory/practical work contact hours per week per module. Lectures focused on the development of appropriate domain knowledge and the exploration of the nature of capability beyond the vocational focus of practical skills development. Lecture activities also examined the role of assessment and the communication of capability in practical design based learning activities.

The concept of quality applies in disciplinary and professional contexts where complex learner productions are expected to be non-standardised. The concept of quality is then abstract and typically difficult for students to grasp. ‘Quality’ in this context refers to the degree to which a work comes together as a whole to achieve its intended purpose. When complex phenomena are being evaluated, quality is often determined holistically rather than as the ‘sum’ of ‘measures’ of its components. Such holistic judgments may
amount to more, or sometimes less, than would result from formal consideration of the various qualities taken separately. These qualities are, of course, usually called criteria (Sadler 2009). In practice, quality is often easier to recognise when it presents itself than it is to define in the abstract, or account for fully in the particular. Not uncommonly, something significant is lost when attempts are made to express quality in propositional or declarative form, that is, in words, including rubrics and expansions of fixed criteria.

3.3 DESIGN AND IMPLEMENTATION

This section outlines the elements of the approach to teaching, learning and assessment for the study. This happened in three distinct stages:

1) Skills development
2) Design based task
3) Assessment of capability

3.3.1 Skills Development

With the aim of students developing a personal construct of capability and educational value of design based activities, the initial concern was to ensure that students had relevant knowledge, skills and experience in the subject discipline. To help equip the students with relevant experiences and background in the content domain, the initial six weeks of the semester concentrated on the development of core knowledge and skills in both areas of study. The practical based activities in this period were predefined structured tasks with some potential for student variation to encourage near transfer of newly acquired knowledge and skills. The goals and focus of the initial six weeks of activity was:

- Knowledge and skill development in the area of process technology, specifically decorative processing
- Explore the transferability of processes and tasks to establish the feasibility of achieving their desired creative expression
- Explore stages and functions of design and analyse the project design brief
- Scaffolding of creative activities / synthesis / lateral thinking and inspiration
• Solving the design brief and planning the work schedule for the second part of the semester.

This front loading pedagogical approach is selected to support the students in the development of transferrable knowledge and skills that were required as a basis for engagement and learning through the task based design activity. This period provides the opportunity for mentorships and apprenticeships which provide potential for new avenues of learning and development (Csikszentmihalyi and Wolfe 2000).

Fundamental to the approach in this activity was the establishment of a collaborative working relationship between teachers, technical support staff and students. The role of the teacher shifted to that of a facilitator and mentor, recognising the valuable input of the student in the learning process which aligns with the approach of Black and Wiliam (1998). Development of student confidence in their skills and ability was encouraged by a constructivist approach that places the student at the centre of the activity whilst endeavouring to cater for a broad range of learning approaches and ability. Mistakes were not regarded as a negative action if their potential for exploration and learning, about fundamental principles of the activity, was exercised. The outcomes of the activity were evaluated and formative as opposed to summative feedback was provided to the students on an individual basis. During this time lectures concentrated on the construct of capability within the subject domain and the role of design based tasks in an educational context. A list of lecture topics is presented in Appendix 1. Active participation in lectures was encouraged through discussion inducing activities. Initial lectures were attended by both module leaders to stimulate discussion, argument and varying points of view. The role of this approach in lectures was to encourage students to think and express their ideas and values on the domain topic of discussion and to critically reflect on its value in their educational development.

### 3.3.2 Design Based Task

The second six weeks of the modules provided opportunity for the execution of the design based task building on the initial skills developed, giving a context to the learning and resulting in an exercise in ‘near’ and ‘lateral’ transferability of knowledge and skills. Students were given autonomy to design their workshop schedule, select
appropriate process and materials to achieve their design solution. As the design task was presented at the beginning of the module students had the initial six weeks as a scaffolded incubation period. The completed task accounted for 50% of the academic credit for both modules. The approach taken was to set a design task that bridged the learning outcomes of the wood and metal based modules (limiting material bias), monitor and support student’s progress throughout the task through formative feedback and discussion, and evaluate both the process of learning and the outcomes of the activity in terms of capability. The key aspects of this six week activity were:

- Refining the creative direction of their project solution
- Organising the material, processes, and requirements of their workshop activities
- Executing their designed solution
- Narrating their design journey, using an electronic diary of data collected throughout the process, and building a unique holistic insight for assessment.

In this period students were actively encouraged to pursue creative and diverse ideas for suitability to the task development. Teaching staff supported students in the activity, taking care not to guide or influence the decision making process, but rather inform it. Their role was to create an awareness with the student of the need for appropriate knowledge, skills and experience to inform their decision making process. Analysis of the critical nature of the decisions and their implications for their design solution was also encouraged. Peer to peer engagement was not employed as a specific pedagogical strategy but rather it was encouraged if the students felt it may be of benefit. Similarly, predefined stages or structures to design engagement were not provided as this could influence the designerly activity, potentially seeing students conform to the proposed model thus rendering any analysis of the impact of the methodology on design engagement as skewed or invalid. Teaching staff instead, encouraged students to explore methods that may be most appropriate to their needs in sourcing, investigating, validating and evaluating knowledge and procedures to inform or make explicit their design ideas. The recording of what was of value in this process was at the discretion of the student and was facilitated by the use of minimally invasive methods of capture and storage of data relevant to the evidencing of capability and learning. Communicating the outcomes of the learning activity was done through the compilation of an electronic portfolio from the individual student data base generated throughout the duration of the
activity. The structure of the portfolio, contents and modes of communication were at the discretion of the student. Again the emphasis was on the student presenting what they valued as being evidence of learning capability with a conscious effort being made by teaching staff not to impose values or structures external to the students’ own personal experience in the learning task.

3.3.3 Assessment

The influence of assessment on learning in design based activities is a problematic area. To provide a true measure of student capability in a design based task the method of assessment, or assigning value to the students work, must not negatively impact on how the student engages in their design activity. Providing explicit weighted criteria has been shown to influence pedagogical approach which can result in students aligning their engagement and experiences to ensure they “tick all the boxes” leading to the formulaic, routinised and predictable approached to learning that Kimbell (2004) identifies as not aligning with the goals of design based learning activities. It is recognised that students engaged in these design based modules will have a semi-constructed view of criteria relating to capability from their previous experiences in the domain during their second level education. The approach in this study supports the students in questioning these predetermined values and beliefs as a starting point in the further development of their personal construct of capability. Throughout the learning task students are facilitated in establishing their own criteria for assessment based on what they value from their engagement in the design based learning task. This necessitates an approach to assessment that provides over-arching criteria or goals for learning and assessment that students consult with when developing a personal construct of domain capability. The over-arching criteria used in this study are based on the findings of Kimbell (2004) that identified indicators of innovative and creative solutions to design tasks as Having, Growing and Proving of ideas. This approach has significant implications for both teachers and students engaging in the learning task. For the teacher the emphasis will be placed on helping students establish what is of value in their work and whether or not it demonstrates capability within the subject domain. This must be achieved, as much as is feasible, without the imposition of the teacher beliefs and values on that of the student. With the potential for diversity of response to
such an approach, the model of assessment must present a fair and valid method of assigning value to the outcomes of the learning activity.

The method used in the study highlights the design of the student activity, the infrastructure to support quality engagement and the assessment mechanism employed to assign value to the outcomes. With the emphasis on assessment capturing and valuing a wide range of skills and capabilities it was essential that the learning task for the study provide the potential for the development of such attributes. This was facilitated through the use of a semi-open design brief.

### 3.3.4 Design of the Semi-Open Brief

Following the initial skills building element of the module, students were challenged with the completion of a semi-open design brief. The brief was designed to align with specific learning outcomes of the relevant modules (Wood and Metal based decorative processing techniques) and provide scope for individual design input. Students were required to make an A4 framed pictorial scene with the composition of the scene being of the students own choosing, but portraying a dominant feeling or emotion. In addition, students were required to complete a second artefact. They were challenged to design and make a flower (without facial expression) to express or reflect the emotion or feeling conveyed in their pictorial scene.

The objectives of these design tasks were:

- To provide students with a medium to explore and develop new knowledge and skills in the production of a coherent set of artefacts, that enabled students to transfer their new knowledge and skill into a project that embodied their creative expression.
- Not to require students to discuss or present their designs under a series of predefined headings. Students were not given assessment criteria, but instead were encouraged to identify what they perceived to be significant about their design solution and therefore were encouraged to present for the assessor what they perceived to be evidence of their capability and learning throughout the activity.
The inclusion of the human feeling or emotion was such to provide the student with an opportunity to explore and express ideas, based on personal experience, through the medium of materials and acquired skills and capabilities. The personalised nature of this activity was potentially seen as a source of intrinsic motivation for engagement in the learning task and also shifted the ownership and direction of the design activity onto the student due to the unique theme derived from personal experience. It was also included to help broaden the perception of the subject domain from one of providing vocationally focused product manual skill outcomes to one that is more intellectually and conceptually based. The inclusion of the second (flower) artefact requires the student to explore different methods of conveying their feeling or emotion. The removal of facial expressions from the flower inadvertently creates the need for the students to explore shape, form, texture, colour etc. to create the link between the two elements.

3.3.5 Data Collection

Data collection for analysis of performance based capabilities must capture what is in the mind, created by the hand and the interaction between the two. The design of an instrument capable of capturing such a broad spectrum of data is central to the validity of the study.

3.3.6 Design of Electronic Infrastructural Support

Moving from the traditional deliverables of a predefined, prescribed practical artefact requires a defining of not only the narrative skills to communicate creative inspiration and design but also the defining of what is deemed appropriate deliverables. With the emphasis on both the mastery of craft skills, and design, it was important that the medium used to respond to the task was appropriate. Students need the capacity to capture, manage, record and order information in an attempt to communicate the design journey, therefore the approach taken was to utilize accessible technologies (the students’ mobile phones) and a data repository where students could construct their evidence of capability and learning throughout the activity. The benefits of integrating this technology were:
• Students had the capacity to capture inspiration in real time. The creative activity that is core to the education objective of the design brief was no longer confined to or constrained by the scheduled environment of the module. The creative activity of designing was now an exercise in synthesising global inspiration.

• The capacity and functionality of modern mobile phones enables students to capture information through a variety of media. Information can be later evaluated and synthesised. The integrated technology enhances the design process and acts as an additional pedagogical tool.

• The exploration of possible solutions and the development of divergent thinking require a robust and flexible management system. Flexibility in supporting inspiration and encouraging the synthesis of information is critical to developing ideas. Students need to capture, express and communicate information in the most appropriate manner for their needs. The mode of representation will vary considerably across data sources, but more importantly can capture and illustrate the idiosyncrasy of the students ‘Presage, Process and Product’ model of their learning process (Prosser and Trigwell 1999).

Students were encouraged to use their mobile phones to capture, manage, and store their inspiration and design decisions as they happened. A survey of the access and functionality of student phone devices was carried out to ensure equity of opportunity for all in the capturing process. Students were also surveyed to establish their current experience in utilising the functionality of their phones for communicative purposes. To facilitate the utilisation of these personal hand held devices (phones), two stages of support for their integration were developed (see Figure 3.2 below).

i. Students had access to a digital repository to facilitate the seamless transfer of data from their phones (or any other electronic device) to their own diary space. Data was generally transferred through bluetooth, memory card or hardwire upload from their phones to the digital repository, though the system could support SMS or MMS upload but at a cost to the student. In this repository students managed and ordered their data for output to their holistic portfolio. This allowed them to present, order, reflect on, and communicate their design
journey through a medium they felt was most appropriate to evidencing their learning and capability. Students had the freedom to present and emphasise what they deemed to be important about their design solution.

ii. Secondly, these digital repositories were linked to a non-directive, holistic software application that presented the students electronic portfolio of their work to the assessor in a single screen on their PC. This portfolio was populated from the student data repository (Figure 3.2). To facilitate the multiple file formats that were used by the students in the capture and compilation of their data, a file compatibility server was used to convert all data to formats supported by the electronic portfolio interface. The use of this file conversion server ensured that the students could utilise a technology device that they were familiar with (their phone) and had access to at all times. This web based portfolio together with the finished artefacts formed the evidence for assessment of capability and learning. This student-defined portfolio was the blank canvas used to present students design journey and more significantly supported the student in leading the assessor towards what they valued about their solution(s), in essence what they were presenting as criteria for assessment.

![Diagram of Mobile Phone Data Collection, Digital Repository, File Compatibility Server, Holistic Interface](image)
The portfolio comprised a number of panes (Figure 3.3) that could be populated by the student from their data repository. Students made all decisions in relation to the completion of their portfolio from the number of panes required to pane titles and contents.

The construct of the portfolio was defined by each student to reflect the experience of their design process and represent the significance of their individual approach to forming their solution to the brief and showing evidence of learning. A unique feature of the portfolio was the colour coded tagging system that the student had the option to employ during the management of their data. While uploading their files to the data repository students had the option to create a tag or link between that specific piece of data to the overarching criteria of Having, Growing, or Proving of ideas. This required the student to reflect on the data being considered and to present it in terms of how it related to their engagement in the design based activity. This process also presents the opportunity to analyse the meta-cognitive process as defined by the student throughout the duration of the design based learning task. Tagging provides the judge/assessor with an insight to the student perception of how they conceptualised and developed their
ideas throughout the learning process. The colour coding of the student tags allows the judge/assessor to visually follow the student in one or all of the three tag categories throughout the portfolio (Figure 3.4). The scale of occurrence of a tag category within the pane is reflected in the proportion of the tagging bar represented by the individual tag colour. In the example in Figure 3.4, the tagging bar shows an equal distribution of tagging within the posts in that particular pane of the portfolio. The purpose of the tagging process was to afford the student an opportunity to engage with the assessor (if they wished), presenting their interpretation of their cognitive engagement in the task. This aligns with view of Hager and Butler (1996) that the judgemental model of assessment has the potential for the student to indicate to the assessor what they feel is of value in their work. It is also utilised as a stimulus for appraisal for the student judges when engaging in both the learning and judging process.

**FIGURE 3.4 - EXAMPLE OF TAGGED POSTS TO AN INDIVIDUAL PORTFOLIO PANE**

### 3.4 ASSESSMENT INSTRUMENT

The design of the research method embraced both traditional weighted assessment and holistic assessment in valuing student performance in the task. The purpose of the study
was to validate the use of peer holistic judgement in generating a valid assessment of student capability developed through the design task. With the method requiring the students to apply their own individually constructed assessment criteria in the holistic judgement, significant attention is focused on the ability of the assessors to identify and value qualities of capability presented in the electronic portfolios. This was achieved through analysis of the student portfolios for qualities of capability, analysis of student judging comments on qualities of capability observed in the portfolios and comparative analysis between student judging and expert judging of capability.

### 3.4.1 Conventional Assessment Method

The traditional criteria for both the practical skills (which were not made explicit to the students as this could define the approach taken to the design task) and theoretical knowledge were employed by the module leaders to establish competencies as defined by the learning outcomes of the module. The traditional assessment of practical work focused on Material Selection 25%, Process Selection 25%, Process Execution 30%, Accuracy 10% and Finish 10%. Subject knowledge in both module disciplines was assessed using traditional written assessment at the end of semester.

### 3.4.2 Holistic Assessment

The use of the holistic assessment interface facilitated the presentation of student engagement in the design activity. This was achieved by the student tagging data to the overarching criteria of Having, Growing and Proving of ideas throughout the activity providing an insight into their design inspiration, motivation, and process, presenting evidence of individual engagement in the process of designing that was not influenced by the compulsion to align with traditional criterion referenced assessment. The approach also supported peer assessment, as a student generated rank order of task solutions facilitated an insight into not only how effectively students evidenced capability but also to what extent their peers valued it.

The student rank order was generated using an Adaptive Comparative Judgement (ACJ) method of assessment (Pollitt 2004) employed by project e-scape for the assessment of a design based task in Design and Technology in the UK (Kimbell et.al 2009). Judging
sessions were completed remotely by the students using the secure licenced web based e-scape assessment software provided by TAG Developments. A judging profile and security access code was generated and distributed to all student judges. Judging groups were created and assigned to strategically address specific research questions over the three years of the study. The assignment of the judging groups focused on the following questions in each year of the study:

Year 1: Two judging groups set up with judges being stratified by their programme discipline of study, Engineering Technology or Architectural Technology. The analysis of the outcomes of the judging sessions focused on the impact of the material discipline of the student on their assessment of capability.

Year 2: One judging group was created in year two of the study where the reduction in the number of judgments to be completed amplified the impact of odd decisions by judges. This will indicate whether the variance in judgement is concentrated on the individual judges or on the portfolios in that individual rank.

Year 3: Three judging groups were created for the third year of the study. The groups were stratified by task domain performance indicators from a previous semester. The focus of the research was to investigate if student ability had an impact on the outcome of the judging process.

Expert Judging: On completion of the student judging in Year 3, a sample of portfolios were selected from across the three years of the study and combined into one judging session. These portfolios were assessed by a selection of expert judges from the subject domain. The results of this assessment were used for comparative analysis between student and expert judges.

Judges were provided with training on the use of the judging software and provided with a description of how the system operated which is now outlined.

The method presents a judge with two portfolios of students’ work. The judge has to analyse each portfolio for evidence of capability and then decide which portfolio is better. The judgement process is based on criteria, but these criteria are not directly scored, instead they are interpreted by the judge to form a single judgement. A “pairs engine” is used to generate and manage the comparisons of the student electronic
portfolios as the process evolves. To produce a valid rank the judges must form a consensus of decisions on portfolios that they perceive to be evidence of capability and learning. Each judge is monitored by the system where data generated can give an indicator of their consensus within the judging group. Judges that lie outside of the judge “fit criterion” can be identified and monitored/advised in relation to their judging process. In the case of Initial Teacher Education students it also provides the student with an insight into their construct of capability and whether it aligns with capability as defined by their peers and the curriculum. With the objective of the study to investigate if student teachers are capable of assessing performance capability in the design task the internal reliability of the assessment is of paramount concern. The following section presents the method of generating the reliability coefficient for the ACJ model which will be used to validate the student judgements of capability as presented in the electronic portfolios.

### 3.4.3 Reliability of ACJ Model of assessment

This section is based on the work of Pollitt (2011) and presents the robustness of the ACJ model of assessment in generating a rank order of performance. As previously outlined the model is based on the probability of any piece of work (object) being better than another in a group of tests. The comparisons of the individual objects generate a set of probability parameters for each object. This parameter value is not a direct measurement of the quality of the work but is rather an indicator as to where the work would lie on a scale of the comparisons of all the work in an assessment. The following section presents the statistical outputs generated by the ACJ approach that will be used by this study to address the research questions on the ability of the student judges to generate a reliable and valid assessment of capability in the subject domain using holistic judgement.

### 3.4.4 The Logistic Model for Comparative Judgement

Let the “value” of any two objects, A and B for a comparative judgement be \( v_a \) and \( v_b \). The natural logarithm of the odds that A will win over B is the difference in value between A and B. Thus:
\[
\text{logodds}(A \text{ beats } B | v_a, v_b) = v_a - v_b \quad \text{EQ 1}
\]

So if we knew how good or bad the pieces of work A and B were the anti-log of their difference would give us the odds of one winning over the other. This can then be converted from odds to probability.

\[
\text{prob}(A \text{ beats } B | v_a, v_b) = \frac{\exp(v_a - v_b)}{1 + \exp(v_a - v_b)} \quad \text{EQ 2}
\]

Converting between odds and probability is straightforward:

- To convert from a probability to odds, divide the probability by one minus that probability. So if the probability is 10% or 0.10, then the odds are 0.1/0.9 or “1 to 9” or 0.111.
- To convert from odds to a probability, divide the odds by one plus the odds. So to convert odds of 1/9 to a probability, divide 1/9 by 10/9 to obtain the probability of 0.10.

The left hand side of EQ 2 represents the probability of the judgement based on the data generated by the judging process. If this value is known then the relative values of A and B can be estimated i.e. \(v_a\) and \(v_b\). Pollitt outlines a number of critical points about this model that will be synopsised here.

- The values \(v_a\) and \(v_b\) are relative. The method requires the setting of an arbitrary measurement point and develop a suitable scale. The scale used in this study is from -10 to 10 units with zero set as the base point of the scale.
- It is not necessary to observe every possible comparison of assessment objects. The system will generate a data set that is adequate to estimate the values of every object on the scale if items are compared to similar other objects a minimum of ten times.
- The system requires judges to make holistic judgements of the work against a notional scale that is a shared consensus among all the judges.
- The algorithm used to calculate the values of the objects uses an iterative maximum likelihood procedure. This was adapted and developed by Alistair Pollitt and software company TAG Developments (UK) for use in the assessment of design and technology performance based portfolios.
• The model has powerful statistics generated by the observation of the deviation from the norm for the judges and the assessment objects. The method assumes that judges are equally good in their ability to discriminate between objects, that every object is equally “discriminable”, and that each judgement is independent of every other one. These are presented as judge misfit and object misfit and bias respectively.

### 3.4.5 Adaptive Comparative Judgement Model (ACJ)

Pollitt (2011) outlines the nature and benefit of adaptive testing of student ability. He outlines that a judge will learn more about a student’s performance if the two assessment objects or portfolios in the case of this study are reasonably similar in quality. He presents the following in relation to the application of the ACJ model.

The increase in efficiency is described by the statistical concept of information. For the case of this study, the information in a result, $I$, is defined by:

$$I = p(1 - p) \quad \text{EQ 3}$$

With comparative judgement there has to be a winner. Ties are not allowed. Therefore the result of the judgement is a win for the first portfolio and a loss for the second or vice versa. In either case the information is the product of the probability of one outcome ($p$) and the probability of the other ($1 - p$). Graphing the information, probability relationship shows that this reaches a maximum at $p = 0.5$ (Figure 3.5)

![Figure 3.5 - Information as a Function of Probability (Pollitt 2011)](image)

The ACJ model utilised in this study chooses pairs of portfolios for comparison so that the probability of one of them winning is between 0.3 and 0.7 in terms of probability
which gives at least an 84% optimal efficiency based on using a range of 0.04 information units. Information is maximised when \( p = 0.5 \) but this makes the judging difficult for judges. On the other hand when the probability approaches 0 or 1 the decision is very easy and information is at a minimum. In this study the assessment is optimised by choosing a comparator for each portfolio so that \( p \) is approximately 0.67 or 0.33. As the portfolios win and lose throughout the judgement process the probability parameter for an individual portfolio will go up and down accordingly and subsequent judgements will be based on the most resent probability estimation for that portfolio.

To begin this process the portfolios of work would need to have a probability value assigned to them. However at this starting point nothing is known about the quality of the work and so the process has to start out randomly selecting portfolios for the paired comparisons. When every portfolio has been judged once, the system can begin to perform more efficiently. At this stage half the portfolios will have won and the other half will have lost. The next round compares the winners with the winners and the losers with the losers. This is likely to be closer in quality than a random pair. This round will result in three categories: Those that have won both judgements, those that have won one judgement and those that have not won any judgement. This is known as rough sorting of the portfolios and generally generates enough data after 6 rounds to estimate each portfolio’s value using the Rasch model in EQ 2. From here on the efficiency rises dramatically as the values are known with increasing accuracy and the paring is closer to optimal (Pollitt 2011). After a number of rounds of judging the estimation errors on the portfolio probability will reduce and stabilise at which further judging is unlikely to produce significant movement of the portfolio on the ranked order of quality work.

### 3.4.6 Statistical Analysis for Quality Control

When a judge compares two portfolios, Eq 2 can be used to measure the degree of ‘surprise’ in their decision. It gives us the ‘predicted’ outcome, \( p_{a,b} \), where ‘expected’ has the standard statistical meaning of the average outcome if we could repeat the judgement many times. The value of \( p_{a,b} \) is calculated from the final estimates of the
quality of portfolios A and B, and will be a real number between 0 and 1. However, the ‘observed’ outcome will be *either* 1, if A wins, or 0, if B wins. The difference between the observed outcome and the expected one is called the *residual*, and this is at the heart of all the analysis that can be carried out to monitor measurement quality.

\[ \text{Residual}_{j,a,b} : \quad X_{j,a,b} - p_{a,b} \mid X = 1,0 \]  \hspace{1cm} \text{EQ 4}

This is the residual when judge \( j \) compares portfolios \( a \) and \( b \). The residual is first standardised by dividing by the square root of the Information in the judgement (from EQ 3):

\[ \text{StdRes:} \quad z_{j,a,b} = \frac{\text{Residual}_{j,a,b}}{\sqrt{p_{a,b}(1-p_{a,b})}} \]  \hspace{1cm} \text{EQ 5}

These standardised residuals can now be aggregated in any appropriate way and interpreted as a mean chi-square statistic (Pollitt, 2011).

### 3.4.7 Judging and Portfolio Misfit

Performance of judges and portfolios can be evaluated by averaging the squared standardised residuals from all the judgements made, by the judge, or on the portfolio. The best indicator of judge or portfolio infit is presented by Pollit in (Kimbell 2009) as the Weighted Mean Square (WmnSq) value. The following is an extract from Pollitt (2011) on the calculation of this statistic:

Whenever a judge decides in favour of the portfolio that the consensus says is ‘better’, the residual will be smaller than 0.5; when they favour the ‘poorer’ one the residual will be larger. If all the residuals for a particular judge are summarised, the size of the resulting statistic indicates the degree to which that judge tends to deviate from the consensus, or *mis-fits*. The residuals can be summarised producing what is known in the Rasch literature as *Infit Mean Squares*. The Infit Mean Square is calculated as follows.

First, each standard residual is squared and then weighted by its Information:
\[ W^2_{\text{Row},a,b} = \sum_{a,b} (w_{a,b} - I_{a,b})^2 \]  \hspace{1cm} \text{EQ 6}

These are summed across all the judgements made by judge \( j \), and divided by the sum of the information, to give the Infit Mean Square:

\[ \text{InfitMS} : \quad wms_j = \frac{\sum_{a,b} w_{a,b}^2}{\sum I} \]  \hspace{1cm} \text{EQ 7}

This statistic is reported in the TAG e-scape system (under \textit{full report}) as WmnSq and an example of such data is presented in Table 3.3.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Count</th>
<th>Mean</th>
<th>UWmnSq</th>
<th>Unwghted Z</th>
<th>WmnSq</th>
<th>Wghted Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Judge 1</td>
<td>22</td>
<td>0.5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Judge 2</td>
<td>22</td>
<td>0.54</td>
<td>22.06</td>
<td>5.70</td>
<td>1.64</td>
<td>5.22</td>
</tr>
<tr>
<td>3</td>
<td>Judge 3</td>
<td>22</td>
<td>0.46</td>
<td>0.89</td>
<td>-1.23</td>
<td>0.91</td>
<td>-1.23</td>
</tr>
<tr>
<td>4</td>
<td>Judge 4</td>
<td>22</td>
<td>0.44</td>
<td>0.97</td>
<td>0.30</td>
<td>1.05</td>
<td>0.43</td>
</tr>
<tr>
<td>62</td>
<td>Judge 62</td>
<td>21</td>
<td>0.48</td>
<td>1.47</td>
<td>1.64</td>
<td>1.37</td>
<td>1.86</td>
</tr>
<tr>
<td>63</td>
<td>Judge 63</td>
<td>19</td>
<td>0.48</td>
<td>1.25</td>
<td>1.11</td>
<td>1.28</td>
<td>1.48</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td></td>
<td>0.47</td>
<td>2.19</td>
<td>5.01</td>
<td>1.20</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>S.D.</td>
<td></td>
<td>0.05</td>
<td>3.23</td>
<td>11.16</td>
<td>0.27</td>
<td>1.56</td>
</tr>
</tbody>
</table>

The Infit mean square (WmnSq) is interpreted as a mean chi-square, and a conventional criterion is to treat as mis-fitting any judge whose value exceeds the mean plus two standard deviations: in this case the criterion would be \( 1.20 + 2 \times 0.27 = 1.74 \) (Pollitt 2011). Thus “Judge 62” with a value of 1.86, would be considered outside the parameter for conforming to the consensus. When a judge’s WmnSq exceeds the limit it may be
worth exploring how they made their judgements (they may see some value that all the
others miss, or balance originality versus practicality differently) but, in the end, reliable
assessment requires that the judges are consistent with each other.

A similar procedure gives a misfit statistic for the portfolio. If a portfolio’s WmnSq
exceeds the mean plus two standard deviations, then this means that the judges did not
judge it consistently with some considering it better than others. This may be an
indicator that the portfolio may warrant some investigation to establish if there is some
unusual feature that may explain the disagreement.

The use of the misfit statistic for both portfolio and judge will highlight the level of
consensus by judges on the quality of work. It will also be used to indicate the source
of variance within the assessment task.

3.4.8 Bias

The portfolio and judge misfit statistics are special cases of a more general form of
analysis. Because every judgement is assumed to be strictly independent, the summation
can be carried out over any subset of comparisons, not only those involving one judge
or one portfolio. If there is any reason to suspect that a subset might be systematically
different from the rest, the weighted squared residuals for that subset can be
summarised in the same way, giving a significance test for bias (Pollitt 2011).

3.4.9 Reliability of Student Judgements

In ACJ analysis, the reliability of the assessment process is calculated in the following
way. For every portfolio, $i$, the analysis generates a parameter, $v_i$, and a standard error,$e_i$. From these, the standard deviation of the parameters is calculated, $sd_v$, and the root
mean square average of the standard errors, $rmse$. A separation coefficient is then
defined as the ratio of the $sd_v$ to the $rmse$:

$$\text{SepCoeff: } G = \frac{sd_v}{rmse} \quad \text{EQ 8}$$
The rmse can be thought of as the amount of ‘fuzziness’ in the scale, then $G$ tells us how the spread of the measures compares to this – the higher the value of $G$, the more clearly separated the objects are. $G$ can be directly converted into an analogy of the traditional reliability index:

\[
\text{Reliability: } \alpha = \frac{G^2}{1+G^2}
\]

EQ 9

Reliability refers to the precision of measurement. The reliability coefficient in Eq 9 is equivalent to Cronbach’s *alpha coefficient* which is usually considered to be relative (Pollitt, 2011). Reliability is calculated on a scale between 0 and 1 with 1 being the optimum reliability.

### 3.4.10 Validity of Student Judgements

Pollitt (2011) outlines that a very general set of criteria is needed for ACJ as it requires holistic assessment of the student work. Having been clear on what was to be measured (technological capability), the validity of the assessment relies on students firstly identifying qualities of capability in the electronic portfolios and secondly that they make their judgements based on their personal construct of capability defined through their engagement in the design based task.

Dealing with the first issue of the student rank being generated from the electronic portfolio, it was critical to investigate if the portfolios provided the data necessary for the assessor/judge to evidence the capability of the student. A descriptive analysis of the portfolio content was completed based on Gibson’s model of capability (2008) which outlines skills, values and problem solving in the context of conceptual knowledge as the cornerstones of technological capability. Table 3.4 illustrates the criteria and scale used to determine the evidence of capability in the portfolios. It is important to note that the criteria are broad and the analysis was carried out by experienced experts in the domain of technology education and learning.
The second issue is more complex as it is difficult to analyse what contributed to each judgement, and to what level, when students were making their judging decisions. Indeed, it is quite possible that judges may use different criteria to judge the same portfolio depending on the type and quality of portfolio it is paired against. In essence what is needed is an indication that the consensus generated by the student rank order of performance showed evidence of valuing capability on a sliding scale of relative performance. The data collected from the rubric in Table 3.4 can only give part of the picture. The findings may indicate that the portfolios communicate capability, but has the judging process rewarded student attainment in terms of quality of performance. To address this issue the design of the research method embraced comparatively both traditional weighted assessment and holistic assessment for comparison.

**Conventional Assessment Method** - The traditional criteria for both the practical skills (which were not made explicit to the students as this could define the approach taken to the design task) and theoretical knowledge was employed by the module leaders to establish competencies as defined by the learning outcomes of the module within the domain. A sample of the traditional craft processing assessment criteria is presented in Table 3.5.

### TABLE 3.4 - PORTFOLIO ANALYSIS RUBRIC FOR EVIDENCE OF CAPABILITY

<table>
<thead>
<tr>
<th>Skills</th>
<th>Knowledge</th>
<th>Problem Solving</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criteria</strong>*</td>
<td><strong>Rating</strong></td>
<td><strong>Criterion</strong></td>
</tr>
<tr>
<td>Diversity of Skills</td>
<td>(1-10)</td>
<td>Within Module</td>
</tr>
<tr>
<td>Level of skill acquisition</td>
<td>(1-10)</td>
<td>Beyond Module</td>
</tr>
<tr>
<td>Justification for selection</td>
<td>(1-10)</td>
<td>Application</td>
</tr>
</tbody>
</table>

**Note:**

* Skills were rated based on evidence from the electronic portfolio and not the physical artefact.

** Frequency of problems created was rated as None (0) Low (1) Medium (2) or High (3)
Subject knowledge in both module disciplines was assessed using traditional written assessment at the end of semester. Both modules (WT4302 and PN4102) required students to complete a 1.5 hour examination designed to establish competency in subject knowledge relating to the module learning outcomes.

With data from three approaches to identifying and valuing student capability, statistical analysis was employed to establish if there were significant relationships between them.

FIGURE 3.6 - TRIANGULATION OF EVIDENCE OF CAPABILITY

However, the issue of identifying and valuing creative endeavour in students’ work must also be addressed as this is one of the goals of education, both general and technological, both internationally and in the Irish context. The removal of explicit rated assessment criteria and the nature of the student derived portfolio structure, necessitates the assessor to navigate their way through the students work to establish its

TABLE 3.5 - SAMPLE OF TRADITIONAL CRAFT PROCESSING ASSESSMENT CRITERIA

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weighting</th>
<th>Score (1-10)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Selection</td>
<td>0.25</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Process Selection</td>
<td>0.25</td>
<td>7</td>
<td>1.75</td>
</tr>
<tr>
<td>Process Execution</td>
<td>0.3</td>
<td>6</td>
<td>1.8</td>
</tr>
<tr>
<td>Accuracy</td>
<td>0.1</td>
<td>8</td>
<td>0.8</td>
</tr>
<tr>
<td>Finish</td>
<td>0.1</td>
<td>8</td>
<td>0.8</td>
</tr>
<tr>
<td>Total (10 marks)</td>
<td></td>
<td></td>
<td>7.15</td>
</tr>
</tbody>
</table>
value or quality. To aid the assessor in this process the colour coded tagging bar at the top of the portfolio panes may be used. As stated earlier, Kimbell et al. (2004) identify three elements to an assessment framework based on student ideas within the design activity that are indicators of creative and innovative solutions as, Having, Growing, and Proving of ideas. The tagging process potentially operates on two levels. Firstly, it provides the student with the opportunity to reflect on their cognitive activity and provide an insight into what they believed it represented. Secondly, it allows them to signpost their work for the assessor, to draw focus on what they perceived to be evidence of the indicators of creative endeavour. An analysis of tagging data will give an insight into the cognitive process as presented by the student throughout the design activity. Incidence and occurrence of tagging across the portfolios will indicate the student perception of the creative nature of their work.

3.4.11 Analysis of Tagging Data

Analysis of student tagging will provide significant data for this study. Student tags were analysed and compared with the problem solving scores from the rubric in Table 3.4 to establish if significant relationships exist between problem solving and students’ perception of what is deemed to be indicative of creative activity. Significant correlations between the ACJ rank, problem solving rubric and tagging analysis may provide indicators of student valuing creativity through the ACJ model of assessment.

Student tags of Having, Growing and Proving ideas were recorded by portfolio pane for each of the 137 student portfolios from Group 1. The percentage of tag category was
recorded for each pane across the portfolio which gives an insight into how the student perceived they engaged in the learning task activity. It was not mandatory to tag as this may cause the students to tag work for the sake of doing so. Students were asked to tag any work that they felt was of value to the assessor in gaining an insight into both their conceptual and functional design process. With the structure of the portfolio defined by the students, they could decide which way was best for them to communicate their design journey. This means that the portfolio, as seen in the holistic interface, might not be presented in the chronological order of the task engagement but rather could be presented in terms of what the student felt was of value in communicating their work. For this reason a holistic interpretation of the portfolio tagging is more appropriate than a linear interpretation of a design process model.

3.4.12 Implementation and Analysis

The study was implemented with the 3 groups over a 15 week period in the second semester of their first year on their programme of study. Table 3.6 illustrates the timeline for the study within the 15 week semester.

- Lectures were delivered over a 12 week period addressing the key areas related to technological capability associated with the learning outcomes of the modules. Students had a 1 hour lecture per week per module.
• The skills development took place from week 1 to week 6 inclusive.
• An electronic survey of student phone capacity and usage was implemented, collected and analysed between week 1 and week 3.
• The design task brief was presented to students in lectures in week 4 which gave students 3 weeks incubation period for the task where they could explore ideas in the context of the skills building activity they were engaged with.
• The task execution commenced on week 6 and ran until week 12 inclusive. Students had 7 hours access to the laboratory facilities during this time on a timetabled basis providing equal access for all. They also had a one hour tutorial session per week that took place outside of the workshop environment where they could discuss and plan their activities for the coming week(s). The task submission deadline was Friday of week 12 of the semester.
• Software training for the management of the data and creation of the electronic portfolio took place over a two week period from week 6 to week 7. This focused on uploading and managing data on the data repository and tagging data to the criteria of Having, Growing and Proving.
• Data recording, data tagging and portfolio construction took place between weeks 6 and 12 inclusive. The deadline for the completion of the portfolio was Monday of week 13.
• A pilot ACJ session was completed by the students to make them familiar with the assessment interface and method. This also provided opportunity for the module leaders to observe and rectify any technical and managerial issues that may impact on the judging performance. This was completed in the University IT facilities under controlled conditions.
• The student ACJ assessment was completed between weeks 14 and 15 inclusive. This was carried out remotely from the University based on the findings of the pilot judging session.
• During the course of the semester teaching and lecturing staff recorded general observations in relation to student behaviour and performance in all activities. Attendance at all sessions was recorded, though attendance was not mandatory.
• 1.5 hour terminal examinations for both modules took place between week 14 and 15 inclusive.
• On submission of the student practical outcomes on Friday of week 12 all projects were put on public display in the students’ base building at the University of Limerick. They were displayed for 3 weeks. During this time academic leaders graded the product outcomes of the design task from the display.

• Following the completion of each year of the study data was analysed for findings that would inform the evolutionary nature of the approach. Figure 3.8 illustrates the elements of the research method implemented in the study. Statistical analysis was employed to explore the relationship between the traditional and holistic assessment methods in an attempt to indicate relevant relationships.

The data analysis thus far has concentrated on the validity and reliability of the method in developing and assessing domain capabilities set out in the learning outcomes of the modules at the centre of this study. However, this is only part of the story. The impact of the approach (to learning and assessment) on the students’ behaviour and learning can only be partly captured by the methods presented to date. To capture the richness of the experiences of the study participants calls for a qualitative analysis of the student engagement with and perception of the learning activity. A qualitative questionnaire was implemented to capture the nature of the student experience.
3.4.13 Design of the Research Questionnaire

Following the completion of the design task and the ACJ, peer assessment focus groups were conducted as a preliminary to designing the research questionnaire. The topics for discussion were generated from classroom observations, portfolio analysis, statistical analysis of the ACJ assessment process and qualitative commentary by students from the ACJ assessment task. The purpose of the focus groups was to help maximise the validity of the questionnaire and to identify, from the participants, topics of importance for them, having completed both modules. Three focus groups were conducted; one from each year group participating in the study. Details of the focus group, guiding questions and audio transcript of participant contributions are presented in Appendix 2.

Following an analysis of the focus group contributions a research questionnaire was compiled to generate both qualitative and quantitative data that would give an insight into the students experience and reaction to the experimental learning and assessment strategy. To help with the analysis of responses, closed questions with a five point Likert scale were used to elicit participant views on the impact of the experimental method on their learning experience. The questions were chosen to address critical issues identified in the literature review, commentary from the student focus groups and to address issues pertinent to the objectives of the study. Each question was accompanied by a non-compulsory comment box where participants could leave qualitative commentary on the particular question being addressed. The non-compulsory nature of this commentary option provided participants with the opportunity to voice their opinion should it not have been adequately addressed in the question. It also presents the study with the opportunity to collect unsolicited responses to issues that were of critical importance to the participant. These responses will help contextualise and aid with the interpretation of the Likert scale responses for that question. The results from the questionnaire were used to inform both the statistical analysis of the research findings and the qualitative responses of the student groups. The key focus of the questionnaire can be categorised by the following sections:

- Social constructivist paradigm for learning
- Learning through design based activity
- Role of assessment and impact on learning
• Value of the learning experience

An electronic medium for distribution and completion of the survey was utilised to help ensure a high response rate. The survey was distributed via e-mail to all students that participated in the three years of the study. Students were required to submit the year in which they completed the study and their identification number as part of the survey response. This was required to analyse if there were particular trends or bias across the year groups and to examine any potential trends between response and academic performance in the modules. A copy of the questionnaire is presented in Appendix 3.

3.5 SUMMARY

The method outlined in this chapter has many components and variables. The central issue of concern is the creation of a learning environment that is supported rather than guided by assessment procedures and that facilitates students in pursuing innovative and creative endeavours. It is critical to note that the role of the module leaders in creating and managing the learning environment that facilitates students developing an internal construct of domain capability is central to its success. It is also of critical importance that the nature of the assessment procedure is explored in full with the student group so that they have a clear understanding of how their capability will be valued. The next chapter will present the findings from the implementation of the study.
4 FINDINGS: RELIABILITY AND VALIDITY OF PEER ASSESSMENT USING ACJ
4.1 OVERVIEW OF RESEARCH FINDINGS

From the outset, this study was designed to establish the impact of peer assessment using the ACJ model on learning activities in design based technology education. Evaluating the effect of this study’s approach requires the collection and analysis of data to give insight into how the method impacted on student behaviour and learning outcomes as well as evaluating the potential of the ACJ assessment model to validly and reliably assess domain capability. The research findings for this study are drawn from the analysis of the mixed methods approach previously outlined. The study findings will be presented with four main section headings. The initial concerns of the study relate to the validity and reliability of the ACJ assessment model to assess student capability presented through electronic portfolios generated throughout the task activity of the subject modules. Research questions relating to validity and reliability were sequentially addressed over the three years of the study with each year’s findings informing the direction of the following year’s approach to the organisation of the judging process. The focus of this chapter will establish that peer assessment through the use of the ACJ model can reliably generate a valid assessment of student capability in the subject domain of the modules of study. Findings for reliability and validity of the ACJ assessment method will be presented on a year by year basis focusing on the specific research question that was the focus of that year of the study. Figure 4.1 presents a schematic representation of the structure of the research findings in this section.
The second research question (section 1.4) focuses on the effectiveness of holistic assessment in valuing student capability. Objective 4 (section 1.5.1) identifies the importance of validity and reliability of the peer assessment approach. Critical factors that may impact on the validity and reliability of the peer assessment were identified and were investigated over the course of three consecutive years of student engagement with the modules of study. The issues concerning reliability are as follows:

- Do material biased epistemologies affect student’s abilities to determine capability? (Year 1)
- Can students reach consensus on qualities of capability and use these to determine capability without the influence of external explicit assessment criteria? (Year 2)
• Is student ability a discriminating factor in their capacity to consensually judge the quality of capability in their subject domain? (Year 3)

The first section will present the findings that establish the reliability of the ACJ assessment model in assessing capability within the domain of the modules of study. An analysis of the consensus between students from both programmes of study (LM094 and LM095) is presented. The second year of the study examines the reliability of individual student judges in making decisions on levels of capability using the ACJ assessment model. Also examined in this phase of the study is the distribution of performance indicators, identified by judges in the portfolios, across the rank order and across individual judges. The focus of this analysis is to see what the judges are identifying as evidence of capability and to evaluate if judging criteria are influenced by the individual capability of the judge. The final year of the study focuses on the stratification of judges across three groups based on subject domain competence where the reliability of the ACJ assessment model will be presented through a correlation of the portfolio positions across the three independent rank orders of capability.

4.2 RELIABILITY OF ACJ ASSESSMENT MODEL

The reliability of the ACJ assessment model will first be presented in order to establish if consensus on the level of capability of student could be achieved by the student judging cohort. Two critical features of the study that must be kept in mind are:

• The portfolios of work presented for assessment were peer assessed by the student group completing the task

• No explicit assessment criteria were given to the students to complete the assessment task.

The method does not present the student assessors (judges) with a pre-determined consensus on qualities that represent capability on which to draw inference or make their assessment decisions. In other words, explicit assessment criteria are not provided for students to guide them through either the learning or the assessment stages of the module task. Reliability in the assessment will be determined if a consensus emerges across the range of judges on what is identified as being qualities of capability, having
not being told what to value at the outset. The level of agreement across a range of judges on the clusters of qualities exhibited in one portfolio being better or worse than those in another portfolio will present the reliability of the ACJ model in democratically assigning value to students work.

Analysis of the consensus of the ACJ rank orders of student portfolios (generally referred to as the rank or ranks) will be presented using the Cronbach Alpha reliability coefficient outlined in section 3.4.9. Further analysis of the portfolio misfit statistic outlined in section 3.4.7 will indicate the degree of consensus on individual portfolios position on the rank order. Individual judge misfit statistics will indicate the level of agreement by judges across the cohort on what represents the various levels of capability as presented in the portfolios. Six rank orders of student portfolios were generated over the three years of the study. For the purpose of statistical analysis the portfolio parameter value was used as it determines both the position of the portfolio and the distance between objects on the rank order².

4.2.1 Reliability of ACJ Rank Order (Year 1)

Year One of the study focused on the implementation of ACJ as an assessment tool to evaluate student performance in the design task. The initial concern for the research study was to establish if the material bias of the individual student programmes of study (LM094 and LM095) would have an impact on what the student judges would value as qualities of capability in the task. With this focus, two stratified judging sessions Year 1 Rank 1 and Year 1 Rank 2 were created with the selection of the judges based on the material discipline of their degree programme of study (LM094 = Rank 1, n = 53 and LM095 = Rank 2, n = 63). Both judging groups judged the full range of 137 portfolios produced by both class groups during the semester. All students were not included in the judging activity due to technical difficulties with an initial judging session.

² It must be noted that parameter values are not comparable across different ranks produced by individual judging sessions. Any comparisons across rank orders will be conducted by converting the parameter values to a traditional percentage grade for each of the individual ranks.
Commitments to module coursework and exams prevented them from taking part in the second judging session.

4.2.2 Rank 1 (Architectural) and Rank 2 (Engineering) ACJ Reliability Statistics

The ACJ sessions ran for 16 estimation rounds with Rank 1 and for 19 estimation rounds with Rank 2. Table 4.1 presents the important reliability statistics for both judging sessions.

<table>
<thead>
<tr>
<th>TABLE 4.1 - RANK 1 AND RANK 2 RELIABILITY STATISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank Order Data</td>
</tr>
<tr>
<td>Scale Properties</td>
</tr>
<tr>
<td>Standard deviation of Object parameters</td>
</tr>
<tr>
<td>rms estimation error (root mean square average of standard errors)</td>
</tr>
<tr>
<td>Separation coefficient (sd/se)</td>
</tr>
<tr>
<td>Reliability coefficient (Cronbach Alpha)</td>
</tr>
<tr>
<td>Assuming these represent a population 6 sd's wide and that bands 3 se's apart are distinguishable, then the number of reliably distinct bands of objects is:</td>
</tr>
</tbody>
</table>

The Cronbach Alpha reliability coefficient for both ranks is very highly reliable (Cohen et al. 2007 p. 506) with the Architectural Technology students judging session = 0.948 and the Engineering Technology students judging session = 0.955. Both groups generated 9.1 and 9.7 reliably distinct bands of objects indicating similar distance between objects on both rank orders.

Figure 4.2 to Figure 4.5 present the parameter value error plots for estimation rounds 6, 7, and 12 for the Rank 2 (Engineering) judging session. The portfolio rank order position is plotted along the X-axis with the portfolio parameter value being plotted along the Y-axis. The vertical red lines represent the magnitude of standard error for each portfolio at that point in the judging session. The longer the red error line, the fewer consensuses there is with regard to the position of the portfolio at that point in the judging session.
The graphs show a high level of consensus on the portfolios across the majority of the rank after round 6 with less agreement on the position of the portfolios at either extreme of the rank. This is a common feature of the ACJ process once the initial rough sort of the portfolios is completed by estimation round 6 (Kimbell 2009). By estimation round 12 the parameter error is significantly reduced across the rank with the further estimation rounds consolidating the consensus of the position of each portfolio position relative to all other work on the rank. A full analysis of the Rank 1 (Architectural) judging session is presented in Appendix 4 where a similar pattern of parameter error reduction is observed.

![Parameter value error plot](image)

**FIGURE 4.2 - R2 PARAMETER VALUE ERROR PLOT (ROUND 6)**

High standard error recorded in the rough sort rounds as the error plot is calculated within the smaller bands of the swiss-tournament style sorting method.
From round 7 onward the full range of portfolios is used to calculate the standard error thus reducing the magnitude of the error. This identifies portfolios across the full rank where there is less consensus about their position. Judging is then concentrated on these portfolios to reduce the error.

By round 9 the focus of the judgements on the high error portfolios significantly reduces the uncertainty of their position on the rank order.
By round 12 the standard error for each portfolio parameter has stabilised indicating consensus on the portfolio positions on the rank order.

Figure 4.6 shows the Rank 2 parameter error plot for the 19th and final estimation round for that judging session. An even spread of parameter values is observed across the majority of the rank order. However a noticeable drop in parameter value is observed at the lower end of the rank indicating that these portfolios are of significantly less quality than those immediately before them on the rank order. A full range of the parameter error plots for the Rank 2 Engineering judging session can be viewed in Appendix 5.

4.2.3 Rank 1 and Rank 2 Descriptive Statistics

The range of parameter values for each rank was recorded as 7.5 to -8.11 for Rank 1 and 6.72 to -5.69 for Rank 2 with both ranks having approximately half the group above and
below the 0.00 parameter value mark. The shape and distribution of both ranks appear
to be quite similar except for object distance at the top section of the ranks. Rank 2
shows a significant distance in parameter value between the top 3 portfolios and the rest
of the rank order. This would indicate a consensus by the group that these three
portfolios were judged to be of a significantly higher quality than the other portfolios at
the top of the rank. The distribution of parameter values for both Rank 1 and Rank 2
ranks was investigated to see if the object distance (relative quality of the work) was
normally distributed across the rank order. The magnitude of the distance between
parameter values is an indicator of the distance between objects in terms of quality as
determined by that group of judges. Both ranks were tested for normality, skewness
and kurtosis. Table 4.2 presents the results of the descriptive statistics run on both
ranks.

**TABLE 4.2 - RANK 1 AND RANK 2 RELIABILITY STATISTICS**

<table>
<thead>
<tr>
<th>Rank Name</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Kolmogorov-Smirnov Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Statistic</td>
<td>Std. Error</td>
<td>Statistic</td>
</tr>
<tr>
<td>Rank 1</td>
<td>-0.137</td>
<td>0.207</td>
<td>1.162</td>
</tr>
<tr>
<td>Rank 2</td>
<td>0.078</td>
<td>0.207</td>
<td>0.095</td>
</tr>
</tbody>
</table>

A negative skew value was recorded for Rank 1 with a positive skew value recorded for
Rank 2. As the absolute skewness statistic value is less than two times the standard
error of skewness (0.207*2 = 0.414) for both ranks, both distributions are deemed not to
have significant skew. Rank 2 does not present significant kurtosis as the kurtosis
statistic is less than two times the standard error of kurtosis. However, Rank 1 presents
significant kurtosis with the kurtosis statistic of 1.162. Both ranks were found to be
normally distributed having a Kolmogorov-Smirnov significance value greater than
0.05. This implies that both Rank 1 and Rank 2 rank values can be interpreted as
parametric data for the purpose of further statistical analysis. The full data sheet for the
descriptive analysis of Rank 1 and Rank 2 parameter distributions can be found in
Appendix 6.
4.2.4 Rank 1 and Rank 2 Rank Order Correlation

The high reliability scores achieved by both judging sessions indicate the level of certainty among the individual judging groups on the position of the portfolio of work on the rank order. The question now focuses on the similarity or difference between the portfolio positions on both rank orders. To investigate if a significant correlation of the portfolio rank order positions exists between the Rank 1 and Rank 2 ranks a Pearson’s correlation test was run between the two rank orders of portfolio parameter values. A moderate to strong (Cohen et al. 2007 p.521) correlation was observed (r = 0.695, p<0.001, n = 137). This indicates a moderate to strong positive relationship between the two ranks which would suggest that the decision making by student judges reached a similar consensus on the relative positions of the portfolios with two separate assessment activities. While this gives no indication of what the students based their decisions on during the judging activity, it indicates a strong consensus on the order of the work presented in the portfolios by the class group. This significant correlation of consensus of both assessment groups suggests that the material subject discipline, on which the groups were formed, did not create a bias or significant difference in the assessment of technological capability.

4.2.5 Analysis of Portfolio Statistics

One of the strengths of the ACJ assessment process is the statistical data that is gathered on both the portfolios and the judges as the process evolves. The following section analyses the portfolio and judge statistics that relate to the reliability of the Rank 1 and Rank 2 rank orders. Portfolio statistics were analysed and seven portfolios were observed to be outside the fit criterion for both rank orders. Pollit (in Kimbell 2009) presents this level of misfit as acceptable for a 5% significance test. In that study (Kimbell 2009), a similar level of misfit was observed with a group of professional teachers assessing portfolios in a design and technology based activity. Comparing the low levels of misfit in both studies, it counts as a very good achievement for the groups of novice assessors in this study to have such a high level of consensus using individually constructed criteria for capability within the domain. Analysis of the misfit portfolios is presented in Table 4.3.
TABLE 4.3 - PORTFOLIO MISFIT DATA

<table>
<thead>
<tr>
<th>Portfolio Data</th>
<th>Rank 1</th>
<th>Rank 2</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio WmnSq (Mean)</td>
<td>1.14</td>
<td>1.18</td>
<td>Theory Predicts Ave Should = 1</td>
</tr>
<tr>
<td>Portfolio WmnSq (SD)</td>
<td>0.22</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>Portfolio misfit criterion</td>
<td>1.58</td>
<td>1.69</td>
<td>Mean + 2*(SD)</td>
</tr>
<tr>
<td>No. of Portfolios Outside</td>
<td>7</td>
<td>7</td>
<td>Criterion</td>
</tr>
<tr>
<td>Position of misfit portfolio on Rank</td>
<td>4,5,8,9,10,26,36</td>
<td>1,3,4,7,13,43,127</td>
<td></td>
</tr>
<tr>
<td>No. of common misfit portfolios</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Portfolio misfit</td>
<td>5.1</td>
<td>5.1</td>
<td>Satisfactory for a 5% significance test</td>
</tr>
</tbody>
</table>

The misfit criteria for the ranks were calculated from the mean and standard deviation of the weighted mean square (WmnSq) for the range of portfolios across the individual ranks. Any portfolio with its WmnSq greater than two times the standard deviation outside the mean is deemed to have significant misfit. Table 4.4 and Table 4.5 show the range of WmnSq values for the misfit portfolios. The un-weighted mean square value (UWmnSq) is a more sensitive indicator of judgements outside of the predicted outcome by judges on a portfolio. A high UWmnSq value indicates that a very unusual judgement has been made on that portfolio and may warrant further investigation. In other words, one or two judges’ decisions could have contributed to the portfolio being in the misfit category. From the tables it can be seen that the majority of the misfit portfolios had a number of unusual decisions made on them which would contribute to the portfolios ending up in the misfit category. Misfit portfolios with a low UWmnSq value indicate that there was less consensus on that portfolios quality across a broad range of the judges.

TABLE 4.4 - RANK 1 PORTFOLIO STATISTICS

<table>
<thead>
<tr>
<th>Rank Position</th>
<th>Parameter</th>
<th>WmnSq</th>
<th>UWmnSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4.4</td>
<td>2.02</td>
<td>7.48</td>
</tr>
<tr>
<td>5</td>
<td>4.28</td>
<td>1.62</td>
<td>33.3</td>
</tr>
<tr>
<td>8</td>
<td>3.931</td>
<td>1.68</td>
<td>21.88</td>
</tr>
<tr>
<td>9</td>
<td>3.93</td>
<td>2.18</td>
<td>4.99</td>
</tr>
<tr>
<td>10</td>
<td>3.65</td>
<td>2.07</td>
<td>20.07</td>
</tr>
</tbody>
</table>
On analysis of the judgement history of the misfit portfolios it was noted that technical problems with the portfolio were cited as reasons why some portfolios lost to a portfolio of a lower parameter value. Judging comments:

“portfolio B would have won only for the text being in computer language”

“could not load portfolio A??????”

Generally the portfolios in this misfit category lost their judgements to portfolios that were lower but relatively close to them in parameter value. This would account for them being outside the fit criterion. Some also had unusual decisions made on them which is highlighted by the UWMnSq value. Portfolio 1 on Rank 2 won all of its 13 judgments except for one where it was compared with a portfolio that was separated from it by 5.48 in terms of parameter value. The judge made no comment on this judgement.

The analysis of the portfolio statistics shows that the level of disagreement between judges overall was very low but that where there was disagreement it tended to be concentrated on a number of individual portfolios.
4.2.6 Analysis of Judge Statistics

The judging statistics present the high level of consensus within the groups with only 2.11% and 3.89% of the judgements being outside of the judging fit criterion for the Rank 1 and Rank 2 judging groups respectively. This indicates that the student judges had a high level of agreement on what they perceived to be of quality in the work that they assessed. The judging misfit statistic gives an indication if the misfit judgements were spread across the entire judging group or if they were concentrated on a number of particular judges. Analysis of the judging data (Table 4.6) shows three judges from the Rank 1 group and two from the Rank 2 group outside of the judge fit criteria for their corresponding ranks. The misfit criterion for the judge is calculated in the same way as for the portfolio suing the judge WmnSq value generated for the judge across the range of their judgements.

<table>
<thead>
<tr>
<th>Judging Data</th>
<th>Rank 1</th>
<th>Rank 2</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judge WmnSq (Average)</td>
<td>1.12</td>
<td>1.2</td>
<td>Theory Predicts Ave Should = 1</td>
</tr>
<tr>
<td>Judge misfit criterion</td>
<td>1.52</td>
<td>1.74</td>
<td>Mean WmnSq +2(SD)</td>
</tr>
<tr>
<td>No. of Judges Outside Criterion</td>
<td>3</td>
<td>2</td>
<td>Judges (Rank 1) 53</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Judges (Rank 2) 63</td>
</tr>
<tr>
<td>Position of misfit Judge on Rank</td>
<td>(71,67)</td>
<td>(91,91)</td>
<td></td>
</tr>
<tr>
<td>(Rank 1, Rank 2)</td>
<td>(101,108)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Judge misfit</td>
<td>5.2</td>
<td>3.2</td>
<td></td>
</tr>
</tbody>
</table>

It should be noted that one of the misfit judges from the Rank 2 judging session only made one judgement while all other judges averaged 20 judgements each. The second judge from the Rank 2 group was outside the misfit parameter by only 0.01. This judge’s average judgement time was 2 minutes 27 seconds, approximately half that of the group average of 4 minutes 07seconds (Table 4.7), which may indicate that this judge may not have analysed the portfolios for capability to the same level as others.
within the judging group. Table 4.7 presents the average judging times of the misfit judges in comparison to the average judging time across the group of assessors.

### Table 4.7 - Misfit Judge Judging Analysis

<table>
<thead>
<tr>
<th>Judge</th>
<th>WmnSq</th>
<th>No. of Judgements</th>
<th>Average Time (Min)</th>
<th>Group Average Time (Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Judge 1 (Rank 1)</td>
<td>1.55</td>
<td>20</td>
<td>00:06:44</td>
<td>00:04:46</td>
</tr>
<tr>
<td>Judge 2 (Rank 1)</td>
<td>1.62</td>
<td>20</td>
<td>00:08:59</td>
<td></td>
</tr>
<tr>
<td>Judge 3 (Rank 1)</td>
<td>1.97</td>
<td>20</td>
<td>00:05:58</td>
<td></td>
</tr>
<tr>
<td>Judge 1 (Rank 2)</td>
<td>1.75</td>
<td>21</td>
<td>00:02:27</td>
<td>00:04:07</td>
</tr>
<tr>
<td>Judge 2 (Rank 2)</td>
<td>1.95</td>
<td>1</td>
<td>00:17:32</td>
<td></td>
</tr>
</tbody>
</table>

Average judging time does not seem to be a factor in the misfit of the three judges from the Rank 1 judging group with all three of them spending longer than average on each judgement. This may indicate that the judges were struggling to make their decision but were genuinely engaging in the process of trying to judge capability. All three judges left detailed comments about the portfolios judged. Analysis of comments made by Judge 1 (Rank 1), shows that the majority of decisions were made on how good the artefact looked and how well it was finished. Analysis of comments by Judge 2 (Rank 1), shows that many of the decisions were given on the basis of the quality of presentation of the folder, with folders with large volumes of text being viewed negatively. Judge 3 (Rank 1) has detailed comments about the portfolios but only comments on two of the judgements made. Both of the judgements with comments aligned with the rank consensus and would not have contributed to the misfit. This judge made 6 judgements out of 20 that were out of line with the consensus of the group. On analysis of the comments on the portfolios it was observed that the judge tended to favour portfolios and projects that had bright and vibrant colours. The following is an extract from one of the Judge 3 (Rank 1) judgements:

Portfolio A (Rank Position 13th) Judge 3 (Rank 1) comment:
"Thought enamelling was good and idea was good. Loved the detail on the frame. the only thing I didn’t like was the lack of colour. Flower was really cool and different”.

Portfolio B (Rank Position 22nd) Judge 3 (Rank 1) comment:

“Like everything about this portfolio. Detail is cool. Like that there is a real piece of nature in the frame, gives great affect. Thought the veneering was well done and liked the materials used especially for the flower”.

Judge 3 (Rank 1) deemed portfolio B as the winner in this comparison. This analysis may indicate that the judge valued the aesthetic qualities of the work and may not have analysed the work deeper for other aspects of capability. See Appendix 3 for all judge 3 (Rank 1) comments and decisions.

Overall the low level of misfit for the novice assessors indicates that their interpretation of capability, having engaged in the design task at the core of this study, has converged on qualities observed in the portfolios that hold the key to what it is that they valued as a group. The judges whose judgements fall outside of the consensus indicate a misalignment with the epistemological understanding of the group as a whole.

### 4.2.7 Summary of Year 1 Reliability Findings

Two independent rank orders of portfolios, Rank 1 and Rank 2, were produced with rank a Cronbach Alpha Reliability Coefficient of 0.948 and 0.955 respectively.

In summary this section presented the high level of consensus on qualities of portfolios by student judges in a peer assessment activity. The significance of the high level of consensus lies in the fact that the judges were not given explicit assessment criteria to identify these qualities or make their judgements. The consensus was reached on the basis of the epistemological understanding developed by each individual student as a result of their engagement in the design task at the core of this study. This consensus was achieved despite students producing their own unique and diverse interpretations of the task brief. The findings report that the assessment and ranking of capability by both judging groups significantly aligned indicating that the epistemological understanding of these students has moved beyond the material discipline.
Having achieved a strong correlation between both judging groups in year 1 of the study, the judging group selection for year 2 comprised of the whole class group (n=133). The focus of the research with this group was to investigate if a large group of assessors could produce a rank order of portfolios with the same high reliability and low misfit as was achieved in year 1 of the study. The implications for this approach on the judging session was that there were the same number of judges as there were portfolios of work to be assessed. This meant that the number of judgements to be completed by an individual judge was reduced from the previous year. With the reduction of the number of judgements the impact of a misfit judgement is amplified for the individual judge. Low judging misfit would therefore indicate the consistency of the individual judge within the overall process.

Analysis of the portfolio misfit statistics for this judging session revealed that the misfit judgements were concentrated at the top end of the rank order having an overall negative impact on the magnitude of the parameter value at this end of the distribution. The significance of the skew in the data indicates that the judging group as a whole indicate the quality of the work observed in the portfolios is considered to be concentrated to the upper end of the quality scale.

The Year 2, Rank judging session produced a rank order with a Cronbach Alpha Reliability Coefficient of 0.942 after 19 rounds of judging. This indicates that the judging group reached a high level of consensus on the position of each portfolio on the rank order of performance. The parameter value error plots for the estimation rounds indicate that the consensus within the rank on the distance between objects is clear in particular at the upper and lower end of the scale. (For the full range of year 2 estimation round parameter value error plots see Appendix 7.)
Analysis of the parameter value plot indicates that the portfolios at the top and bottom of the rank distribution are significantly separated from the main body of portfolios with their standard error being high in comparison to the main body of portfolios on the rank distribution. A high standard error on portfolios at the extremes of the rank is a normal feature of the ACJ system at this early stage in the judging process (Kimbell 2009).

By estimation round 10, the portfolio error was reduced through concentrated judging on the high error portfolios. From the graph in Figure 4.8 the parameter value of the top portfolios on the rank is nearing the value of 10 on the scale. As the judging rounds continue to estimation round 19 it can be seen that the parameter value at the top of the rank has been reduced back to approximately 5 units on the scale (Figure 4.9).
The portfolio error has been reduced and the consensus has been reached that the significant difference in value between the top portfolios and the main body of the rank seen in the initial rounds has been reduced. At the other end of the rank scale the distance between portfolios is greater than other areas across the rank indicating a clear separation of the quality of the portfolio in comparison to the portfolios around it on the scale. This clear separation of quality at the lower end of the scale contributes to the non-normal distribution of the data on the rank scale but is telling us something significant about the quality of the work at this area of the rank. This separation at the lower end of the scale coupled with the compression of the portfolio parameters at the top end of the scale clearly indicate why the distribution violated the assumption of normality (see Appendix 8 for descriptive statistics for the Year 2 rank).

The significance of this analysis tells us two things about the judging group:

- The perception of the group of judges is that there is a significant difference in quality of student work as you reach the bottom of the scale
- The perception of the group is that there is a concentration of similar quality work toward the top end of the scale

Having reached a high level of consensus on the rank order of the portfolios the misfit statistics for portfolios and judges were examined to see if disagreement among the judging group was concentrated in any particular area of the rank. Table 4.8 presents the misfit portfolio statistics generated through the ACJ software for the Year 2 rank. Of the 1337 judgements made in the judging session only 39 judgements (2.92%) were deemed to be outside the fit criterion. Seven portfolios were deemed to be outside the
misfit criterion of 1.64 indicating the concentration of the misfit judgements on them during the judging process.

TABLE 4.8 - MISFIT PORTFOLIO DATA

<table>
<thead>
<tr>
<th>Rank Position</th>
<th>Portfolio Parameter</th>
<th>UWmmSq</th>
<th>WmmSq</th>
<th>Misfit Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.52</td>
<td>3.27</td>
<td>1.68</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4.37</td>
<td>11.27</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.30</td>
<td>3.28</td>
<td>2.38</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3.94</td>
<td>6.93</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>2.89</td>
<td>3.26</td>
<td>1.65</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>2.27</td>
<td>3.18</td>
<td>1.65</td>
<td></td>
</tr>
<tr>
<td>118</td>
<td>-2.58</td>
<td>2.18</td>
<td>1.66</td>
<td></td>
</tr>
</tbody>
</table>

What is interesting from the data is the position of the misfit portfolios on the rank order. Table 4.8 presents that there was a lack of consensus when judging portfolios from the top section of the rank order with six out of the seven misfit portfolios coming out of the first quartile of the rank. This may result in the portfolio parameter value at the upper end of the distribution being kept low if the majority of the misfit judgements had a negative impact on the portfolio parameter values, thus contributing to the kurtosis and skewness of the data. The judgements on the top six misfit portfolios were analysed where it was observed that on average 38% of the judgements on them were not aligned with the predicted outcome. This lack of consensus at the top end of the rank had a significant impact on the kurtosis significance statistic and the skewness of the data. The lack of consensus however is not on whether or not the work should be placed in that region of the rank; it is rather on the relative position of the work within that region. From the analysis the refinement of their judgements on high quality work seems a greater challenge for the novice assessor. The significance of this finding has the potential to inform module leaders on the progression of the student from novice to expert on the continuum of their Initial Teacher Education programme of study.

The observation of this issue led to an examination of the judgements made on the portfolios at the top end of the rank to see if any reason for the disagreement may become more apparent. The top 8 portfolios from the rank were analysed as they were close in parameter value, thus perceived to be of similar quality. Four of the portfolios are within the fit criterion of 1.64 and four of the portfolios are outside of the fit
criterion. The focus of the analysis was to see if all 8 portfolios made it to the top of the rank order in a similar fashion and to see if the misfit portfolios and judgements showed any significant difference to those within the fit criterion. Table 4.9 shows the portfolio data for the 8 portfolios analysed.

**TABLE 4.9 - YEAR 2 RANK PORTFOLIO FIT/MISFIT DATA**

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>Rank Position</th>
<th>Parameter</th>
<th>WmnSq</th>
<th>Misfit Criterion</th>
<th>Fit/Misfit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>4.52</td>
<td>1.68</td>
<td>1.64</td>
<td>Misfit</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>4.50</td>
<td>1.37</td>
<td>1.64</td>
<td>Fit</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>4.37</td>
<td>2.30</td>
<td>1.64</td>
<td>Misfit</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>4.30</td>
<td>2.38</td>
<td>1.64</td>
<td>Misfit</td>
</tr>
<tr>
<td>E</td>
<td>5</td>
<td>4.17</td>
<td>1.19</td>
<td>1.64</td>
<td>Fit</td>
</tr>
<tr>
<td>F</td>
<td>6</td>
<td>3.94</td>
<td>1.80</td>
<td>1.64</td>
<td>Misfit</td>
</tr>
<tr>
<td>G</td>
<td>7</td>
<td>3.73</td>
<td>1.34</td>
<td>1.64</td>
<td>Fit</td>
</tr>
<tr>
<td>H</td>
<td>8</td>
<td>3.64</td>
<td>1.25</td>
<td>1.64</td>
<td>Fit</td>
</tr>
</tbody>
</table>

The analysis of the top 8 portfolios from the rank order indicated that the judges assessing these portfolios were distributed across the rank (Figure 4.10).

**FIGURE 4.10 - STUDENT JUDGE DISTRIBUTION ACROSS PORTFOLIOS BY RANK ORDER POSITION**
The distribution of the student judges across the top 8 portfolios indicate an even spread of judge domain capability as determined by the Year 2 rank. This suggests that any agreement/disagreement between judges did not appear to relate to their perceived level of ability by the group. The judgements were further sub-divided into two categories, those that did not contribute to the portfolio misfit (predicted judgements) and those that did contribute to portfolio misfit (not predicted judgements). The distribution of judges across both categories revealed that there was no significant difference, in terms of rank order position, between the judges that contributed to misfit and those that did not.

The distribution of the judges across the portfolio judgements was also analysed by judge practical craft score in the modules. This was the practical craft grade assigned by the module leaders and is an indication of the students level of mastery of craft and processing skills developed within the modules. Again there was an equal distribution of judges across the predicted and not predicted judgements on the portfolios, indicating that the judge’s level of practical skill ability did not seem to have an effect on the portfolio misfit.

The misfit judgements were analysed to look at their impact on the parameter value of the portfolios on the rank order. A positive misfit judgement would increase the parameter value, with a negative misfit judgement decreasing the parameter value. Table 4.10 shows the number of misfit judgements per portfolio and its impact on the parameter value for the top 8 portfolios on the Group B ACJ rank.
From this table it can be seen that the misfit judgements can have both a positive and negative impact on the portfolio parameter value with the scale of the impact dependant on the magnitude of the portfolio parameters at the time of that judgement. The greater the distance between objects in the judgement, the greater the impact it would have on both portfolio parameters. Looking at portfolio A at the top of the rank there is one positive misfit judgement with a parameter distance of 1.46 between the two portfolios being judged. Two negative misfit judgements with parameter distances of 2.17 and 3.29 between them also impacted on this portfolio. This indicates that the misfit judging has a greater negative impact on this portfolio than positive, thus reducing its parameter value and the resultant upper end of the parameter scale. Concentrated judging misfit, at this end of the parameter scale, leads to a distorted distribution of the parameter values and thus perceived value of the work by the overall judging cohort.
The judging history of the top 8 portfolios and range of portfolio parameters per judgement can be accessed on the e-scape web site (see Appendix 9).

It must be noted that the decision of the judges in the misfit judgements must be regarded as genuine attempts to assess capability from what they observed in the portfolios. The strength of the ACJ model of democratic assessment is that it can value the judgement of a wide range of assessors and aggregate that judgement to produce the rank order of performance. The misfit statistic, based on the weighted mean square, was calculated and identified four judges outside the misfit criterion. Table 4.11 presents details of the misfit judges.

**TABLE 4.11 - YEAR 2 MISFIT JUDGE DETAILS**

<table>
<thead>
<tr>
<th>Judge</th>
<th>ACJ Rank Position</th>
<th>WmnSq</th>
<th>Misfit Criterion</th>
<th>No. of Judgements Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>96</td>
<td>2.35</td>
<td>2.05</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>115</td>
<td>2.37</td>
<td>2.05</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>129</td>
<td>2.06</td>
<td>2.05</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>130</td>
<td>4.47</td>
<td>2.05</td>
<td>2</td>
</tr>
</tbody>
</table>

Of the misfit judges only one of them, Judge A, judged in the top 8 portfolios on the rank. This judge made two misfit judgements on portfolios C and one negative misfit judgement on portfolio F. Judge A’s fourth judgement was also on portfolio F where it positively influenced the portfolio position. As a whole looking across the top 8 portfolios there seems to be uncertainty about the relative positions of the portfolios but consensus that the portfolios should be placed at the top region as seen from the parameter error plots (round 1 to round 19) on the e-scape data base (see Appendix 7).

A Spearman’s correlation between the student rank order position and their judging misfit statistic (WmnSq) showed a very weak correlation ($r = -0.162, p < 0.001$) (Cohen et al. 2007 p.521), again indicating that any disagreement in the judging was not specific to any area within the perceived ability of the class cohort. The low level of judging misfit in this year of the study is a significant finding. The reduction of the number of judgements the judge had to make, amplified the impact of any misfit judgement on the judge’s misfit statistic. The fact that only four judges were outliers with such tight parameters is a strong indicator that the judges are valuing similar
qualities in the portfolios, whatever they may be. What is sure is that the rank order of portfolios generated based on decisions on qualities of capability is a reliable assessment of student performance. With a reliability coefficient of 0.942, it is clear that the ACJ assessment model is effective in reliably assessing the capability of students through the electronic portfolios.

4.2.9 Summary of Year 2 Reliability Findings

Year 2 of the study generated a single rank order of student portfolios with a Cronbach Alpha reliability coefficient of 0.942. The distribution of the parameter values indicated a clear separation in the quality of the work at the lower end of the rank with portfolios at the top end of the rank indicating less separation in quality. Low levels of portfolio misfit were recorded indicating the high level of consensus by the student assessors on the qualities observed in the portfolios. The low level of disagreement on portfolio qualities was concentrated at the top end of the rank order indicating that any uncertainty in the judging process related to the high quality work presented in the student portfolios. The significance of the low level of judging misfit recorded is amplified by the tightening of the judging parameters contributing to the calculation of the misfit statistic. This is a strong indicator that the large number of assessors in the judging group reached high levels of consensus without the aid of explicit assessment criteria, thus validating this approach to assessment in the learning task.

The findings in this section presented that the rank order of portfolios did not seem to be impacted by the perceived student ability in the subject domain. To further investigate if this issue may impact on the validity of the novice judging activity a stratification of judging groups by subject domain ability was proposed for Year 3 of the study.
### Year 3: Reliability of the ACJ Rank Order

The Year 2 rank order presented that judges, irrespective of their own performance, appeared to identify and value similar attributes across the full range of portfolios on the Year 2 ACJ rank. The third year of the study focused on the impact of student capability on the ACJ judging process. The class cohort of judges was divided into three individual judging sessions for this analysis. The judging groups were stratified according to a performance indicator of domain capability from a previous semesters materials processing module. Of note, is that, of the 16 mature students in the class cohort only two were outside of the top 33% of the stratification criteria. The three groups are labelled Y3 Rank A, n = 46 (Top 1/3 including mature students), Y3 Rank B, n = 46 (Middle 1/3), and Y3 Rank C, n = 44 (Bottom 1/3).

All three ranks were found to be normally distributed having a Kolmogorov-Smirnov significance value greater than 0.05. A full data sheet for the descriptive analysis for Year 3 Rank A, Year 3 Rank B and Year 3 Rank C parameter distributions can be found in Appendix 10. The rank order parameter error plots for all 3 student generated ranks in Year 3 can be viewed on the e-scape data base (see Appendix 11). All 3 ranks stabilised by the 9th estimation round of judging. This indicates a high level of consensus on the quality of the work at an early stage in the judging process. The 3 rank order distributions of parameter values showed similar characteristics indicating consensus on the distance between objects on the 3 rank orders. Table 4.12 presents the reliability data for all three ranks in Year 3 of the study.

#### TABLE 4.12 - YEAR 3: RANK ORDER RELIABILITY DATA FOR RANK A, B AND C

<table>
<thead>
<tr>
<th>Scale Properties</th>
<th>Rank A</th>
<th>Rank B</th>
<th>Rank C</th>
</tr>
</thead>
<tbody>
<tr>
<td>rms estimation error (root mean square average of standard errors)</td>
<td>0.699</td>
<td>0.693</td>
<td>0.762</td>
</tr>
<tr>
<td>Separation coefficient (sd/se)</td>
<td>6.988</td>
<td>6.288</td>
<td>5.900</td>
</tr>
<tr>
<td>Reliability coefficient (Cronbach Alpha)</td>
<td>0.98</td>
<td>0.975</td>
<td>0.971</td>
</tr>
<tr>
<td>Assuming these represent a population 6 sd's wide and that bands 3 se's apart are distinguishable, then the number of reliably distinct bands of objects is:</td>
<td>14.3</td>
<td>12.9</td>
<td>12.1</td>
</tr>
</tbody>
</table>
The reliability coefficients for the three rank orders in this year of the study are extremely high, and the highest recorded across all six ranks generated during this study. What is particularly interesting is that all three groups were independently consistent in their judging. The question that remained was to see if all three groups rewarded the same thing. To investigate this, a Pearson’s correlation test was run between the Year 3 Rank A, Year 3 Rank B and Year 3 Rank C portfolio parameter value rank order positions. Table 4.13 shows the results of these correlation tests.

**TABLE 4.13 - YEAR 3 RANK A, RANK B AND RANK C PORTFOLIO RANK CORRELATIONS**

<table>
<thead>
<tr>
<th></th>
<th>N = 136</th>
<th>Year 3 Rank A</th>
<th>Year 3 Rank B</th>
<th>Year 3 Rank C</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 3 Rank A</td>
<td>----</td>
<td>0.787</td>
<td>0.702</td>
<td></td>
<td>p&lt; 0.001</td>
</tr>
<tr>
<td>Year 3 Rank B</td>
<td>0.787</td>
<td>----</td>
<td>0.671</td>
<td></td>
<td>p&lt; 0.001</td>
</tr>
<tr>
<td>Year 3 Rank C</td>
<td>0.702</td>
<td>0.671</td>
<td>----</td>
<td></td>
<td>p&lt; 0.001</td>
</tr>
</tbody>
</table>

The results show that there is a strong relationship between the rank order positions of the 136 portfolios across the three ranks. This indicates that the stratification of the groups by domain related ability was not a critical factor when generating the ranks order of capability as evidenced in the portfolios.

The strong correlation’s between the three ranks of student portfolios demonstrates that the ACJ model of assessment is a reliable method for assessing capability in this subject domain. It is significant that student ability in the stratified groups does not impact on the order and reliability of the portfolios on the rank. This significance will be discussed later in the context of the overall learning approach taken to the modules.

The portfolio misfit statistics for the three ranks were analysed and their results are presented in Table 4.14

**TABLE 4.14 - YEAR 3 PORTFOLIO MISFIT DETAILS**

<table>
<thead>
<tr>
<th>Rank Name</th>
<th>No. of Misfit Portfolios</th>
<th>Misfit Criterion</th>
<th>Misfit Portfolio Rank Position</th>
<th>Misfit portfolio WmmSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 3 Rank A</td>
<td>4</td>
<td>1.53</td>
<td>18, 26, 35, 44</td>
<td>1.82, 1.55, 2.11, 1.57</td>
</tr>
<tr>
<td>Year 3 Rank B</td>
<td>5</td>
<td>1.6</td>
<td>26, 27, 36, 101, 109</td>
<td>1.67, 1.8, 1.88, 1.74, 1.69</td>
</tr>
<tr>
<td>Year 3 Rank C</td>
<td>5</td>
<td>1.63</td>
<td>15, 26, 39, 40, 80</td>
<td>2.12, 1.93, 1.65, 1.81, 1.89</td>
</tr>
</tbody>
</table>
The overall level of portfolio misfit for the 3 ranks is 2.9% for Y3 Rank A with Y3 Rank B and Y3 Rank C having 3.6% of portfolio misfit. The misfit portfolios are observed to be evenly spread across the rank order than in year 2 of the study. This level of misfit is acceptable for a 5% significance test. Table 4.15 presents the judging misfit statistics for all 3 ranks.

**TABLE 4.15 - JUDGE MISFIT STATISTICS FOR THE YEAR 3 STUDENT RANKS**

<table>
<thead>
<tr>
<th>Rank Name</th>
<th>WmnSq Mean</th>
<th>WmnSq SD</th>
<th>Misfit Criterion</th>
<th>No. of Judges Outside Criterion</th>
<th>Misfit Judge WmnSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 3 Rank A</td>
<td>1.14</td>
<td>0.15</td>
<td>1.44</td>
<td>1</td>
<td>1.49</td>
</tr>
<tr>
<td>Year 3 Rank B</td>
<td>1.19</td>
<td>0.18</td>
<td>1.55</td>
<td>1</td>
<td>1.59</td>
</tr>
<tr>
<td>Year 3 Rank C</td>
<td>1.16</td>
<td>0.17</td>
<td>1.5</td>
<td>2</td>
<td>1.56, 1.58</td>
</tr>
</tbody>
</table>

The analysis shows that the level of judging misfit across the three ranks is very low. This is an indicator of the high level of consensus reached on the portfolios. This high level of agreement further strengthens the argument that the ACJ assessment method can reliably assess capability in design based practical craft based tasks.

Looking at the misfit judges from the three judging groups, it can be seen that their WmnSq value is close to the misfit criterion value for their particular rank. Overall, the level of judging misfit is low with the total percentage of misfit judgements across the three ranks being Y3 Rank A = 2.22%, Y3 Rank B = 3.07% and Y3 Rank C = 2.54%. This level of misfit has a low effect on the generation of the portfolio rank order. Table 4.16 presents the average judging times for the misfit judges. This shows three out of the four judges taking longer than the average time to complete their judgements which would indicate that the student judges were making a conscious effort to engage with the judging activity. A review of the misfit judges for judging commentary can be accessed on the e-scape data base.
### Table 4.16 - Judgement Time Data for the Year 3 Rank A, Rank B and Rank C

<table>
<thead>
<tr>
<th>Rank Name</th>
<th>Average Portfolio Judgement Time</th>
<th>Average Misfit Judge Judgement Time</th>
<th>No. of Judgements Made by Judge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 3 Rank A</td>
<td>5min 10 Sec</td>
<td>5min 40 sec</td>
<td>29</td>
</tr>
<tr>
<td>Year 3 Rank B</td>
<td>5min 33 Sec</td>
<td>7min 25 sec</td>
<td>29</td>
</tr>
<tr>
<td>Year 3 Rank C</td>
<td>5min 14 Sec</td>
<td>11min 09 sec, 2min 22 sec</td>
<td>29, 29</td>
</tr>
</tbody>
</table>

Year 3 of the study reports high levels of consensus by the student assessors on the rank ordering of the portfolios. The strong correlation between the 3 independent judging groups rank orders adds further strength to the reliability of ACJ as an assessment method. The strong correlation also indicates that student’s domain capability at the beginning of the task did not impact on their ability to consensually judge the quality of the student portfolios across the judging groups.

### 4.3 Analysis of Reliability Across 3 Years of the Study

The purpose of this analysis is to investigate if the student assessment of capability through the ACJ process aligns with the values of professional practitioners engaging in design based educational activity. This was achieved by conducting an expert judging session using a number of portfolios from across the three years of the study. The analysis investigates if there is an alignment on the consensus on quality of student work between the professional and student judges.

#### 4.3.1 Judge Demographic

16 judges were selected to complete the judging session comprised of 48 portfolios selected from across the three years of the study. The rank order of portfolios from this judging session is labelled the Expert Judge rank in this document. All judges were
graduates of the LM094 or LM095 programmes of study between 1993 and 2010. All judges had experience in teaching through design based tasks in either second or third level institutions or both. 12 of the 16 judges had previous experience in using the ACJ assessment interface. The 4 judges unfamiliar with the process were provided with training on the use of the judging interface through practical or online tutorials.

4.3.2 Stratifying the Expert Judge Judgement Portfolios

A total of 48 portfolios from across the three years of the study were selected for the Expert Judge judging session. The selection of the portfolios aimed to give a spread of quality across the three rank orders of portfolios selected. This selection was based on the rank order generated percentage grade for each portfolio for the individual ranks. A linear transformation was used to calculate the parameter value percentage score equivalent for each rank selected. This was achieved by assigning a percentage value to the top portfolio on the rank and then deciding where the pass threshold of 40% would be along the rank order. The parameter value distance was then used to distribute the percentage valued to each portfolio. 6 of the selected portfolios exhibited high levels of judge misfit in their respective ranks. Table 4.17 presents the data from the student ranks for the portfolios used in the Expert Judge judging session with the misfit portfolios highlighted in red.
### TABLE 4.17 - R7 PORTFOLIO DETAILS

**Expert Judging Session Portfolio Selection Details**

<table>
<thead>
<tr>
<th>Year 1 Rank 2 Rank Position</th>
<th>Year 1 Percentage Grade</th>
<th>Year 2 Rank Position</th>
<th>Year 2 Percentage Grade</th>
<th>Year 3 Rank A Rank Position</th>
<th>Year 3 Percentage Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>89.4</td>
<td>2</td>
<td>94.9</td>
<td>1</td>
<td>95.00</td>
</tr>
<tr>
<td>5</td>
<td>88.1</td>
<td>15</td>
<td>86.5</td>
<td>2</td>
<td>92.02</td>
</tr>
<tr>
<td>7</td>
<td>83.6</td>
<td>17</td>
<td>85</td>
<td>12</td>
<td>84.37</td>
</tr>
<tr>
<td>10</td>
<td>80.1</td>
<td>18</td>
<td>84.7</td>
<td>18</td>
<td>74.74</td>
</tr>
<tr>
<td>18</td>
<td>75.6</td>
<td>24</td>
<td>81.7</td>
<td>26</td>
<td>73.72</td>
</tr>
<tr>
<td>26</td>
<td>72.3</td>
<td>33</td>
<td>79.1</td>
<td>32</td>
<td>63.09</td>
</tr>
<tr>
<td>38</td>
<td>68.6</td>
<td>62</td>
<td>73.4</td>
<td>35</td>
<td>72.76</td>
</tr>
<tr>
<td>50</td>
<td>65.9</td>
<td>73</td>
<td>71.9</td>
<td>64</td>
<td>63.09</td>
</tr>
<tr>
<td>78</td>
<td>59.1</td>
<td>74</td>
<td>71.6</td>
<td>80</td>
<td>59.90</td>
</tr>
<tr>
<td>96</td>
<td>55.4</td>
<td>77</td>
<td>71.5</td>
<td>95</td>
<td>56.89</td>
</tr>
<tr>
<td>111</td>
<td>52.0</td>
<td>79</td>
<td>70.6</td>
<td>101</td>
<td>54.43</td>
</tr>
<tr>
<td>119</td>
<td>48.9</td>
<td>82</td>
<td>69.3</td>
<td>113</td>
<td>48.98</td>
</tr>
<tr>
<td>131</td>
<td>40.0</td>
<td>95</td>
<td>66.5</td>
<td>117</td>
<td>46.33</td>
</tr>
<tr>
<td>132</td>
<td>38.7</td>
<td>111</td>
<td>61.4</td>
<td>119</td>
<td>44.88</td>
</tr>
<tr>
<td>134</td>
<td>36.3</td>
<td>121</td>
<td>57</td>
<td>131</td>
<td>33.81</td>
</tr>
<tr>
<td>135</td>
<td>34.4</td>
<td>----</td>
<td>134</td>
<td>32.87</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>----</td>
<td></td>
<td>133</td>
<td>33.45</td>
<td></td>
</tr>
</tbody>
</table>

### 4.3.3 Reliability and the Expert Judge Rank Order Statistics

The judging session was completed over 15 estimation rounds. Table 4.18 presents the reliability statistics for the R7 rank order.

**TABLE 4.18 - EXPERT JUDGE RANK ORDER RELIABILITY STATISTICS**

<table>
<thead>
<tr>
<th>Reliability Statistics R7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard deviation of Object parameters = 4.585</td>
</tr>
<tr>
<td>rms estimation error = 0.883</td>
</tr>
<tr>
<td>Separation coefficient (sd/se) = 5.193</td>
</tr>
<tr>
<td>Reliability coefficient (Cronbach Alpha) = 0.963</td>
</tr>
<tr>
<td>Assuming these represent a population 6 sd's wide and that bands 3 se's apart are distinguishable:</td>
</tr>
<tr>
<td>There are up to 10.72 reliably distinct bands of objects.</td>
</tr>
</tbody>
</table>
The portfolio misfit criterion was calculated as 2.13 from the mean and standard deviation of the weighted mean square values for the range of portfolios. No portfolio was outside the criteria. Judging statistics were analysed for misfit with the misfit criterion calculated as 2.41. One judge was outside the misfit criterion with a WmnSq = 2.45. It must be noted that this judge only made six judgements and was unable to complete the judging activity due to external commitments. Of the 6 judgements completed by the judge 4 were outside the consensus of the judging group.

**TABLE 4.19 - EXPERT JUDGE RANK ORDER DESCRIPTIVE STATISTICS**

<table>
<thead>
<tr>
<th>Rank Name</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Kolmogorov - Smirnov Sig.</th>
<th>Rank Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert Judge</td>
<td>-0.301</td>
<td>-0.982</td>
<td>0.200</td>
<td>Parametric</td>
</tr>
</tbody>
</table>

The mean and median parameter value was -0.0002 and 0.86 respectively with a standard deviation of 4.68. A negative skew value was recorded for the Expert Judge rank. The distribution of the portfolio parameters was found to be normal with no significant skew or kurtosis (Table 4.19). The full data sheet for the descriptive statistics of the Expert Judge parameter value distribution can be found in Appendix 12.

The stratified portfolios from the three years were identified on the Expert Judge rank and their rank position recorded. A Spearman’s correlation test was run between the portfolios original rank position from the student generated ranks from Year 1, 2 and 3 and the Expert Judge rank. Table 4.20 presents the rank correlations.

**TABLE 4.20 - PROFESSIONAL ASSESSOR AND STUDENT ASSESSOR RANK ORDER CORRELATIONS**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Portfolio Rank Order Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 1</td>
</tr>
<tr>
<td>Expert Judge</td>
<td>0.917</td>
</tr>
<tr>
<td>n = 16</td>
<td>n = 15</td>
</tr>
</tbody>
</table>

All significant: $p < 0.001$
The very strong correlations (Cohen et al. 2007, p 521) between the Expert Judge rank positions and the corresponding Year 1, 2 and 3 rank positions indicate that the student and expert judgments ranked the performance of the portfolios in a very similar way. This is further strengthened by the high reliability scores recorded for all of the rank orders showing the high level of consensus on the work within each individual group.

### 4.3.4 Variance Between Student and Expert Portfolio Judgements

Having established the strong correlations between the professional and student assessor rank orders, the data was further analysed for variance in the portfolio positions within the rank orders. Figure 4.11, Figure 4.12 and Figure 4.13 graph the relative portfolio rank positions for the individual year groups against the relative portfolio rank position on the Expert Judge rank order.

![Expert and Student Judge Portfolio Rank Variance (Year 1)](image)

**FIGURE 4.11 - EXPERT JUDGE AND YEAR 1 RANK 2 PORTFOLIO RANK VARIANCE**
From the graphs it can be interpreted that both the student and professional assessors agreed on the general location of a portfolio on the rank order but it is evident that within these regions of the rank order there is variance on the perceived quality of the work.
4.3.5 Summary of Year 3 Reliability Findings

Year 3 of the study generated three independent rank orders of portfolios with very high reliability. The very strong correlation between the ranks, indicate that the student judges formed a strong consensus on quality of performance without being given explicit assessment criteria. This not alone indicates the student ability to establish their own criteria for assessment but also indicates the convergence of the group on what was valued as capability in the task.

The expert judging group generated a rank of portfolios from across the three years of the study with high reliability and very low levels of judging and portfolio misfit. This indicates that work from across the three years exhibited similar characteristics indicating the effectiveness of the method approach to teaching and learning in the study, on consistently delivering on the learning outcomes of the modules. This validates the use of exemplar portfolios from previous years of the task as quality indicators for future engagement of student groups in the modules completing the same task. The correlation between the expert and student judges on the rank order of the portfolios from the individual years of the study indicate a strong correlation and consensus between novice and expert assessors on the quality of performance as evidenced in the electronic portfolios. However variance between the expert and student judges was observed on some portfolios and warrants further investigation to establish the potential source of the variance. This will be explored under the reliability question in section 4.4.9.

Concluding on the validity it is clear from the six student ranks and combined expert judge rank that the ACJ model using holistic judgement gives a reliable consensual outcome in terms of ranking the student portfolios. The question that remains is what was rewarded in terms of perceived capability in the task. The following section presents the findings relating to the validity of the rank orders of the peer assessed student portfolios using the ACJ model.
4.4 VALIDITY OF ACJ ASSESSMENT MODEL

Having established the reliability of the ACJ judging process to produce consistent rank orders of student portfolios within and across individual judging sessions the next research question to be investigated was if the ranks produced validly represented the capability that it was intended to measure. This section will be presented chronologically across the three years of the study with different aspects of validity being assessed in each year. The approach for this analysis is through descriptive analysis of the student portfolios and judging commentary data.

Each year of the study examines data that relates to specific research questions that impact on the validity of the holistic peer assessment approach using the ACJ assessment model. The analysis of the first year of work presents the relationship between the ACJ rank order of the portfolios and the module leader’s evaluation of evidence of capability presented in the portfolios by the students. The focus was to establish if it was possible to evidence domain capability through electronic portfolios and if student judges had the capacity to evaluate this capability using the ACJ pairs comparison method. Having established high levels of consensus between the rank and evidence of capability, the second year of the study focused on what the judges identified as qualities of capability to base their judgement decisions on. This is presented through an analysis of judge commentary on the attributes of each portfolio encountered during the judging process. This section focuses on the identification and rank distribution of clusters of qualities perceived by the judges to represent capability. The third year of the study examines if latent values of the student judges have an impact on their ability to reach a consensus on what constitutes capability within the modules of study.

4.4.1 Year 1: Validity of ACJ Rank Order

To address the issue of rank order validity in the first year of the study, both module leaders analysed the student portfolios and rated students work in the key areas
presented in the rubric in Table 4.21. This analysis centred on exploring the full range of portfolios for evidence of capability qualities as defined by the modules of study.

<table>
<thead>
<tr>
<th>Skills</th>
<th>Knowledge</th>
<th>Problem Solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversity of Skills</td>
<td>Within Module</td>
<td>Frequency of problems created**</td>
</tr>
<tr>
<td></td>
<td>(1-10)</td>
<td>(0-3)</td>
</tr>
<tr>
<td>Level of skill acquisition</td>
<td>Beyond Module</td>
<td>Sophistication of problems</td>
</tr>
<tr>
<td></td>
<td>(1-10)</td>
<td>(1-10)</td>
</tr>
<tr>
<td>Justification for selection</td>
<td>Application</td>
<td>Success in solving problems</td>
</tr>
<tr>
<td></td>
<td>(1-10)</td>
<td>(1-10)</td>
</tr>
</tbody>
</table>

Note:
* Skills were rated based on evidence from the electronic portfolio and not the physical artefact.
** Frequency of problems created was rated as None (0) Low (1) Medium (2) or High (3)

The analysis focused on mastery of craft skills (justification of material and process selection), evidence of theoretical knowledge (its need and application), and evidence of problem solving. The analysis of the portfolios was randomly completed to avoid the assessor being influenced or guided by the ACJ rank order of capability. For the purposes of statistical correlation analysis the Rank 2 rank order of portfolios was used as it had a higher reliability score and less judging misfit than the Rank 1 rank. Identifying and rating capability qualities in the portfolios and correlating them with the rank order will give an indication if the judges valued qualities similarly to the module leaders without being given explicit judging or assessment criteria.

4.4.1.1 Craft Skills documented in the holistic portfolio

Craft skills were analysed and rated on the evidence of diversity of the selected processes, level of execution of skills and the justification for selecting the appropriate craft skill in the context of the project (Figure 4.14).
A Spearman’s correlation coefficient test was completed for all three categories of craft skill against the Rank 2 rank and indicated a significant relationship for level of skill, justification of skill and diversity of skills with a strong effect ($r = 0.810$, $0.800$, $0.783$ respectively). Table 4.22 shows the correlation between the skills categories and the Rank 2 rank order of portfolios. These strong correlations indicate that there is a significant relationship between skills evidenced in the portfolio and the Rank 2 rank order of capability.

**TABLE 4.22 - CORRELATIONS BETWEEN SKILLS CATEGORY AND THE RANK 2 RANK**

<table>
<thead>
<tr>
<th>Skills Category</th>
<th>Rank 2 Portfolio Rank Order</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spearman’s Correlation ($r$)</td>
<td>N = 137</td>
</tr>
<tr>
<td>Level of Skill</td>
<td>-0.638</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Diversity of Skill</td>
<td>-0.632</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Justification of Skill</td>
<td>-0.669</td>
<td>$p &lt; 0.001$</td>
</tr>
</tbody>
</table>

When the skills evidenced through the electronic portfolio were compared with scores from conventional craft and processing skills assessment methods, the results showed statistical significance ($p < 0.001$) with moderate to large effect sizes (Cohen et al. 2007) ranging from $r = 0.533$ to $0.633$. The negative correlation indicates that the higher the craft skill score the higher you were likely to be on the rank order.
4.4.2 Knowledge Evidenced in the Holistic Portfolio

Student portfolios were analysed for knowledge as defined by the module outcomes. Three categories were used to analyse use of knowledge. The categories are, knowledge within the module, applied knowledge, and knowledge that was acquired as defined by the students’ needs beyond the remit of the module (Figure 4.15). Knowledge within the module was assessed for evidence of students identifying an appropriate range of subject knowledge covered in lectures and during the skills frontloading exercise at the beginning of the modules. The rating from 1 to 10 was awarded based on the appropriateness and level of knowledge presented by the student. Knowledge beyond the module was assessed by identification of instances where students presented appropriate knowledge of materials or processes that were acquired outside the content of the modules of study. The scoring from 1 to 10 was awarded on the frequency of incidence and appropriateness to the knowledge to the task. Application of knowledge was assessed and rated on the level of successful application of knowledge to the task at hand. This was rated on a scale from 1 to 10.

![Diagram showing the distribution of scores for knowledge within module, beyond module, and application.]

**FIGURE 4.15 - EVIDENCE OF KNOWLEDGE IN THE HOLISTIC PORTFOLIO**

Table 4.23 shows the correlation between the knowledge categories and the Rank 2 rank order of portfolios. These strong correlations indicate that there is a significant relationship between knowledge evidenced in the portfolio and the Rank 2 rank order of capability. It should be noted that the significant spike in the knowledge beyond the modules at point 1 on the scale indicates that a high percentage of students drew on...
some knowledge from outside of the modules but its frequency within the portfolios and impact on the work was deemed to be low.

**TABLE 4.23 - CORRELATIONS BETWEEN KNOWLEDGE CATEGORY AND THE RANK 2 RANK**

<table>
<thead>
<tr>
<th>Knowledge Category</th>
<th>Rank 2 Portfolio Rank Order</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Within Module</td>
<td>-0.618</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Knowledge Application</td>
<td>-0.867</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Knowledge Beyond Module</td>
<td>-0.530</td>
<td>p &lt; 0.001</td>
</tr>
</tbody>
</table>

The findings indicate that students developed and presented a broad range of relevant knowledge which is outlined by Sadler (2009) as critical in the development of the ability to reflect and evaluate on the quality of personal and peer capability.

**4.4.3 Problem Solving Evidenced in the Holistic Portfolio**

When examining problem solving capability qualities, two distinct categories were identified. The first category of problem, created by the students, centred on design based processing problems arising from proposals centred on the realisation of the student ideas. The problems related to material selection, jointing selection, processing procedure and craft skill technique. The second problem solving category centred on the issues relating to the development of ideas that related to the aesthetic communication of the emotion. The focus here was on material and process selection for effect and also on how shape form, colour, scale etc. could impact on their overall design. Students’ problem solving ability was rated (1= low to 10= high) by sophistication of problems created and level of success in solving that problem. Figure 4.16 and Figure 4.17 present these findings.
The relationship between sophistication (processing) and success (processing) was significant with a strong effect size ($r = 0.830$).

The relationship between sophistication and success was significant with a strong effect size ($r = 0.789$). A moderate to strong relationship between the Rank 2 rank order and the problem solving categories was recorded and is presented in Table 4.24.
<table>
<thead>
<tr>
<th>Problem Solving Category</th>
<th>Rank 2 Portfolio Rank Order</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems Created (Processing)</td>
<td>-0.474</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Problem Sophistication (Processing)</td>
<td>-0.592</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Problem Success (Processing)</td>
<td>-0.603</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Problems Created (Aesthetic)</td>
<td>-0.406</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Problem Sophistication (Aesthetic)</td>
<td>-0.536</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Problem Success (Aesthetic)</td>
<td>-0.609</td>
<td>p &lt; 0.001</td>
</tr>
</tbody>
</table>

The negative correlation value indicates that the higher scores from the portfolio observation correlate to the lower number (but higher position) on the rank order. These correlations indicate evidence of problem solving across the portfolios with the higher scores generally being associated with work that is higher up on the rank order.

### 4.4.4 Summary of Year 1 Validity Findings

The findings from Year 1 of the study show that critical aspects of capability were contained in the electronic portfolios, thus validating the use of electronic portfolios as a medium for assessing student capability in the design based practical task. The moderate to strong correlations between the rated score of these elements in individual portfolios, and the position of the portfolio on the rank order indicate the validity of peer assessment using the ACJ model in discriminating on the quality of these elements of capability. What is not yet clear is what the student assessors are identifying as the qualities in the portfolios that relate to capability and whether their valuing of these qualities align with the module descriptors of capability. This was investigated in Year 2 of the study.
4.4.5 Year 2: Validity of ACJ Rank Order

Year 1 of the study presented clear evidence that student capability in the task could be presented and assessed through the use of electronic portfolios and multi modal means of representation. It also presented evidence that the rank order valued the performance of students on capability qualities similarly to the module leaders, thus indicating the validity in the ACJ judging process as an assessment tool for this type of activity.

The second year of the study focused more closely on the judges and the judging process, looking to extract what it was that the judges were seeing or identifying as capability when engaging in the judging process. The source of data for analysis, are the comments that judges had the option to record in relation to a portfolio or judgement during the judging process. The voluntary nature of the comment recording ensures that the data recorded is a true reflection of what the judge valued in the portfolio and not a reaction to predetermined or standardised rubric for capability or influenced by their perception of what the researcher was looking for. It was also a concern that the commentary may become the focus of the activity and not the holistic judgement that is at the heart of the ACJ assessment method.

Analysis of the judging commentary was codified for the purposes of analysis and interpretation. Judge comments were analysed to see if the students identified any specific details in the portfolios that may relate to capability. An initial sampling of the comments revealed four general areas that students identified as relating to quality in the portfolios. The quality clusters identified from the student comments were codified for analysis under the following categories:

- Inspiration – Student judge comments on issues relating to the inspiration for and development of ideas relating to the task
- Conceptualisation – Student judge comments on the analysis and interpretation of the task brief.
- Realisation – Student judge comments on the manufacture and finish of the artefact/outcome of the task
- Communication – Student judge comments on issues relating to the communication of the project through the electronic portfolio.
These four clusters of qualities were used to categorise the portfolio comments made by student judges in the Year 2 judging session. A total of 1649 judgements made on the Year 2 judging session were analysed under the headings outlines.

These quality clusters are at the heart of holistic assessment with the relationship of how well they work together being a key element of the decision making process (Kimbell et al. 1991). The focus of the analysis of these clusters was to see if they existed and if so, did they or elements of them seem to impact on where a piece of work ended up on the rank order of student work. Analysis of how well the judge perceived them to work together was not possible as this would require a data recording process that would be overly intrusive on the judging process by attempting to make explicit something that is by its nature tacit and difficult to articulate. The focus here was to see if there were elements of the work in the portfolios that the student judge deemed worthy of comment. The initial review of judging comments observed that judges identified the elements outlined above as having a shared quality or an opposed quality with their own personal construct of capability. Shared comments were generally positive in nature with the opposed comments focusing on negative aspects of work. The codification was subdivided into comments that were viewed as being shared with or opposed to the judges’ personal construct.

### 4.4.6 Analysis of Portfolio and Judgement Comments

A total of 1238 comments out of a possible 1649 comments were made on 133 portfolios by 114 judges. The 19 judges that did not leave any comments were evenly distributed across the R3 rank order. This averaged 9 comments per portfolio across the group with a standard deviation of 2.3 judgements.

The portfolio comments were quantified for each category and analysed by quartile of the portfolio position on the Year 2 ACJ rank. It was observed that students left well over twice as many shared comments as they did opposed comments. The communication category recorded almost equal numbers of shared and opposed comments. Figure 4.18 and Figure 4.19 present the distribution of the shared and opposed student judge comments on the portfolios by the portfolio quartile position on the Year 2 rank respectively.
FIGURE 4.18 - JUDGE COMMENTS ON PORTFOLIOS BY YEAR 2 RANK QUARTILE

The nature of the comments recorded showed a consistency across the rank order of portfolios with the number of opposed comments increasing with the rank order position (Figure 4.18). This indicates that the qualities identified by the student judges across the clusters of capability align with the rank order of capability determined by the group. The nature of the judging commentary also indicated the dominant clusters that students choose to comment on in the portfolios. Figure 4.19 shows the distribution of judge comments across the four categories identified.

FIGURE 4.19 - YEAR 2 JUDGE COMMENT DISTRIBUTION ACROSS QUALITY CLUSTERS
The graph indicates that the communication of the portfolio content was important to
the student judge with issues around communication being regularly identified.

The distribution of comments by quality cluster across the rank was analysed by the R3
rank position of the judge that made the comment on the individual portfolio. Figure
4.20 and Figure 4.21 present the distribution of the shared and opposed judging
comments on the portfolios respectively.

![Year 2 Judge Quality Cluster Comments (Shared)](image)

**FIGURE 4.20 - YEAR 2 JUDGE QUALITY CLUSTER COMMENTS (SHARED)**

The graph in Figure 4.20 shows a significant trend in the number of shared comments
made by students on portfolios from within the rank order quartiles. The trend indicates
that students shared qualities with the portfolio cluster elements more frequently the
higher up it was on the rank order. The graph also indicates the emphasis placed on the
cluster categories by the student judges.
It is noticeable (Figure 4.21) that the frequency of negative comments relating to the quality of the portfolio communication directly increases as you move from the 1st to the 4th quartile of the Year 2 rank. Equally it is noticeable that the trend of the frequency of positive comments relating to communication is the inverse. This is a strong indicator that the content and nature of the electronic portfolio is instrumental in the judging process.

The following is a selection of the qualitative comments made by the student judges on the elements of capability they observed in the portfolios. The rank order position of the portfolio and the rank order position of the judge that left the comment are presented in brackets after each comment respectively.

**Shared judge comments on inspirational ideas:**

“I really like the idea of the flower being intimidated by the horse. It is very clear that a lot of effort was put into the project. I found the idea of the horse very good with the sinister burn at the back and the recession proof front. The project story is told very well in the final video.” (3) (59)

*The story obviously has a very deep meaning. It portrays love very strongly and shows the importance of support even when things are going bad. I think that the symbols (people in frame, shattered glass and wane edge timber) are excellent and challenges one to think about the project. (9) (17)*

“The idea is simple and to the point. They brought me through the several stages from getting the idea on placement to how they could show it to how they
brought it to life. Maps (Portfolio) was very descriptive and showed the different processes that were involved in the making of the project.” (17) (3)

“the varying ideas at the beginning of the project were confusing but as the project went along they became clearer and how the emotion tied into the project. The different tasks incorporated within the project were also good. Also using the colluseum contributed well to the theme” (34) (3)

“Very original idea which I really like. It relates well to the tutorials we had and also to the different processes. The idea has been developed well and also pulled off well. It is very simple but yet it makes you think. Fits the criteria well and shows a good connection between flower and scene” (53) (101)

**Opposed Judge comments on inspirational ideas:**

“Had a good idea but didn’t develop it very well. Overall finish of scene isn't very good and lets the project down. Visible connection between flower and project although could be emphasised better! The idea is original and a lot of time has gone into making the project and incorporating the different processes.” (91) (101)

“I can see that this person has a lot of ideas and I like the way the project is based on a friends ended relationship. I do believe that there is not enough growing and proving. We don’t even get to see the final finished project.” (63) (59)

“I wasn’t very impressed with this project I felt there could have been more thought put into the idea.” (18) (116)

“Didn't clearly state the idea at the start and focused a lot on the manufacturing rather than developing ideas and making them better.” (21) 130

He developed the project throughout the portfolio which was good but I felt all of his ideas were based on pitchers which is fine to get inspiration but I feel he just copied. Frame looked well.” (35) (45)

“I don’t think this project had as much effort put into it as many of the other ones I have seen. The flower is quite plain and the scene could have done with more thought and planning. Also there is no evidence of how he grew and improved on the ideas he had.” (108) (28)

“I like the way this person gets their idea from their cousins toy but I think there isn’t enough evidence of growing and proving given. More images would have helped I think. I like the idea of the tank and the river of blood. We don’t get to see the final project.” (111) (59)
“Very little work gone into this portfolio. The idea isn’t exactly original. It reminds you of something that he made up after the project was half way through.” (130) (115)

The judging commentary indicates the ability of the student judge to identify elements and issues that relate to idea generation and inspiration. It is also clear that students put emphasis on idea development throughout the task as being an important aspect of capability.

Shared judge comments on conceptualisation of ideas:

“It’s clear from the start of the story that it is very personal and meaningful. The presence of the model alleviated some problems early in the time as the initial design was well evaluated and improved upon. I think that there is excellent deep meaning in the project. The tunnel does encourage thought about the afterlife and the foetus in the tree is well done. The contrast between the meaning of the Lilly and the basket it is growing from is excellent. I think that the bright colours of the lily and the presence of the bees is very good too.” (15) (17)

“Has a good idea which I like but I can’t really see the relationship between flower and scene there is nearly too much going on in the scene which makes it confusing. There is nearly an over-emphasis on Bruce Springstein in this project and not many people would be able to pick out the emotion trying to be portrayed I feel. However I can still appreciate the originality and creativity of the idea but in this instance I feel that portfolio A is just the stronger project and fits my criteria better.” (52) (101)

“I thought this project was very deep in portraying the emotion of depression. What really impressed me about this project was the flower which was standing tall and proud but this was not the case at all a shadow was used of man with the world on his shoulders I thought this was very creative and was an excellent way to portray the emotion of depression. I thought the carving was excellent and overall the use of craft skills seemed good and for this reason I believe portfolio B is the winner.” (66) (111)

“It is obvious that a lot of thought was put into this project. The portfolio constantly is having growing and improving. From the very start we get a very basic idea of greed. We are then shown how greed affects nature an Indian proverb was used to capture this which I thought was very creative. The level of craft skills was very similar in both these projects but the level of thinking was much greater in portfolio B. I thought having the shadow of the fat cat resembling a starving boy was excellent. There was also good use of both video and voice files. The A4 scene was 3D in a lot of respects the smoke which was carved and the water was very effective. Overall this is why I pick portfolio B over A.” (81) (111)
“I liked this project as it was colourful and meaningful. He shows the emotion quite well through the metaphorical tree being uprooted. The flower was nice also with its bright head and laying down. His choice of processes was well thought up and added to the effect.” (33) (28)

Opposed judge comments on the conceptualisation of ideas:

“I like the emotion and the message of the project. The emotion is shown well in the flower and ideas are well noted. However what I don’t like is how plain and dull the project is. Both scene and flower are just bland and uninteresting. I feel these projects should be believable and have a bit of life to them something that is missing here.” (124) (28)

“Portfolio a was one about spongebob squarepants and his excitement. This person made a lot of preparation work for their piece which was great to see. They put in a lot of work into their scene and as a result the flower suffered. As they said themself the linkage between the 2 was poor and would have been lost but for the explanation given.” (8) (94)

“From reading through this portfolio I felt that his emotion wasn’t very well portrayed at all. Very little thought went into it and his ideas were poorly thought out.” (72) (44)

“Very well thought out and well executed. Could have explored the human suffering caused. This would have aroused more emotion from the viewer.” (58) (81)

The comments relating to this category in particular show the deep engagement of the judges with the portfolios. These comments illustrate the judge’s ability to gain a considerable insight into the students thinking through the electronic portfolio. The comments indicate the ability to the judge to synthesise the nature of the project from the individual qualities exhibited in the portfolio. It is clear that the students are focusing on the interplay between the elements that they identify which is at the heart of holistic judgement (Kimbell et al. 1991).

Shared judge comments on realisation of design:

“This project was very deep. It’s hard to imagine how you would portray love in a way that shows it reliance in hard times but this project was very effective in portraying this. I thought the use of broken glass was very effective. I was also very impressed by the flower because I thought it looked very realistic. I also thought the finish around the frame was excellent. There was not much between the two projects but I thought the craft skills present in portfolio B where better then portfolio A and for this reason I pick portfolio B.” (9) (111)
This project was very well developed the use of video and voice files was used extensively used to show the building of ideas. The idea of rebirth by the use of pollination was very clever in my opinion. The use of craft skills however was not as good as portfolio A in my view so this is why I believe portfolio A is the winner.” (15) (111)

“The level of thinking in this project was excellent. The portfolio was always focusing on having, growing and proving. I thought the idea of the hand grabbing the flower was very unique and effective in portray ing the emotion. I thought the range of craft skills was also good and was much more advanced than portfolio A and for this reason I believe portfolio B is the winner.” (46) (111)

**Opposed** judge comments on realisation of design:

“It’s obvious that a lot of thought and effort was put into this project. I feel that the portfolio could be improved on as the student neglected to include any information on the actual process of manufacture. Everything is centred around planning and the finished product. Also I think that less is more regarding the use of video clips.” (118) (2)

“Brilliant idea. I love the irony of it which really gets across the emotion. Unfortunately I feel the finished flower lets it down & overall it's only ok.” (124) (33)

“After explaining his inspiration well, I felt the processes were explained too much without giving reasons as to why they were chosen. Good portfolio otherwise.” (70) (12)

The judge commentary on the realisation and craft skills is interesting. Many of the comments observed from the judges begin with issues (shared or opposed) in relation to the ideas or the theme of the project. The craft skills were used as the deciding factor when the project ideas and theme are balanced out. It is clear that even though the craft skills are valued and deemed important they are not to the forefront in the judges’ analysis or decision making on the portfolios. This is an important observation in a module subject domain that had a significant emphasis on the development of practical craft and processing skills. This issue will be discussed further later in the document.

**Shared** judge comments on communication:

“This portfolio has been well thought out a good idea well projected with a modern theme but with a link to the past craftsmanship seems to be high.” (3) (102)
“Excellent portfolio it is clear that this project means alot to the student. The layout is excellent and the texts are straight forward and to the point.” (6) (70)

This project was very well developed. The use of video and voice files was used extensively used to show the building of ideas. The idea of rebirth by the use of pollination was very cleaver in my opinion. The use of craft skills however was not as good as portfolio A in my view so this is why I believe portfolio A is the winner.” (15) (111)

“Made good use of voice clips in a detailed explanation of the whole process and link. There was a clear link between flower and scene.” (17) (73)

“A highly impressive portfolio and finished piece. This portfolio has it all and really connects with the viewer. Easy decision.” (25) (33)

“Extremely good portfolio. Colour tags, good story and very good use of pictures. The evolution in the project very clear.” (1) (5)

“This portfolio made a far greater impression on me as it was properly tagged throughout contained video clips to back up the source of inspiration that they have stated and shows clear and concise pictures of much of the build process of the project.” (52) (8)

“I felt that this portfolio had a lot more content. I liked the way that there were voice blogs and videos contained throughout which clearly communicated the persons thought process at the time of recording and visually displayed the processes which they carried out.” (68) (8)

“No photos or videos .... good detail in text.” (130) (129)

**Opposed judge comments on communication:**

“Although there are some good photos highlighting the quality of the practical work I felt that this portfolio did not fully lend itself to showcasing the development of the ideas throughout the build process it was a bit too short and reliant on imagery from the internet.” (80) (8)

“A good idea and very original. However I feel the portfolio is a bit too cluttered and unorganised and doesn’t meet the criteria of having, growing and proving as well as others.” (21) (101)

“The ideas are good but i feel the overall story wasn’t explained as well as portfolio "B"” (74) (102)

“I didn’t really get what he was trying to portray here. Everything I felt was a bit jumbled up and didn’t have a strategic plan! The flower looks good but I didn’t like the scene it’s too plain.” (90) (36)
“Very good idea and finished product looks quite well however could have done a better job on the portfolio. I feel that I haven’t been given enough information in the form of images or video clips to fully appreciate the project.” (121) (2)

“This may have been a decent project but the portfolio did not reflect that and was poorly communicated to me”. (125) (50)

“Very poor use of resources... no photos or videos included which makes it more difficult to imagine the inspiration.” (127) (20)

“There is no explanation in this portfolio as to how the ideas were born for the project. It also gives no information into the construction of the flower or scene.” (133) (36)

“Layed out all wrong!!” (121) (43)

Communication of student capability through the electronic portfolio was important to the judges. It is evident from the qualitative student judge comments that the story being communicated is important. This is influenced by appropriate use of media and the focus and structuring of the content. It was noticeable from the comments that the student judges regularly commented on the presence or absence of portfolio tagging to the over-arching criteria of having, growing and proving of ideas. Appropriate use of tagging was identified as helping the judge to understand the thinking behind the project. The following student judge comments present the role of tagging for the judges during their engagement with the electronic portfolio.

“With respect to the tagging not much of it was tagged. They didn't value the having ideas at all.” (79) (78)

“The tagging is very poor. There is too much text and no videos or voice clips and it goes through too much of the processes that we all know about and not enough of the more important story.” (107) (17)

“Although this had slightly more resources it had no tagging which made judging hard and the whole presentation was too vague.” (129) (20)

“Although tagging of the scenes was done, I don’t think it was done appropriately. ie. almost all the project was having.” (104) (29)

“All tagged but going by the tagging all the ideas and stuff weren’t interconnected.” (11) (78)
“Portfolio B wasn’t tagged so therefore it was hard to tell growing having or proving. The overall emotion and how he expressed it I thought was very good in folder A. Portfolio B was a good idea but I don't think they finished it as well as it could have been or as good as folder A.” (12) (6)

“Huge amount of visual and audio files in fact I think there are too many. No tags assigned and as a result the portfolio becomes messy. Good portfolio in need of significant refinement.” (57) (35)

“This portfolio was completely lacking any tags and the pictures were of poor enough quality however I did like how they clearly stated the changes in design that they made along the way.” (108) (8)

“No pictures but at least there’s tags and a good interesting story... a few pictures and this portfolio could have scored even better.” (131) (47)

It can be seen from the comments that for a range of judges the tagging process brings another dimension to the electronic portfolio, one that gives judges an insight into what the student may value and understand as being capable in the task.

The overall consensus drawn from the analysis of the student judge portfolio comments is that the range of judges seemed to identify similar characteristics in the portfolios and these characteristics, both shared and opposed align with the quality of work as determined by the Year 2 ACJ rank order generated by the group of judges. This consensus coupled with the low level of portfolio and judging misfit from the ACJ judging statistics indicate that similar decisions on the quality of the work exhibited in the electronic portfolios are being made by the student judges.

4.4.7 Summary of Year 2 Validity Findings

The analysis of student judging comments reveal that students identified clusters of qualities they related to capability. The significance of this finding is that the students converged on these qualities without the aid of explicit criteria for assessment. The convergence was based on a consensus independently developed through engagement in the design based learning task. The nature of the commentary reveals that students did identify relationships between the clusters and that the development of concepts and ideas throughout the task was important. This is an indicator of students effectively
engaging in holistically assessing capability. The student judge commentary clearly indicated that the electronic portfolio was a successful medium for communicating both conceptual and procedural aspects of the students’ engagement in the design task. The nature of the communication and the structuring of the design story were identified as important. Overall the student judges were very positive about the content and communication of capability in the portfolios indicating their success as a medium for assessing capability in this domain.

With evidence to support students’ ability to identify and holistically judge capability evident from Year 2 of the study, the final validity question focused on whether or not the capability valued by the student judges using the ACJ model aligned with that of the expert opinion of domain discipline experts using the same assessment process. Year 3 of the study used a panel of expert judges, judging a range of portfolios across the three years of the study. The results of the expert judging session were then compared to student ranks of the selected portfolios for analysis of consensus of performance.
4.4.8 Year 3: Validity of ACJ Rank Order

The portfolio analysis in this section focuses on identifying what it is that may have influenced the judge in making their decisions to place the portfolio in question at that position on the rank order. Being assessed through holistic judgement the analysis focused on the approach to holistic assessment analysis adopted by Kimbell et al. (1991). This approach identifies clusters of individual qualities that judges use to make their holistic judgement. The clusters identified as being at the centre of design based capabilities are represented in Figure 4.22.

![Figure 4.22 - Interaction of three clusters of qualities (Kimbell et al., 1991)](image)

The following analysis of student portfolios identifies these elements within student work in the electronic portfolios. Where audio and video files are used by the student to present evidence of capability, an analysis of the content will be presented along with details of the location of the audio/video file in the electronic portfolio. Portfolios will also be evaluated under communication and conceptual understanding of the task activity.
4.4.9 Portfolio Analysis: Student Judge V Expert Judge

The portfolios selected for this analysis are those that exhibited high levels of variance in rank order positions as identified in section 4.3.4. The analysis examines each portfolio selected for evidence and interaction of the cluster qualities identified in the previous section. An analysis of expert and student judging comments are also presented.

The portfolios selected for analysis from these ranks are number 1 and 5. Figure 4.23 illustrates the variance in rank positions between the expert and student ranks for these portfolios.

![Rank Position Variance (Year 1)](image)

**FIGURE 4.23- PORTFOLIO RANK POSITION VARIANCE (YEAR 1)**

### 4.4.9.1 Analysis of Portfolio 1 (Year 1)

The expert judges indicated that the work exhibited in this portfolio was of a higher level of capability than the student judges.
This portfolio focused on communicating the emotional theme of happiness and fun. It clearly identified issues relating to how this theme would be best communicated through the central character in the scene. The overall impact of the elements of the project were considered as issues for this project and were developed with a constant focus on the communication of the emotion.

This can be identified in the following extracts from the student portfolio.

"I wanted my scene to include Elmo (the sesame street character from the t-shirt). I also wanted to reflect Elmo's personality in this scene, that is a bright and happy one. I planned for my scene to be bright, colourful and aesthetically pleasing. I wanted to include a bright sky and the sun to reflect this." (Pane 2)

"With my stem after being glued and drying in the jig I decided that the next thing to do was to carve my leaves. I had already decided upon the shape, they were to replicate hands being thrown up in the air with joy, so they had to look curvey so as to add to the joy and happiness of the overall scene. I also wanted the leaves to look almost delicate so as to reflect the innocence and cuteness of the character Elmo in the scene. I decided to do most of my carving at home as I had just bought a wood carving set, this would allow me to get more done in my labs. In my lab I cut out 2 pieces of basswood and used these to carve my leaves from as it is a light wood which is particularly good for carving delicate pieces with." (Pane 11)
“My flower was now nearly fully assembled. All that was left to do was to carve my base piece. I had already decided to carve a bunch of leaves for my base as I felt that this would look very attractive and also it would reinforce the effect that my carved leaves on the stem would have i.e it would make them look alive and full of personality, reflecting the emotion in the scene. I carved my base piece out of 2 pieces of basswood (the same wood as the leaves) and did so in stages so as to create the effect of layers.” (Pane 14)

The proposals made in the project related directly to the issues that were raised. Proposals were appraised and developed to compliment and communicate the key issues relating to the project theme. The portfolio was communicated over 20 panes with use of images, text, audio and video modes of communication. The communication of the processes used to manufacture the project artefact were brief, but generally gave reasons for their selection. Good conceptual understanding of the materials and the processes was indicated where appropriate in relation to material and process selection.

On the expert judging rank this portfolio was judged 15 times by 7 judges winning the judgement on 13 occasions. On the student judging rank this portfolio was judged 23 times by 15 judges and won 19 of its judgements. Judging comments reveal that the judges from the expert rank valued the quality of manufacturing and the communication of the emotion through the elements of the project. Student assessors identified similar characteristics as the expert judges but their comments on the portfolio were more superficial noting that they liked the theme and the use of colour.

4.4.9.2 Analysis of Portfolio 10 (Year 1)

The second portfolio being analysed saw the expert judges relatively rank the portfolio 5 positions lower than the student judges.
The central idea presented in this portfolio was the portrayal of the flower as a convict in a chain gang. The inspiration for the selection of the theme and the emotion of the flower was not made clear at the beginning. The idea of convicts in a chain gang was inspired by a film but this is presented as a solution or proposal with the theme and emotion being built around the image. The outcome leads the issues, which is evident in the following extract from the student portfolio:

**FIGURE 4.25 - DESIGN SOLUTION: PORTFOLIO 10 (YEAR 1)**

“I felt that the emotion of shame told a deeper story than that of anger. The observer could confuse the reasons behind the flowers anger. Is he angry because of having to work hard in chains, maybe the warden is on his case, or maybe he's mad that he got caught? Either way, the scene would not evoke a sympathetic viewpoint. However, there is no confusion regarding the emotion of shame. He has come to terms with his actions and the realization of its consequences. I felt that this remorseful reflection of the flower gave the whole concept a more tragic and real feel to it than an angry scene could ever achieve.”

The extract shows that the issues around the selection and portrayal of the emotion are appraised based on what would be more likely to be interpreted by the viewer of the artefact. The appraisal seems to be made without a clear resolution of the issues relating to the focus of the project. Having selected the theme and emotion, the student goes into great detail in ensuring that the elements of the project work together to
communicate his ideas. One expert judge made the following comment on this portfolio which was portfolio B in their judgement:

“This was close but I felt portfolio B provided greater evidence of growing the idea and concept. In contrast Portfolio A probably had better evidence of having an idea. On the balance Portfolio B presented greater evidence. (Judge 04)

The project presents a number of proposals on how the desired effect could be achieved. A detailed description of how that project was manufactured was presented in approximately two thirds of the portfolio. This was a very clear and logical account of the project realisation. The student communicated a broad base of subject knowledge but generally tended to present a declarative rather than a conceptual understanding, telling us how and not why he did things. Good use of media was evident in this portfolio to communicate student ideas and capability. The following extract illustrates the procedural nature of the communication of subject knowledge in this portfolio:

(1) Cutting the copper using a hand held scroll saw. Slow and steady vertical movement required so as not to break blade. The use of oil applied to the copper helped in the fluidity of the process.
(2) 1st stage of enamelling requires the use of wallpaper paste brushed onto copper piece, back and front. The sieving of backing enamell on both sides is then undertaken.
(3) This is placed into the oven for around a minute with the temperature not dropping below 850 degrees.
(4) Thin strips of copper are cut using the guillotine. These are used to create the borders for the enamelling process so as to prevent the colors from running into one another.
(5) Once the wire is annealed and formed into place, a thin layer of flux is applied so as to keep the wire in place after furnacing.
(6) The colored powder is prepared into a paste and applied. This is placed into the oven for around 2 minutes and left to cool resulting in a glass type appearance.

On the expert judging rank this portfolio was judged 14 times by 8 judges winning the judgement on 10 occasions. On the student judging rank this portfolio was judged 23
times by 15 judges and won 19 of its judgements. Judging comments reveal that the judges from the expert rank valued the quality of manufacturing and the attention to detail, level of engagement and clear communication of emotion. Student assessors identified this as a good portfolio commenting on the use of the videos and images in communicating the work and on the clarity of the emotion. From the judging commentary it is clear that both groups valued the portfolio. This is also evidenced with both judging groups placing the portfolio in the top quartile of their individual ranks.

4.4.10 Year 2 Student Judges V Expert Judges Ranking

The portfolios selected for analysis from these ranks are number 2 and 14. Figure 4.26 illustrates the variance in rank positions between the expert and student ranks for these portfolios.
4.4.10.1 Analysis of Portfolio 2 (Year 2)

Portfolio 2 had a relative variance of 3 rank positions between the expert and student judging ranks. The expert judges indicated that the work exhibited in this portfolio was of a higher level of capability than the student judges.

The following extract from the student portfolio communicates the theme of this project:

“Addiction is rampant in modern Ireland. It comes in many forms and is affecting many Irish people and families. This is why I have chosen my emotion as anger or torment.... If the flower turns back he will die or go to the grave.... Instead he has chosen to push forward and leave his addiction behind and go to his family.”

The project portfolio is presented in 16 panes using a range of appropriate media. As you progress through the portfolio a high level of synthesis between issues relating to the brief and proposals for their realisation are evident. This synthesis is grounded in development through informed appraisal with significant attention to how all aspects of the project contribute to the overall theme and goal of the work. Explicit evidence of experimentation with materials and processes is presented with the aim of enhancing the aesthetics and manufacture of the project. The student presents strong evidence of procedural and conceptual understanding in the task domain. However, the portfolio
does not clearly present to the assessor how all of the elements tie together or what they symbolise in the final artefact.

The following extracts identify aspects of capability presented in the portfolio:

“From making mosaic tile pieces, I used alot of recycled materials. I aim to use as much second hand or cheap material as possible. Tiles, lead, copper, timber, plywood are all second hand. How do I depict a struggling form that will communicate my thoughts to the assessor?????? How does the human form show a struggle?????? I used plastercine to throw a few ideas together...”

“The picture and video will show you how the project elements come together to make up scene and base. I found that I had to change some design elements in order to get materials to sit neat and proportionally look right.”

“I have shown in the video how I aim to apply the tile detail. I have worked with this material so I understand the capabilities. The slate detail is shown also. The only disadvantage is the weight added but I think aesthetically it works well.”

A video of the student experimenting with copper oxidation to achieve a desired aesthetic finish can be viewed in pane 9 of the electronic portfolio and shows evidence of the procedural capability of this student.

This portfolio won 11 out of 15 judgements made by 8 expert judges. The following comments were recorded by the expert judges in relation to this portfolio:

“An unbelievable amount of thought and time was invested in this project. The student has evidenced an exceptionally high level of capability in producing a project which is very unique and appealing and effectively addresses the issue of sustainability.” (Judge 05)

“One word: Amazing. Level of engagement is astounding; from having growing and proving ideas it ticks all the boxes.” (Judge 07).

Other expert judging comments identify the level of thought and good ideas as being strong elements of this portfolio. 15 judgements were made on this portfolio by 12 student judges with it winning 10 of those judgements. The judges that selected the project as a winner identified characteristics similar to the expert judges such as the high standard of work, level of engagement and the growth and development of the
project ideas. Student judges that selected the portfolio to lose the judgement seemed to struggle to understand what the project was trying to communicate overall.

The inference drawn from the analysis of the judging and portfolio is that both sets of judges recognised the work as good quality with the expert judges likely valuing the engagement of the student at a complex conceptual level over work that was more procedural in nature.

4.4.10.2 Analysis of Portfolio 5 (Year 2)

Portfolio 5 had a relative variance of 5 rank positions between the expert and student judging ranks. The expert judges indicated that the work exhibited in this portfolio was of a lower level of capability than the student judges.

The project portfolio is presented in 17 panes using predominantly text with an average of 1 image per pane. The portfolio is logically structured clearly communicating its content. The focus of much of the content is procedural in nature. The theme selection for the project is personal to the student and clear from the outset. Issues relating to the brief are not developed in great detail with the student fixating on their initial idea. Proposals and issues are not subjected to appraisal resulting in the project following the singular vision from the beginning.

However the student does critically reflect at the end of the project identifying weaknesses and making proposals for a better solution. The lack of an integration of appraisal and the lack of exploration of issues around the task lead to the project lacking any real depth of capability. However the student on reflection at the end of the task did value the task as a learning experience.
The following comment was the final reflection of the student in their portfolio:

“This was a very worthwhile exercise as it developed my skills in design, woodwork, metalwork and ICT. As I had not worked with wood on a craft skills basis before it was a big learning curve and I would like to further develop these skills. I had never done decorative metalwork to this scale before and the skills I have learned during this project will stand to me in the future. The design and ICT skills I have learned during this project in my opinion will be invaluable to me in the future as it is my belief that design and communication skills will be a major factor in the way forward of my subject area.”

The following examples from the portfolio indicate the nature of the content and level of sophistication exhibited by the student:

“After looking at some images on the internet I decided on the setting of my scene and the shape of my flower. To make the connection between my scene and my flower I decided to make my flower in the shape of a person celebrating and for the scene I created a template of a racetrack with a horse and jockey celebrating as they crossed the line.”

“I used aluminium material for this process as it is easy to bend and twist into shape. I cut out the shape of the hands using a piercing saw and filed them down to the precise shape. I then bent the aluminium to shape and attached them to the back of the stem by means of a screw.”

The student did present valid proposals for the project development but the lack of appraisal in relation to the task issues and active experimentation hampered development. This is evidenced in the following comment relating to the selection of materials and process for the project scene.

“I made the background for the scene out of veneering. I used the different colours of veneers to create the contrast between the different images in the scene. A craft knife was used to cut out the shape of the veneers. A light coloured veneer was used for the track with dark coloured veneers for the railing and mountains in the scene, a bright coloured veneer was used for the sky and winning post. The veneered scene was then stuck to a backing board, sanded and varnished. I then put the scene in a frame.”
The student personally reflected on this aspect of the project at the end identifying it as a weakness in their work.

"On finishing the scene I thought it was a bit dark and plain. If I was to make the scene again I would add colour into the scene to rectify this problem."

The expert judges commented on the success of the flower element of the task but identified the scene as a weakness. The theme was identified as being clear but superficial in its analysis and development. Student judges identified the clarity of the theme and the layout of the portfolio as positives. The flower element was positively viewed with the scene identified as a weakness in the work. The following are comments by student judges:

"Not a bad idea but scene could have being developed a lot more. Limited explanations for having, growing and proving."

"This project was told as a step by step procedure. Wasn't very story like at all."

"The project was developed well but it lacked overall on the craft skills. The veneering was basic I thought more could have been done. The scene remained very dull due to a lack of contrasting colours between the veneering and the horse. However the horse shape and etching was very good. Overall lack of colour and craft skills made me pick portfolio B"

Expert assessors made the following comments:

"Horse racing project. Superficial representation of ideas."

"Horse - Nice Idea with the flower - but seemed to just fix on an idea and little evidence of development."

"I really like the flower and how the jockey's body and whip are formed... Good overall idea. I'm not sure about the picture frame though... Maybe this is because the photograph isn't clear."

Overall this project presented evidence of engagement in the task at a procedural level producing an output of a reasonable standard. The lack of integration between task issues and proposals resulted in a superficial representation of the project theme. This
may have been an underlying factor in the expert judge’s decision making in relation to this project.

### 4.4.11 Year 3 Student Judges V Expert Judges Ranking

Figure 4.29 presents the variance in relative rank position for the portfolios in Year 3 of the study. Portfolios 2 and 9 are selected for analysis based on the magnitude of their variance.

#### FIGURE 4.29 - PORTFOLIO RANK POSITION VARIANCE (YEAR 3)

![Graph showing rank position variance](image)

#### 4.4.11.1 Analysis of Portfolio 2 (Year 3)

Portfolio 2 had a relative variance of 5 rank positions between the expert and student judging ranks. The expert judges indicated that the work exhibited in this portfolio was of a higher level of capability than the student judges.
This project is communicated through 20 panes with extensive use of images, text, audio and video files. The theme is personal in nature to the student. This project is driven by proposals that are appraised in the context of the task issues. Considerable engagement in active experimentation and critical reflection on the project proposals is evident throughout the portfolio. This is exemplified in the following extract from the student portfolio:

“I had a few ideas on how to convey my emotion of passion in the flower. I made a few models of the flower. I then asked my friends and T.A.s what there thought was on the matter. The pictures below show my model and the ideas I had. What I found was that my idea was good but the emotion was not getting across so I decided to put all of the ideas together into one design. I then went back to the lads and asked them the same question. I found that the final collection of all my ideas came together to produce one solution which convey my emotion of passion.”

The nature of the engagement of the student in the design task exemplifies what lies at the heart of capability. The process of realising the outcomes of this project is rich with evidence of problem solving, critique and development of ideas. The product outcomes of the task demonstrate a high level of skill. A criticism of the work is that it is lacking
in creative flair which is evident in the lack of exploration of the task issues at the initial stages where the student fixated on the scene for their emotion. The following are examples of student extracts showing the nature of their approach to the task:

“Making the stem was a difficult process. I was told that banding brass was a bad idea and that it was near imposable due to the size of bar I was bending, 10mm. To bend the stem I first had to run my safety precautions with my TA as it was a very dangerous procedure to do. I had to move the welding bench closer to the braising torch so that I could heat the stem in the vice so to limit personal injury to myself and others working in the workshop. The video below shows how I achieved this. Once I had bent the stem I had to use the milling machine to cut the top of the stem horizontal so that the rose head would sit flat on it. I also drilled holes in the stem for the rose head to be attached and also for the arms to be attached.”

“When trying to come up with an idea for the flower project I was faced with a lot of problems. What flower conveys the emotion of passion? What colours will I use to help convey the emotion? The list was endless. I started off trying to find out what type of flower I should use and I came across one rose in particular which I thought would work well (shown below). I found out that a red or champagne rose is associated with passion and love. So what I did was I made a little mock rose out of toilet paper into a shape that I thought I could replicate out of my chosen material.”

At the end of the portfolio the student made the following reflection:

“I very much so enjoyed making this project as it made me look at my own skills and abilities and what I can actually achieve in such a short period of time. I now have a project which I am very proud of. I only wish I had more time to make this project because the amount of ideas I still have for this project is unbelievable.”

Expert Judge Comments:

“Brilliant realisation of a unique design. This student has evidenced an extremely high level of technological capability. I really appreciate the
emotional attachment to this artefact and how the student overcame different problems throughout.”

“Flower communicated emotion well through shape and form. Etching is poor.”

“I felt that the development of this idea was of a higher standard and was evident of higher levels of engagement. The idea was grown from something close to the student and finished to a high standard.”

“Portfolio B wins because the student appears to have brought technological capability to a higher level. Pushed the boundaries.”

The following judging comments were made where the portfolio being analysed lost the judgement showing comparatively where this portfolio was deemed to have weakness.

“Although Portfolio A is an excellent piece of work... I think Portfolio B evidences more creativity and the higher level of complexity in the frame and flower wins it for me.”

“This was a hard decision to make as well but the unique idea swayed me in the end. I felt overall there was a slightly higher level of growing in portfolio b.”

The expert judging comments identified the overall capability of the student in the task as being evident from the portfolio. This indicates the synthesis of the judges in bringing the individual qualities together to make their holistic judgement. However it is identified that the development of the ideas at the initial stages of the design were not as strong as other aspect of the student’s capability.

Student judging comments:

“Very well done but to look at it, it doesn’t define a strong emotion.”

“Excellent portfolio, every stage well documented. Good audios and video clips.”

“A lot of research and work went into this project. Developed the idea well and portrayed it very well. Also good use of processes.”

“This project had a huge amount of thought, time and effort put into it as portrayed in the portfolio. The idea was original and different and workmanship was high also.”
“Emotion, wasn't sure what the emotion was. Risk of fire hazard using masking tape instead of installation tape for the wiring. Smoking a fag while making the video didn't look good.”

Student judging comments on the portfolio rate the portfolio as being good, identifying the communication, research, ideas and effort as being positive attributes. Both groups of judges placed this portfolio in the top quartile of their respective rank orders indicating that they recognised and rewarded the quality of the work. The expert judges indicated a deeper insight into the capability of the student through synthesis of the qualities revealed in the portfolio which is likely to have resulted in the portfolio being in a relatively higher position on their rank order of capability.

4.4.11.2 Analysis of Portfolio 9 (Year 3)

Portfolio 9 had a relative variance of 4 rank positions between the expert and student judging ranks. The expert judges indicated that the work exhibited in this portfolio was of a lower level of capability than the student judges.

This portfolio was communicated using 15 panes predominantly consisting of text and images. The theme is inspired by a film set in Berlin at the time of World War II. The project identifies issues relating to the theme and makes a number of proposals on how these will be realised in the artefact. The lack of effective appraisal during the design evolution leads to a disconnect between elements of the work and the communication of the overall idea.

The following extract from the student portfolio identifies issues and proposals at the beginning of the project that are presented as solutions with little appraisal:

![Figure 4.31 - Design Solution: Portfolio 9 (Year 3)](image-url)
“For my scene, I decided to come up with something that was three dimensional. I thought it would be best to have the frame tilted back at 45 degrees and have the scene going on inside in it. One of the first things that came to mind that I knew I wanted to use was Barbed Wire. I thought that this would really emphasize the sense of danger and coldness of the troubles in Berlin at the time. I decide that I would use artificial grass on the west side of the wall to show how east Germans always wanted to get to the west side where their loved ones were and visa versa. On the east side of the wall, I decided to go with a cold finish, using darker colours and more metal in order to make it look more raw. I knew from the start that I wanted to put a soldier at the dark side of the wall so that it would look like it was further preventing an etched man from getting over the wall.”

Expert judge comments:

“Good initial idea and manifested itself into a good project. I don't think the craft skills are to a very high standard though.”

“The story was the project was well conveyed through out. Ideas could have been developed a bit more. The student showed evidence of their processing capabilities through out.”

“Developed ideas as the project developed but struggled to tie it all together. Gave details of the processes but did not explain why he was selecting them.”

The following judging comments were made where the portfolio being analysed lost the judgement showing comparatively where this portfolio was deemed to have weakness.

“B is more sophisticated in its thinking - significant problems created and solved A is an average approach and manufacture.”

“This again was close but I felt portfolio B better reflected the concept with greater evidence of growing and proving it. The individual was also better reflected in this project.”

Student judging comments:

“Berlin wall, good idea but badly finished and no having proving or growing.”

“Different format but effective didn’t have having growing or proving.”
“Idea is very good. You would know what the emotion was telling you. Thought it was a bit plain though.”

“Original idea not many else have the same thought process put in to them.”

The consensus across both judging groups identifies that there is a good idea behind this project but that it lacked development. This relates to the lack of development and appraisal of the task issues at the early stages of the work. The lack of sophisticated thinking in the ideas development phase of this project would seem to be a factor in the expert judges having less value on the work in terms of capability.

### 4.4.12 Summary of Year 3 Validity Findings

The portfolio analysis identifies evidence of the three cluster qualities identified by Kimbell et al. (1991). The emphasis (or lack of emphasis) on any one of these clusters was seen to have an impact on the task development and outcomes. The rank ordering of portfolios by expert judges indicated an alignment with the portfolios that exhibit higher levels of interaction between the quality clusters. Student judges indicate that ability to identify and value the quality clusters but the process of refining their judgements at a conceptual level with regard to capability not being as strong as the expert assessor. The significance of this finding is critical to the progression and development of student teachers on the continuum of teacher education. The potential for ACJ to be used as an epistemological diagnostics tool will be discussed later in the document.
5 IMPACT OF PEER ASSESSMENT USING ACJ ON STUDENT LEARNING
5.1 OVERVIEW OF RESEARCH FINDINGS

With validity and reliability of the model established the findings section examines the impact of the learning and assessment activity on the behaviour and learning outcomes of the students. Figure 5.1 presents the structure of this section of the research findings.

**FIGURE 5.1 - SCHEMATIC REPRESENTATION OF RESEARCH FINDINGS**

Motivation and engagement with the learning activity are examined through the triangulation of observations, portfolio analysis and qualitative feedback from the students across the three years of the study. Observational and qualitative analysis on the nature of the evolved learning environment is presented. This will present two central issues identified by the students, peer learning and the role of active
experimentation, in facilitating their needs throughout the design based learning process.

The final section of the findings will present the outcomes resultant from the study over the three years of student engagement. This will be presented in the following five categories:

- Communication through electronic portfolio
- Engagement with the process of design education
- Supporting skills transferability
- Active experimentation and managing uncertainty
- Developing and refining ideas and learning

The first two categories are analysed across the portfolios from the initial year of the study with the final three categories being observed across all three years of the study. This section will present the impact of the ACJ assessment model on the nature and quality of the learning experience of the students that engaged in the study.

5.2 IMPACT ON STUDENT BEHAVIOUR

The method employed in this study to achieve the learning outcomes of the modules changed the structure and nature of the learning experience of the students from that of previous years of the modules delivery. The impact of implementing the new approach on student engagement and behaviour was the initial focus of the study observations. What was apparent was that the nature of how they did things, analysed problems, solved problems, developed ideas, selected materials and processes, were now being done in a much more collaborative and experimental manner than in previous years of the module delivery.

5.2.1 Qualitative Findings

A qualitative questionnaire was distributed to all students that engaged in the study over the 3 years (N = 387). The purpose of the questionnaire was to provide a means to evaluate the students’ experience of engaging in the design task and the peer assessment activity. A survey response rate of 72% (N = 278) was recorded. The results of the
qualitative responses to the questionnaire along with observations from the classroom workshop activities will be presented in this section.

5.2.2 Student Engagement

The structure and learning approach employed in the modules placed the emphasis on the student to develop a personal construct of what was to represent capability in the design based practical craft task. Students were not guided through a process, but rather supported in their journey to developing their design solution to the task brief. Initially this led to some confusion with students struggling with what direction to take. This struggle may be partially due to the experience students had in achieving success in educational tasks prior to these modules. This is indicated in the following students’ comments:

“I saw some other students struggle to come up with ideas or struggle to put their chosen theme to good effect. I threw some random thoughts and ideas at them to see if a small input could help them to come up with more ideas of their own that they could then execute. A lot of people were frustrated at the beginning not understanding why we "had to" be creative and come up with our own ideas and projects. I reckon this might be due to them having come from a school environment where things may have been quite concrete for the most part. They did not seem used to or comfortable with the idea of being creative, innovative or abstract in their thinking. I am a mature student who admittedly has difficulty somewhat in these areas but I put a lot of time into attempting to build on being open-minded and trusting myself to be all of these things. I felt at the end that it worked to some extent although I could have really pushed the boat out a lot further in hindsight - Lesson learned hopefully!”

“I must admit at first this was a daunting task as I found it hard to grasp what was really being asked of us and how the hell I was going to come up with an idea, surely we weren’t being asked to think for ourselves”.

However, once students established their goals and validated them as appropriate to the task there seemed to be clarity of purpose to their actions. Figure 5.2 illustrates that the majority of the students across the three years of the study agreed that the design task was appropriate to the development of their skills for teaching.
When asked if their engagement in the design task was beneficial to them, students responded very positively with 85% of students either agreeing or strongly agreeing with the statement of the question (Figure 5.3)

When students were asked if they enjoyed learning in the task over 75% of respondents agreed or strongly agreed with the statement. Of the survey respondents, ten students which represents 3.5% of students across the three years of the study, disagreed with the statement that the design task was beneficial to them. When analysed these students generally came from the lower half of the rank order(s) generated for their class group.
Student engagement in the activity became much more focused even though they were now considering a much broader spectrum of potential ideas and solutions to their work. In defining their brief they became much more aware of how their actions and decisions could potentially influence the direction of their future work. They set about creating meaning for something that was abstract, inside their head, something that didn’t yet exist. There was a strong sense of ownership of the project with over 85% of the students surveyed agreeing or strongly agreeing that they took ownership of their work throughout the project (See Q22(b) Appendix 13). Students indicated that the lack of explicit assessment criteria was a factor in their autonomous approach to the learning task. Figure 5.4 presents the response to the question:

Explicit assessment criteria or reporting guidelines were not given to you for this task. Rate the following statements relating to assessment criteria for the modules:

![Graph showing student responses](chart.png)

**FIGURE 5.4 - Q.16(C) IMPACT OF ASSESSMENT APPROACH ON RESPONSIBILITY FOR LEARNING**

The graph indicates that between 78% and 82% of students, across the three year groups, agreed or strongly agreed that non-explicit criteria and lack of structured guidelines caused them to take on the responsibility for their learning. The following qualitative comments were observed in student portfolios from Year 1 of the study.

“Probably the best 6 weeks we’ll have in our time in college, because we got the power to make something that was ours, and that really motivated us”.
“I enjoyed the fact that we had control of this project from the word go and allowed to make decisions on the spot to suit ourselves. This motivated me to do my best and go into extra labs to try and get it done. I felt that this project opened my eyes when it comes to designing.”

This ownership and responsibility resulted in enthusiastic engagement in the modules which is supported by the level of enjoyment students got from engaging in the task.

The approach resulted in unprecedented lecture and laboratory attendance. Average lecture attendance was recorded at 88% (this is not accounting for students with genuine reasons for not attending). The high level of attendance resulted in a dynamic and enquiring lecture series that aided in exploration of the philosophical shift in technological education. Full attendance was recorded for the developmental and self-directed phases of the workshop activities with more than 25% of the students attending additional laboratory sessions over the self-directed phase.

5.3 STUDENT MOTIVATION

Overall student motivation was observed to be very high. This seemed to have a direct relationship to the ownership and personalised nature of the project. This was evidenced in the classroom workshops through student’s articulation of their ideas, requests to further develop processing techniques to facilitate ideas, sourcing of knowledge and information from a diverse range of sources, active experimentation and reflection, attention to detail, taking educational risk and learning from making mistakes. As indicated in the previous section, students generally led the initiative in all of these areas. With the focus of the study on assessment of capability, three issues, peer assessment, assessment criteria and paired judgement, were examined for impact on student motivation in the design task through the survey.

5.3.1 Peer Assessment

Students were asked to rate the impact that being assessed by their peers had on them during the project. Figure 5.5 presents the response of the students to Q.15(d): It motivated me to come up with something new and innovative in my project.
This indicates the majority of the three year groups agreeing that having their peers viewing and assessing their work caused them to focus their effort in the idea generation stage. Figure 5.6 shows the response to the same question under the statement heading: It motivated me to impress the person assessing my portfolio.

This aspect of the findings indicates that over 75% of the student group generally considered the assessor when they were engaged in the project work. With the full class of students assessing the work in each year group it was of interest to the research study how the impact of peer assessment may affect student behaviour in the learning
environment. Over 60% of the students agreed that peer assessment encouraged them to interact more with their peers during the task activity (Appendix 13 Q15 (b)). The nature of this interaction will be presented later in this section. When presented with the idea of democratic assessment of student capability in the modules over 80% of the students across the three groups agreed that having a large group of assessors would give a more accurate assessment of their work (Appendix 13 Q17 (a)). Only 15% of the students across the three years agreed that they would prefer to have only one person assessing their work (Appendix 13 Q17 (b)). This presents the consensus and confidence that the student groups had in the democratic assessment process employed in the study.

5.3.2 Assessment Criteria

When surveyed over 75% of the students across the three groups agreed that the lack of rigid assessment criteria and reporting guidelines allowed them to explore a wide range of solutions to the brief (Appendix 13 Q16 (a)). Students also indicated, 70% across the three groups, that this approach to assessment and reporting caused them to think about what constituted capability in the subject area (Appendix 13 Q16 (b)). This was a key factor in students developing their own values in relation to the subject domain. On average 80% of students agreed that having to generate their own criteria for assessment made them take responsibility for their own learning (Appendix 13 Q16 (c)) with an average of 70% of the students agreeing that this had a positive effect on their learning experience (Appendix 13 Q13 (b)).

The findings indicate that the removal of explicit assessment criteria had a positive impact on the student groups in terms of developing an understanding and value for the subject domain of study. This is a critical finding indicating the positive impact of the research approach on the epistemological development of the student teacher cohorts.

5.3.3 Comparative Paired Assessment

The impact of student’s work being directly compared to other students within the class group was investigated to establish if it may have had an impact on student behaviour. Figure 5.7 presents the student response to Q14(d) from the survey.
An average of 77% students across the three years agreed that the paired comparison method of assessment created competition within the student group. Observations of student’s behaviour in the classroom environment did not see this competition impacting on learning in a negative way. Figure 5.7 indicates that student’s generally felt that the paired comparison method of assessment did not negatively impact on student collaboration in the classroom environment. This may indicate that students were more concerned with the task rather than the assessment instrument.
No statistically significant correlation was observed between the response to Q14(b) and the rank order position of the student indicating that the collaboration occurred across the ability range of the student groups. The direct comparison of students work through the ACJ process might suggest that students may not be willing to engage with or help others but the opposite has occurred here in an environment where competition was high. The non-use of explicit assessment criteria is considered a key factor on this point and will be discussed in section 5.3.5 under student collaboration.

A more normal distribution of response was observed for Q14 (a) where students indicated that the method of assessment was not a critical issue for them (Appendix 13 Q14 (a)). This would indicate that students were more concerned with what they would present for assessment rather than how it would be assessed. An average of 72% of student’s across the three years agreed that the paired comparison method motivated them to demonstrate high levels of skill (Appendix 13 Q14 (e)) with an average of 70% agreeing that it motivated them to work hard (Appendix 13 Q14(f)).

5.3.4 Knowledge and Skills

From the observations of the classroom workshop activities it was noted that students were engaging in additional activities by comparison to the traditional experience. Students were making decisions; all students were deciding on materials that would best represent their designs, processes were selected on the grounds of desired effect with students projecting their ideas forward in the form of models and/or prototypes for varying elements of their work. Experimentation with newly learned processes and techniques created a constructivist comprehension of the core building blocks as students attempted to transfer knowledge and skills into their conceptual solution. The mastery of craft and processing skills was evident in the majority of student projects as students strived to push their limits to best represent this idea that was so unique and personal to them. Another interesting feature of the student engagement and development related to the ownership issue. Students were taking responsibility for all aspects of the work including the acquisition of new knowledge that was appropriate to their work. This required students to source, synthesise, evaluate and sort through the
material they deemed relevant to their particular needs and then decide how it would be used to best progress their work.

Question 11(a) to 11(e) in Appendix 13 present the response of the students when asked to rate the increase in their level of capability as a result of completing the modules. Moderate to significant and significant increases in the areas of craft skills, design skills and problem solving abilities are recorded on average as 70%, 79% and 67% across the areas respectively. It is clear from the graphs that the modules have had a positive impact on the student’s perception of their abilities. A moderate correlation was observed \( r = 0.467, \ p<0.001. \ n = 278 \) between student rating of craft and design skills increase. A moderate correlation was also observed between student ratings of increase in craft skills and problem solving ability \( r = 0.379, \ p<0.001. \ n = 278 \). A strong correlation was observed between increase in craft skills and knowledge of materials and processes \( r = 0.55, \ p<0.001. \ n = 278 \). A strong correlation was also observed between student rating of increase of design skills and problem solving skills \( r = 0.558, \ p<0.001. \ n = 278 \). What these findings indicate is that there is general agreement by the students that the modules had a broad ranging positive effect on their capability.

Figure 5.9 indicates that the majority of students developed their skills to meet the demands of their project design. This is an important finding as it indicates that students did not feel that their ideas were restricted by their processing and craft skills. What it does suggest is that the initial skills building activities, that were focused on the development of transferrable rather than a prescribed skillset, was successful in its purpose.
FIGURE 5.9 - Q12(B) SKILLS DEVELOPMENT TO MEET DESIGN REQUIREMENTS

Student’s response to question Q12(d) show that on average across the three years of the study 73% of students across the three groups agreed that they developed their subject knowledge to meet the demands of their design (Appendix 13).

A critical inference that can be drawn from the student responses is that their engagement in the design task was not restricted by their knowledge or skills in the domain. The students approach saw them develop appropriate knowledge and skills to realise the ideas and proposals that emerged from their process of designerly activity. This shows the central nature of the conceptual engagement of the student in driving the learning and development in the task.

5.3.5 Student Collaboration

This aspect of the activity initially manifested itself in peer to peer support when using their mobile phones to capture critical issues relating to their project during their laboratory sessions. The mobile phone functionality and operability audit showed that students were confident in using the technology in the capture of data (audio, video, text & image) but had been provided little opportunity for its meaningful use in the context of their educational development. Students collaborated to take video shots of critical elements of their work, often resulting in them needing to articulate the need for and nature of the capture of the data. Students began to share ideas and to make suggestions on enhancing the quality of data capture. It was observed that students were not overly
protective of their ideas but were rather enthusiastic about articulating them, their origins and progression to members of their group. They did not see themselves as competing for marks or grades but rather as contributors to the overall quality of the work being produced by the group as a whole. As the activity was not determined by explicit criterion reference assessment, students were at liberty to share, critique and support their workshop based activities. Students understood that the value of the activity could not be effectively measured by a linear application of predefined criteria and therefore were not competing at that level. How the individual qualities of their work combined to create the whole was now seen as the discriminating criteria not the parts themselves. So presenting the individual elements of their work or helping others with elements of their work was not problematic for the student as they understood that it was how well they presented the relationship between the qualities in their electronic portfolio that was important in terms of the holistic judgement approach to assessment.

From the qualitative survey of the student groups over 60% of the students across the three groups indicated that they regularly initiated discussions with peers about their work (Appendix 13 Q.1). While the nature of what ‘regularly’ means is subjective to each student it does indicate that it seemed to be a normal practice within the group. Looking at why these interactions and discussions were initiated, 89% of students across the three years indicated that it was to clarify their thinking, 87% to solve a problem, 79% to find out information and 74% to help generate ideas (Appendix 13 Q2(a), (b), (c) and (h)). These responses are significantly skewed in the positive direction. The responses indicating help with manufacturing and help capturing data are more normally distributed recording an average positive response of 56% and 49% respectively (Appendix 13 Q2(d) and (e)). Comparing the mean score of student response for each question category it is clear that the higher value was placed on interactions that related to conceptual rather than procedural aspects of their work. Student responses across the three years indicated an average of 88% agreeing or strongly agreeing that the peer discussion was mutually beneficial to them (Appendix 13 Q4) indicating that they valued discussions on other peoples work as positively contributing to their educational experience. This is a strong indicator that that the overall approach to the modules learning and assessment was supportive of the social constructivist learning theory. An average of 89% of students across the three years of
the study indicated that at some point in the task they initiated communication to help their peers with their work (Appendix 13 Q6). This has significance as ultimately students were going to be compared with one another to generate the rank order. It is clear that the impact of the norms reference nature of comparative pairs assessment did not have a negative impact on student collaboration.

As students were the drivers of the learning activity, they made the decisions on how to best progress their learning. Figure 5.10 indicates the value that students placed on the various learning supports available to them in the modules.

![Student Value of Learning Support](image)

**FIGURE 5.10 - ELEMENTS OF LEARNING SUPPORT VALUED BY STUDENTS**

The graph indicates interaction with the teaching assistants and peers as being beneficial to supporting their learning. Lab demonstrations from the initial skills building phase of the modules is also highly valued. However what stands out in the graph is the value students placed on risk taking with ideas, trial and error procedures and by making mistakes. This type of learning activity is categorised in Kolb’s learning cycle as the active experimentation stage (Kolb 1984). Kolb (1984) outlines the relationship between reflective observation and active experimentation in transforming experience
into learning. The following section will present an analysis of student engagement in active experimentation learning activities in the design based task.

### 5.3.6 Value of Active Experimentation

Having identified experimentation as being important to students in their learning, the study then focused on the nature and value of this activity from the student perspective. The mean score response to question 8 from the student questionnaire (Appendix 14) presents that overall, student’s saw value in experimental activities. What is important to note is that students placed value on making mistakes with them identifying that learning from these mistakes was very beneficial to them. A moderate to strong significant correlation was found between the students that said they made mistakes and those that said they learned from making mistakes ($r = 0.583$, $p<0.001$). The following student comments were observed in the qualitative data.

“The latter is funny because it's true and beneficial. You see mistakes and successes that peers make during the project and you pick up on them and work on.”

“In terms of making the artefacts, I did so to the best of my ability and I was surprised at my ability but it still wasn't perfect. I focused more on the design and making sure every aspect was significant and meant something. Mistakes and learning from these mistakes seemed to be crucial to doing a good project and learning in general.”

“I tried something I wasn't sure on I did make mistakes and if I was to do it again I wouldn't be afraid of trying something I wasn't sure on.”

Having rated mistakes as being valuable to them in the learning process, the next question was to establish if students presented evidence of this type of learning in their portfolios. Figure 5.11 shows the student response when asked if they were confident that presenting evidence of mistakes made during the project could show evidence of learning.
From the graph there is clear agreement that mistakes could be presented as evidence of learning. It is observed that there was greater confidence in this question in years 2 and 3 of the study. It is clear from the findings that the approach and implementation of the study had a significantly positive impact on the students’ behaviour and how they engaged in the learning process. With this established the next question must focus on the outcomes of student learning as a result of this approach.

5.4 IMPACT OF STUDY ON LEARNING OUTCOMES

The key focus of the modules at the core of this study was for ITE students to develop capability through a design based approach to learning, in a craft based practical discipline. Development of craft and processing skills and abilities were a key outcome of the design based approach implemented in the study. The acquisition and application of subject knowledge was developed to support all activities. Particular emphasis was placed on the students developing a personal construct of what represented capability in the subject domain of the modules. Their capacity to do this would be presented in the communication of their work through their electronic portfolio, the manufacture of their physical solution to the brief, and their ability to assess capability through the ACJ model of assessment. This section presents observations and student reflections on the outcomes across the three years of the study.
5.4.1 Knowledge and Skills Development

As presented earlier, students across the three years of the study demonstrated high levels of skills acquisition and application. This was particularly evidenced through the practical artefacts created by the students as solutions to the project brief. The following are some examples of student work across the three years of the study illustrating the diversity of solution to the brief and the range and level of the skill exhibited.

FIGURE 5.12 - EXAMPLE 1 OF STUDENT PROJECT WORK (YEAR 2)
FIGURE 5.13 - EXAMPLE 2 OF STUDENT PROJECT WORK (YEAR 3)
FIGURE 5.14 - EXAMPLE 3 OF STUDENT PROJECT WORK (YEAR 1)
FIGURE 5.15 - EXAMPLE 4 OF STUDENT PROJECT WORK (YEAR 1)
FIGURE 5.16 - EXAMPLE 5 OF STUDENT PROJECT WORK (YEAR 2)

FIGURE 5.17 - EXAMPLE 6 OF STUDENT PROJECT WORK (YEAR 2)
FIGURE 5.18 - EXAMPLE 7 OF STUDENT PROJECT WORK (YEAR 2)
The examples of student work in Figure 5.12 to Figure 5.20 indicate the high level of craft and processing skill demonstrated by the students across the three years of the study. The images also communicate the diversity of ideas and approach to communicating their theme through the materials and processes.

5.4.2 Consensus on Capability

The high reliability statistics for the student rank orders across the three years of the study indicate a high level of consensus amongst the students on what represented capability in the modules. The validity of the student rank orders of portfolios indicates that students values on domain capability in design based practical craft activity aligns with that of the module descriptors and expert assessors. The critical aspect of this finding is that the consensus was reached through the student developing their own individual criteria on which to base their assessment of capability in the task. The establishment of this personal construct of value was facilitated through the experiential engagement in the design task itself. Reflection and appraisal on value happened on both an individual and collaborative basis with the sharing of experiences between peers being instrumental in creating meaning for the students. The richness of the learning experience and the ability of the students to critique and self-reflect are outcomes that are of significant value in the learning activity.

5.4.3 Learning Through Design Based Activity

Traditionally, craft skills development was approached from a prescribed process model where students would replicate artefacts, from working drawings, which were marked using specific assessment criteria. Changing to a design based approach where there is emphasis on both process and product of learning required the student to communicate more than just the finished artefact. Students were encouraged to develop an electronic portfolio to support and evidence their learning throughout the task. The product outcome of the design task which traditionally dominated practical education now formed the catalyst for creative expression, problem creation and decision making. From the beginning of the design project the workshops became a community of learning, with a culture of teamwork and team building becoming evident within the
workshop, possibly because there was some level of uncertainty as reflected in the following student’s comments.

“I must admit at first this was a daunting task as I found it hard to grasp what was really being asked of us and how the hell I was going to come up with an idea, surely we weren’t being asked to think for ourselves”.

“I also learned a lot from my classmates as I got an insight into their ideas for their own projects and if I was doing mine again I would definitely do something differently and try and include some of their ideas into mine.”

“I think the fact that we were given the freedom to make whatever we wanted and to use our imagination as much as possible enabled a lot of positivity amongst us as students, and for us as teachers it will allow students to develop their own thoughts, goals and aspirations, through our guidance and link imagination and thought with a set of workshop skills and problem solving skills”

Over the course of the design task each student produced on average 50 unique electronic files on their mobile phone and submitted them to their individual digital repository. Files were produced in real-time and ranged from video to text and addressed all facets of their design activity. The following student comments are examples of real time capture of inspiration:

“I got my idea from a flower my girlfriend had in the apartment, it was one of those fake flowers and I never really paid much heed in it until I was looking for my idea. I studied it closely and only started to realise its beauty and potential it had for my flower in the project. I actually took the flower apart and realised it would be a nice design to make out of copper because it was really only one leaf and when opened out it resembled a conical shape”.

“This is the flower that gave me the original idea for my frame project. I saw it as I was walking to college one morning. This flower accurately depicts the emotion of sadness in my opinion”.

Engagement in the electronic portfolio was explored in the first year of the study to determine how it was used by the students in communicating their design capability.
Figure 5.21 illustrates the portfolio pane usage by the student cohort. The data is presented in quartiles of student performance from the student generated ACJ rank order. The data is presented in quartiles of the ACJ rank order to indicate if the number of panes used correlated with performance on the rank. The graph shows little difference between the quartiles and the position on the ACJ rank order indicating that the number of panes used did not influence the performance of the portfolio during the judging process. Generally all students used a minimum of 12 panes to communicate their design story. Figure 5.22 and Figure 5.23 shows two examples of the types of electronic portfolios that students produced. A full range of the portfolios produced across the three years of the study can be viewed at the following link: http://escape.maps-ict.com/exec/eab/login/

Logon details and instructions to navigate the portfolio website are provided in Appendix 9.
The portfolio illustrated in Figure 5.22 was in first place on the Year 2 rank. The portfolio clearly illustrates the use of various media to communicate the portfolio content through 28 panes.
The portfolio illustrated in Figure 5.23 was in second place on the Year 2 rank. The volume of content in the portfolio is less than the portfolio in Figure 5.23 but again this portfolio clearly illustrates the use of various media to communicate the portfolio content through 17 panes.
The portfolio illustrated in Figure 5.24 was in sixth place on the Year 2 rank. This portfolio clearly illustrates the use of various media to communicate the portfolio content through 24 panes.

The use of non-explicit assessment criteria was coupled with a non-descriptive holistic interface. Students had complete autonomy to decide on the structure, content, and medium to present their design story. This gave the students the opportunity to present the assessor with something more than just a chronological reporting of their engagement in the design activity. The portfolio was built from their digital repository during engagement in the learning process. The student was facilitated in presenting the assessor with an insight into their meta-cognitive process throughout the activity by subtly presenting the individuals’ design process model, approach, and emphasis through the use of the electronic tagging system introduced in this study. The reflective tagging process gave students the opportunity to tag their files in terms of the overarching criteria of Having, Growing and Proving of ideas (Kimbell et al. 2004).
Figure 5.25 illustrates the colour coded tagging bar that is output in the portfolio at the head of each portfolio pane tagged by the student. This colour coding allowed the student to present to the assessor the nature of the content of each pane.

Figure 5.26 presents the mean tagging per portfolio for the entire cohort of portfolios presented for assessment in Year 1 of the study. This presents a more interrelated dynamic indicator of the activity. From the graph it is clear that on average students illustrated that they were engaged in idea generation and development throughout the entire design activity. This to-ing and fro-ing within having, growing and proving of ideas would seem to align with Kimbell’s dialectical model of interaction between hand and mind (Kimbell et al 1991).
Although it was not mandatory to tag portfolio elements, 90.22% of students tagged their work. Evidence of this reflection was presented by students tagging the elements that related to the criteria in their portfolio. Of the students that did tag their work, a mean percentage of these tags per portfolio was calculated and showed a mean distribution of 25% Having, 27% Growing, 33% Proving with 15% of posts not tagged (possible transition periods).

What is evident from Figure 5.26 is the students did not present their work as a linear process of standardised headings similar to the design and assessment process models illustrated by the State Examinations Commission (SEC), (Appendix 15). However, there is evidence that the portfolios contain content and qualities that relate to the headings presented in the SEC design process. The significance of this finding is that when explicit criteria for assessment, and structured reporting of the learning process were removed, students reported in a manner that resembled the way in which designerly activity organically evolves. This also indicates that the negative conformist impact of assessment, as highlighted in the literature review, would seem to have had little effect on student engagement and reporting of their learning activity. In essence, the students did not conform to the structure or format of an assessment sorting mechanism but instead presented what was of value in their learning process.
5.4.4 Critical Reflection Through ACJ

The approach to this study placed the student at the centre of the learning and assessment activity. This challenged the student to personally define capability in the subject domain and develop a strategy to communicate that capability to others. The final aspect of the approach required the student to holistically judge the quality of their peers’ work based on their own conception of capability developed throughout the task.

On average across the three years of the study 81% of students agreed that this overall approach made them think about their subject in a new light (Q 20(c) Appendix 13). An average of 80% of students across the three years agreed that the approach helped them develop their own personal value for the subject area (Q 20(d) Appendix 13). Both of these findings highlight the effectiveness of the approach in engaging students with more than just subject content, presenting them with the need and opportunity to explore the subject domain for themselves. An average of 74% of the students surveyed agreed that having completed the modules that they have a better understanding of the value of craft-based education (Q11(e) Appendix 13).

Looking at the impact of the ACJ judging process, an average of 72% of students surveyed agreed that having completed their paired judging session, it broadened their understanding of capability (Q18(a) Appendix 13). An average of 79% of the students surveyed agreed that they re-evaluated their own performance in the module as a result of judging other people’s work with 77% of students surveyed agreeing that the judging session was a valuable educational experience (Q18(c), (f) Appendix 13).

The following are examples of some of the qualitative comment by students on the task:

“This module gave me great confidence and motivation for other modules. I felt under pressure in the course until I found that I was more than capable in the area of design and manufacture from this module. It was my kick-start.”

“It was great to get the opportunity to have such complete autonomy in a module, it was refreshing because often I find I feel that very particular things are being sought by a lecturer whereas here I was allowed to decide myself what I wanted to show - this would likely never be shown in a more strictly formed brief.”

“The project allowed us to go as far as we wanted in terms of how high level the skill was in the project or how creative they were. This seemed a good idea as if
you were more creative you could hone in on that, but that is not learning and so with some projects it was evident that the pupil may have relied too heavily on what they were already good at rather than stretching themselves to new ground. On the whole though most people strived to improve both sides which was nice to see and surprising too, how when pushed, the people who found it difficult to come up with ideas were producing very good work.”

“I tried not to think too much about what my processing capabilities were during project design. I felt that this could be a limiting factor in the design. Instead, I designed first, and then had to figure out a processing method.”

“I think I designed my project to a level that was above my processing capability but this turned out to be good as although it wasn't made perfectly I learned a lot of new skills.”

“Easily the most beneficial project we have completed during the course so far. Mixing metalwork and woodwork together with such an open brief really leads to lots of learning as you can support what you are not good at with what you are good at allowing you to experiment and be creative.”

“I am more confident in my ability to think for myself and produce work to a fairly high level of workmanship that is also creative and interesting.”

The following student comments present a reflection on student engagement with the task:

“The task didn’t suit me, but that’s because I like having a structured brief where it can be shown for what marks are going for. But many others I’ve talked to about the task loved it. Thinking back it is really brilliant in most aspects and I just didn’t take full advantage of the freedom we had.”

“I thought that by thinking outside the box too much in my design, the concept would be lost on people. Therefore I kept the theme stark but simply communicated. If I was doing the project again and was aware of the high level of creativity in the class group, I would increase the level of abstract creativity in my project.”

The final student comment presented in this section shows a significant insight by the student into some of the critical issue raised in the literature review for this study. The discourse on the role and nature of assessment in the modules and the experience of the ACJ process is likely to have had a significant impact on this students thinking:
“I found this module very interesting and motivational however now after two teaching placements and seeing closely the reality within schools it is somewhat disheartening to see that much of what we learned in this module seems irrelevant in the face of a very set exam structure.”

The evidence so far indicates that the engagement in the task was a rich learning experience for the students. It also indicates the student’s ability to generate a consensual rank order of student capability through the ACJ process of assessment.

5.5 SUMMARY OF LEARNING OUTCOMES

The critical outcome of the study is the positive effect that the approach had on students while engaging in a learning activity. It is clear that the outcomes were led by the students, their motivation, enthusiasm and uninhibited exploratory journey through the learning task. Having to establish what was of value stimulated thought and inquiry leading to convergence on qualities that exemplified capability. Communicating these qualities through the electronic portfolio required critical reflection and evaluation of their definition of capability to determine how best to showcase their ability. Confidence in the assessment to value the learning process as well as product outcomes facilitated meaningful engagement in the learning activity.
6 DISCUSSION
6.1 UNCOVERING THE VALUE OF DESIGN DRIVEN EDUCATION

The diverse and creative nature of design based education is potentially its strongest attribute. It provides a medium for learning that supports students’ in developing a broad range of qualities and skills contributing to their holistic development. The concern with design based education is that its strongest attributes are often difficult to capture and assess through its culmination in a product outcome. Over emphasis on the product outcome as the measure of domain capability sees the purpose of design education being narrowed or lost through the construct of assessment. Learning through the design approach provides rich educational experiences that are essential contributors to the broader conception of capability. To validly assess diverse and creative work the assessment instrument must be capable of valuing a range of qualities across a construct domain. A criterion referenced approach to assessment has limitations in this context. This is amplified when diverse and creative solutions are presented by students for assessment. The democratic approach brings with it a broad interpretation of the assessment construct through a wide range of experiences and values of multiple assessors.

This study integrated holistic assessment through the ACJ model as an integral part of the learning activity. The method employs judgement of quality through skills of appraisal based on a personal construct of capability. Removing explicit assessment criteria required students to identify value in the learning activity that shaped and informed the development of their emerging construct of capability. This allowed students the autonomy to exemplify their construct of capability derived through their personal mediation of the design based approach to learning. The use of electronic portfolios facilitated the democratic approach to assessment that broadened the concept of capability through identification and appraisal of qualities presented by peers. The inclusive and democratic approach instilled confidence in students’ to employ an experimental approach to learning embracing risk and failure as valuable to their personal development.
Integrating assessment as learning with a student derived criterion approach necessitated the development of a personal construct of capability as the foundation for establishing value and meaning.

6.2 STUDENTS SEARCHING FOR MEANING

Developing a personal subject construct is fundamental in teacher professional induction and development, influenced by an amalgam of experiences, knowledge and beliefs. Determining value requires reflection and appraisal of desirable qualities that are outcomes of an educational activity. The complexity of learning and assessment documented by Orsmond (2000), Sadler (2009) and Wiliam (2010) identify the need to integrate assessment at the heart of the learning activity. The difficulties relating to assessment practice outlined in the literature review indicate the negative impact of over-defined assessment criteria on the nature of student engagement in any design activity resulting in convergent solutions to the open ended problems. This can lead to the learning task being led by the assessment resulting in a narrow focus on the development of issues and proposals around the design task. Such an approach leads to a convergent and restricted exploration of the subject domain resulting in a construct of capability that is defined by assessment. The result may be a solution that indicates how well the criteria were addressed but may be devoid of meaning for the student. Having to decide what is of value requires the student to engage in self-directed meaningful learning activities to establish what to value. There are two levels of sophistication in the approach. Firstly, it requires the student to define for themselves their personal construct of capability through their experience in the learning task. The second element is broadening the conception of domain capability through the experience of holistic judgement on the quality of work of their peers. Presenting a project brief that was unorthodox, deviating from the traditional approach to learning in the subject discipline, rendered the traditional framework of a predefined structured approach to the design task redundant.
6.2.1 Defining a Personal Construct

Forming a personal construct of value in the subject domain is complex, with many variables at play for the student to negotiate as they develop their experience and understanding. The introduction of risk and uncertainty through the removal of explicit criteria might expect students to have a negative reaction, rebelling at the idea that there was no ‘plan’ or ‘path’ to follow. However, the reaction to this research was extremely positive. Students found the approach liberating allowing them the freedom to explore and create in their own conception of the subject domain. This was captured through retrospective analysis at three stages on the continuum of their undergraduate development. This provided an authentic insight into the value students placed on the approach with significant consensus on its positive contribution to their learning. Students found it challenging but rewarding. Performance in the task did not affect student’s capacity to value the approach; value was assigned to the process not the reward. The high level of student engagement and motivation was supported by confidence that the democratic nature of assessment could value their individual approach. This was a catalyst in students taking personal responsibility for the development of their personal construct of capability.

Providing the opportunity to develop this personal construct requires a learning environment that supports the student in their exploration of value and meaning (Sadler, 2009). Developing the ability to manage this process is enhanced by inducting students into the process of self and peer assessment by providing them with the opportunity to develop a sense of quality in their work. The removal of explicit assessment criteria authenticated the students definition of capability through the content in their portfolio which was compiled from their construct of what was of value to them in the learning task. An average of 70% of students agreed that having to establish their own assessment criteria had a positive impact on their learning. 78% of the students agreed that the absence of explicit criteria caused them to question what they were thinking or doing, indicating the potential in the approach to initiate reflective practice. An average of 80% of the students agreed that the overall approach to the modules helped them develop their own personal value for the subject area. It is clear that the overall impact
of requiring the students to generate their own criteria for the assessment of their capability had a positive effect on the students’ perception of their learning experience.

To ensure that learning is meaningful the personal construct developed by the student must have validity for the subject domain. A valid construct will indicate the success of the student’s learning approach in establishing what was of educational value. Wiliam (2010) outlines that addressing the issue of construct validity should start by looking at what we are measuring rather than how we are measuring it. Embracing this idea, the study focused students on establishing the epistemological value of their operationalization of learning. This required students to identify qualities of capability and appraise their value in the subject domain. These qualities were clustered and synthesised and presented as evidence of capability through the medium of their electronic portfolio.

The difficulty for the study was establishing if students’ personal constructs aligned with the theoretical construct of domain capability. The study employed the ACJ assessment model by using student judges to holistically assess the quality of work produced by their class cohort in each year of the study. Exercising their capacity to holistically judge requires students to identify and appraise the value of qualities of capability based on their personal construct of domain capability. The democratic nature of the ACJ process then presents a rank order of work that represents the consensus of that group of assessors on what was valued as capability. Two aspects of the ACJ process indicate the validity of the student construct. Firstly, the qualities identified and rewarded through the ACJ process must align with the theoretical construct of domain capability. Secondly, the validity of the individual construct indicates the consensus of the judges on characteristics of capability evidenced and rewarded on a valid ACJ rank order. This is indicated through the level of judge and portfolio misfit parameters generated by the group based on their valid collective construct of capability through the democratic assessment process.

Year 1 of the study focused on an analysis of the electronic portfolios for evidence of capability as determined by the module leaders’ theoretical construct. The purpose of this analysis was to validate if capability in the design based task could be expressed through the medium of an electronic portfolio and if the evidence of capability in the portfolios aligned with the student assessment generated by the ACJ model. The
analysis of the portfolios revealed conclusive evidence that the electronic portfolio was a suitable medium for the communication of qualities of capability. Students provided rich evidence of knowledge, skills and problem solving through the use of a variety of media. Significant correlations with moderate to strong effect sizes were recorded between the evidence of capability in the portfolios and the student assessment. This indicates the ability of the student judges to identify and evaluate capability in the task and assign it value in line with that of the module leaders. This correlation was based on what the student valued, presented and appraised based on their personal construct of domain capability. This presents strong evidence that the student generated rank was a valid measure of capability. This also indicates that the personal construct of the student valued the broader context of capability in technology education contributing to the validity of the construct and assessment by reducing the likelihood of construct underrepresentation.

6.3 JUDGING EMERGING PERSONAL CONSTRUCTS

Having developed a valid personal construct of capability the students were required to exercise their skills of appraisal through the holistic assessment of their peers work. The comparative analysis and judgment of peer capability broadened the students’ concepts of capability. This was achieved by not only presenting them with a wide range of solutions to the brief, but more importantly by requiring them to identify qualities of capability on which to form their judgment. When completing their appraisals and forming their judgements their personal construct becomes the construct of interest. This construct of interest should be the driver of any assessment practice and must be decided independent of the influence of assessment approach to ensure validity (Wiliam 2010). Having established the validity of the portfolio content the analysis focused on the ability of the student judges to validly and reliably distinguish quality of performance using holistic judgement with the ACJ method.
6.3.1 Latent Criteria

Students personal construct are comprised of qualities and the relationships between qualities forming their conception of capability. Holistic judging of capability requires assessors to discriminate on critical qualities that align with their personal construct. However the infinite nature of knowledge and learning can produce valid outcomes to tasks in a variety of different ways. This challenges the personal construct to value newly emerging qualities. Implementing these criteria in assessment is a sophisticated skill that develops with evaluative expertise (Sadler 2009). These skills are drawn on demand as required, depending on the work being evaluated. The research shows that the sharing and use of latent criteria expands the range of qualities and values that inform the assessors’ personal construct. The nature of the work presented for assessment, as a result of the study’s approach, provided a diverse range of solutions to be assessed with potential to exercise the use latent criteria in the process of making judgements on quality. This shows the flexibility of the assessment to react to the qualities of capability providing the students with the confidence to take risk with their design approach. Engagement in the judging process was reported by the students as a valuable learning experience. The consensus was that the judging activity broadened their conception of capability and made them re-evaluate their own performance. This indicates the power of ACJ as a reflective learning instrument. With such flexibility of assessment and individual personal construct, it was significant that high levels of agreement were achieved through the ACJ process. With convergence through a divergent approach, the consensus on qualities represented core attributes of the collective construct of capability developed by the group.

6.3.1.1 Shared and Opposed Values

To establish the basis for the high levels of consensus achieved through the ACJ assessment the study focused on the judges and what they identified as evidence of capability in the portfolios. The findings are based on the analysis of 1238 judgements by 114 student judges on 133 portfolios. The judging comments in relation to the portfolios indicated that the qualities students identified were either ‘shared’ or ‘opposed’. A ‘shared’ comment is one that sees qualities in the portfolio that align with
the judge’s personal construct. An ‘opposed’ comment is one that does not align with
the personal construct of the judge. It should be noted that the comments do not
indicate if the portfolio won or lost nor do they indicate a specific criteria that a judge
used as a basis for their judgement. The clustering of judging comments generate a
profile of the qualities identified in portfolios across the rank order. The categorisation
and distribution of the comments give an insight to the qualities of capability identified
by the student judges as they analysed and appraised the portfolio content during the
judging process. The analysis revealed that two thirds of judges’ comments on qualities
were shared with the personal construct of the judge. A direct relationship between
shared and opposed comments and the rank order quartile was identified and is
illustrated in Figure 4.18. This indicates the consensus among the judges on what they
perceived to be good and bad in portfolios and how this is reflected in the ACJ rank
order. Judging comments revealed four general categories of qualities that related to
capability. The analysis clearly identifies the dominant qualities that caused students to
comment on the portfolios and are discussed in the following section.

6.3.2 Qualities of Capability Revealed Through the Judging
Process

It is clear that communication is critical to the judge as it was the most frequent cause
for comment. A significant spike in the ‘opposed’ comments with regard to
communication in the portfolio is observed and the increase in the frequency of
‘opposed’ comments is directly related to the quartile position of the portfolio with
portfolios in the 4th quartile of the rank receiving the greatest proportion of ‘opposed’
comments. The nature of the comments on communication indicate that the student
judges regularly focused on how effectively the portfolio communicated the design
story, in particular the generation and development of ideas. With the compilation and
structure of the portfolio decided by the individual student it was evident that the
student assessors placed value on the portfolio being able to communicate capability in
a coherent manner. This is a subtle indicator of the judge identifying synthesis and
relationship between the clusters of qualities as being valued in their construct of
capability. This is an important feature of holistic assessment (Kimbell et al. 1991) and
an indicator that students were making their judgements on more than just the sum of
the parts. The analysis indicated that the role of communication is a relevant and important part of the student defined construct of capability.

Tagging was also identified as being helpful when judging, giving an insight to the student’s perception of their conceptual thought process at the idea generation and development stages. This indicates that the student judge was looking deeper than the individual quality trying to establish the purpose and meaning of the portfolio content. This shows evidence of students internalising abstract criteria and through appraisal and reasoning developing their capacity to holistically judge.

The other clusters of qualities identified by the judge comments specifically relate to the design task and its outcomes. The qualities identified relate to inspiration of ideas, conceptualisation of ideas relating to the design task and realisation of ideas through materials and processes. It must be noted that for the purpose of analysis the cluster qualities are quantified by the overall group of assessors and any inference drawn relates to the consensus of the group rather than any individual judge. However the high level of judging consensus allows general inference to be drawn on the nature of the judging process. The proportion of comments attributed to each of the categories clearly indicates that the student judges primary focus when identifying qualities of capability centred on idea generation and development. Figure 4.20 illustrates that the realisation of the project artefact was important accounting for 17% of the overall ‘shared’ comments. However the inspiration and conceptualisation categories comprised of 29% and 23% of the total ‘shared’ comments respectively. A direct relationship between the number of ‘shared’ comments per category and the rank order quartile is observed in Figure 4.18. This shows that a portfolio of lesser quality as determined by the student ACJ rank was less likely to display the qualities attributed to capability by the students. This is a clear indicator of the ability of the student group to discriminate capability based on identification of qualities defined by the values of the groups construct of capability. This is a critical stage in the holistic judging process identified by Kimbell et al. (1991). The figures show that the dominant qualities identified by the students relate to ideas and their development with a combined total of 52% of the total positive comments by judges. Therefore, when allowed to determine their own value on what constitutes capability in the task, students identified the generation and conceptual development of ideas as being the most significant aspect of
capability. This indicates that the student attention was focused on the process of determining the solution to the brief and not solely on the product outcome when making their judgements. The significance of this finding lies in the value students placed on the educational process. It must also be noted that the approach to learning was mediated and directed by the students through social interaction in a constructivist paradigm. This shows students uncovering the educational value of the design based approach in technology education through the development of their personal construct, with the potential to providing a basis to inform their future pedagogical approaches.

The realisation of the concepts and ideas was the least referred to category accounting for 17% of the ‘shared’ comments on the portfolios. The nature of the comments on the realisation tended to lead with the student outlining ‘shared’ or ‘opposed’ appraisals relating to the ideas and their development with the quality and attention to the manufacturing process being presented at the end. The inference drawn from the analysis of the comments is that the realisation and quality of craft skills was important to the student but was secondary to the design based competencies identified in the portfolios. This is another indicator that assessment using the electronic portfolio was predominantly focused on the process of designing, while still valuing the importance of the skills of realisation and manufacture.

The frequency of ‘Opposed’ comments on inspiration, conceptualisation, and realisation aligned with the rank order (from the 1st to the 4th rank quartile), indicating the student’s ability to discriminate quality. The general low level of ‘opposed’ commentary on these qualities indicate the positive disposition students had toward assessment, where they focused on what was good in the work for the basis of their judgement.

The overall analysis of the student’s comments on the qualities in the portfolios indicates that the electronic portfolio is an appropriate medium for the presentation and assessment of capability in a craft based design task. It also highlights the ability of the students to identify, present and discriminate qualities of capability based on a personally derived construct of value in the subject domain.

6.3.2.1 Agreement on Quality

Having established the validity of the identified clusters of qualities the question of the ability of the student judges to generate a valid assessment of quality of capability was
explored. To investigate the validity of the student assessment a selection of portfolios from across the three years of the study were compared using expert judges and the ACJ method. The rank generated had a reliability coefficient of 0.963 with no portfolio misfit. The relative rank positions of the portfolios from each year and their position of the expert rank were correlated to see if the students’ assessment of capability aligned with that of the expert assessors. The analysis revealed a significant correlation with a very strong effect size for all three year groups. This shows that the student assessment and ranking of capability closely aligns with that of the expert assessor further confirming the validity of the student generated ranks. The significance of the findings from the analysis is that requiring students to personally construct the criteria for assessment and applying them to evaluate capability is an effective methodology for the progression of students from novice to expert on the continuum of teacher education. The relative rank positions were analysed for variance between expert and student judgements. The analysis revealed that both groups agreed on the general position of work on the rank with the variance existing on the refinement of the order in that region of quality. Both groups identified and prioritised ideas and their development on their assessment of capability, but the expert judges indicated a greater recognition of, and consensus on, the relationships between clusters of qualities when commenting on portfolios. A qualitative analysis of the variance was completed by examining the student portfolios and judging commentary. The analysis of the portfolios focused on identifying elements of capability as outlined by Kimbell et al. (1991) in the holistic judging of design tasks in the technology domain. This method highlights the relationships between cluster qualities as being at the heart of capability. Evidence of the quality clusters were illustrated through the analysis in sections (4.4.9) to section (4.4.11). Portfolios at the top end of the rank orders exhibited strong relationships between the cluster qualities and high levels of knowledge and skills. Weaker portfolios indicated lower levels of knowledge and skills with the portfolios lacking synthesis of the relationships between qualities. This analysis is further testimony to the validity of the assessment process. Both student and expert judges identified similar qualities in the portfolios which exemplified capability at a level appropriate to the general ranking position. The correlations between the expert and student ranks show uniformity in the direction of the assessment of quality of portfolio as judged by both
groups. Overall the consensus of judgments on the portfolios using the ACJ process confirms the reliability and validity of the assessment process in valuing qualities in the construct domain.

6.4 CONVERGING ON ASSESSMENT CONSTRUCT

6.4.1 Democratic Approach to Assessment

Student confidence in the democratic approach to the assessment formed the basis for unrestricted engagement. As a result the relationship between student and assessor (their peer) was relaxed. Students did not need to second guess the values and preferences of the module leader. The democratic nature of the ACJ model meant that students had confidence that the value of their work could be recognised if their understanding of capability aligned with the consensus of capability within the domain. Not having to predict what ‘the assessor is looking for’ was one benefit of the approach taken. Not being able to align your solution to generic externally defined values or criteria renders the dominant ‘formulaic, routinised, and predictable’ (Kimbell 2004) approach to design redundant. Students quickly became the co-constructors of their own meaning. What resulted, which was strikingly obvious, was the diversity in ideas and solutions of the students work. Barlex (2007) suggests that such a spread of responses is an indicator of a class in which creativity is being supported.

The internal reliability of the ACJ model is presented through the Cronbach Alpha reliability coefficient for the judging session. Reliability coefficients for all judging sessions in this study ranged between 0.942 and 0.98. This is considered to be a high reliability (Kimbell 2009) indicating a low level if inter-assessor variability in the judging process. The real significant point of note is that this level of reliability was achieved using holistic judgement and without providing explicit criteria to the assessors. The consensus of the individual judging decisions presented through the portfolio and judging misfit statistics is also extremely high with none of the ranks generated having greater than 5% of misfit in either category. The democratic nature of the model assumes that judgments by individuals are equitable if the misfit is not high. This indicates that the judges were making similar decisions about similar pieces of
work. The question still remains if the judgements on quality align with the construct of domain capability. This led to an analysis of the portfolio statistics.

With high internal reliability the analysis focused on the external reliability of the assessment process. Two issues that may impact on the external validity of the assessment were investigated. The first issue examined was if the definition of the judging group affected the reliability of the rank order of portfolios. Two judging groups were stratified by their programme of study material discipline. The findings indicate a strong correlation between the portfolio rank positions on the two independently generated rank orders by the students ($r = 0.695 \ p<0.001, n = 137$). The significance of the finding not only highlights the reliability of the ACJ model it also indicates that the judging decisions were not biased by the material based heritage of the students programme of study. This is an indicator that the study’s principles based approach to teaching and learning communicated to the students the transferability of knowledge and skills within the broader technology education domain. The second issue investigated was the impact of student on the generation of the ACJ rank. Three independent judging sessions were completed on one group of student portfolios. The judging groups were stratified based on performance in a technology based processing module in the semester preceding the implementation of the study. Reliability coefficients of 0.971, 0.975 and 0.98 were recorded for the judging sessions indicating extremely high consistency in student judgements. Significant correlations with a strong effect were recorded between the ranks as illustrated in Table 4.13. This indicates that student ability prior to the task is not a significant indicator of variance in the student judging process. The conclusion from this finding is that the consensus on capability was developed through engagement in the modules and developed through experiential and collaborative learning without the aid of explicit criteria for assessment.

### 6.4.2 Individual Consensus on Qualities of Capability

With the group consensus on capability presented through the analysis of the findings a further analysis of the ACJ statistics can indicate the validity of the individual judges’ personal construct of capability. The judge misfit statistic indicates if the misfit
judgements made across the rank are concentrated on any particular judge or judges engaged in the process. The distribution of misfit judges across the rank order of performance was observed to be normal in all the ranks, indicating the level of capability was not a critical factor in students’ ability to make judgements. This also aligns with the high level of confidence students had in their ability to make valid judgements. On an individual basis the majority of the judgements completed by the judges were similar in relation to individual portfolios. Critically, the judges decisions on each portfolio were governed by their individual construct of capability developed through engagement in the learning task. What the judging statistics tell us, quite categorically, is that judges reached agreement on the portfolios likelihood of winning or losing their judgements. Year two of the study focused on the issue of judge misfit. In this year of the study the number of judgements were reduced which amplified the impact of any judgement that was out of line with the consensus of the group. On completion of the judging session the number of judges exceeding the misfit criterion was 7 judges. This was approximately 5% of the judging cohort. What this indicates is that the vast majority of decisions were consensual with the overall group. Similar figures for judging misfit were recorded on all ranks generated over the three years of the study. These misfit statistics indicate that the approach to learning and assessment in the modules was effective for the majority of students developing a consensus on what was of value in the assessment of the quality of the portfolios. While this does not validate the construct or assessment it does indicate that should the assessment be deemed valid, then the approach to the learning task was effective in enabling these students to personally construct value in their subject domain.

6.4.3 Delta Criteria

An important issue arising from this study centres on what can be described as the ‘delta’ criteria. This is the ability of the assessment criteria to change and respond to the work the student presented as their evidence of capability. The meaningful engagement in design based activities allowed students to explore and develop capability in a way that was distinctly personal. How they created meaning for themselves in this process is of critical importance resulting in something unique to the student that was valued by assessment. Evidencing this variable is central to the
assessment model as it enables judges to react to the student work rather than the current practice of students reacting to assessment. This ability to adapt criteria was evidenced in the qualitative judging comments. It was also observed that students used different criteria to judge the same portfolio depending on the pairing. This shows the potential for the ACJ model to require judges to ‘dig deeper’ into the student work uncovering a broad range of capabilities with potential assessment value. The emergence of the ‘delta’ criteria requires the student judge to have a broad understanding of capability in the domain.

The ‘delta’ criterion is a particular feature revealed through the analysis of the ACJ assessment process. The multiplicity of the parings of student portfolios requires the judges to react in different ways to the uniqueness of the paring for each particular judgement. This provides opportunity for the portfolio qualities to be compared by a broad range of assessor criteria but also to be compared on criteria that result from the unique portfolio parings. This may unearth qualities that might otherwise go un-noticed if judgements were to be made against a standard assessment rubric. This is a unique feature of the combination of holistic judgement with the ACJ method and adds a further dimension to the democratic nature of the approach.

6.4.4 Construct Irrelevance Variance

The frequency of comments on communication (both ‘shared’ and ‘opposed’) may bring into question the issue of construct-irrelevant variance in the assessment and thus challenge the validity of the student rank order and their personal construct. The challenge to the validity is that the student judgements may have been overly influenced by a superficial quality rewarding the mode of communication over the quality of capability. Analysing the nature of the comments, it is clear that the majority of communication related comments focused on the effectiveness of communicating the complex issues of idea generation and conceptualisation and not merely the means. A further indication that superficial issues of communication did not influence the judges was that no significant correlation was observed between the number of portfolio panes used by the student to communicate capability and the rank order position of the
portfolio. Students were focusing on content quality rather than quantity when making their judging decisions.

### 6.5 ACJ: A CATALYST FOR LEARNING

The integration of assessment and learning had significantly positive outcomes in this study. The features of holistic judgment using the ACJ model had a significant impact on the students approach and engagement in learning. The following section outlines the implications of the findings on students’ reaction to the integration of assessment with learning.

#### 6.5.1 Appraisal

The role of appraisal in assessment and learning is fundamental to the development and monitoring of the quality of students own work. Developing the skills of appraisal must be an integrative part of the learning activity. Sadler (2009) proposes the use of holistic assessment by students as a vehicle for the development of skills in appraisal. This is the strategy employed in this study where the holistic assessment by the student groups using the ACJ model achieved high reliability and validity. Students’ skills of appraisal were central to this achievement. The validity of the assessment was formed through the appraisal of assimilated qualities that were relevant to the personal construct of the student judge. The validity, reliability and consensus of the student judgments indicate the success of the students in forming critical appraisals. Four factors from the study’s approach were identified as contributing to the development of students’ skills of appraisal throughout the task.

- Student personal construct of capability
- Use of overarching criteria
- Tagging student work
- Student generated portfolio

Defining their personal construct of capability was the first stage of engagement with appraisal. It must be noted that the personal construct was developed throughout the task based on the knowledge and experiences acquired through a variety of activities and interactions with both teachers and peers. With the removal of explicit assessment
criteria students were forced to identify and appraise what was of personal value to them from their engagement in the learning activity. This challenged students on a cognitive level where they had to establish their own epistemology and beliefs by exploring the domain for value and meaning. Having to establish what is of value is said by Sadler (2009) to lead to complex appraisal and reflection. The use of general as opposed to explicit criteria is proposed as acting as “enablers” for the appraisal of the substance of work (Sadler 2009). This study employed the use of overarching criteria at two levels in the study. Students were provided with the criteria relating to the generation and development of ideas based on the work of Kimbell et al. (2004). The introduction of the criteria hoped to stimulate appraisal on the value of their work at a metacognitive level to broaden students construct of capability to include the cognitive benefit of the design based learning task. Tracking the use of the overarching criteria was facilitated through the use of the tagging process. The act of tagging students work again stimulated the student to appraise its nature and to assign it value in their evolving construct. This activity required the student to explore and appraise the relationship between qualities in the refinement of their project development. The student generated portfolio was another critical feature of the approach that utilised the students’ skills of appraisal. Not providing an explicit reporting structure required the students to establish evidence of capability and also to determine the most appropriate means for its communication. This encouraged students to reflect on their journey of learning as a whole assigning value and meaning through appraisal in the process of compiling their electronic portfolio.

Collaboration between students also provided students with the opportunity to view discuss and appraise the quality of other students work. This also provided the opportunity for the student to interpret the appraisal of others on their work. This engagement in formative assessment practice was seen as mutually beneficial by students with the findings indicating that students placed significant value on collaborative practice in the development and progression of their learning. Students’ willingness to engage in collaborative practice indicates their confidence in their ability to positively communicate and contribute to the learning environment. Such interactions are identified by Sadler (2009) as critical to developing skills of appraisal. The culmination of the development of appraisal skills was through the holistic
judgement of peer work using the ACJ assessment model. The high levels of validity, reliability and consensus are strong indicators that students developed an ability to judge and appraise the relevant qualities of work based on their personal construct definition. The significant correlations between the expert and student judges on quality strengthen the validity of the students’ appraisal. Completing the judging activity also caused students to reflect and appraise their personal standards and performance. Overall the approach employed in the study provided opportunity for students to develop and exercise their skills of appraisal leading to meaningful learning and personal development.

6.5.2 Confidence

A general principle of assessment is that it rewards students for the quality of their effort. Identifying this quality and assigning it value are the key challenges for the assessor. Having confidence that your effort will be rewarded is a central issue for the student in particular in an activity where innovation and creativity are key outcomes. Developing a sense of confidence and security where students take ownership of their learning was the central challenge for the study approach. The student reaction to the approach was positive. An average of 63% of the students agreed that they were confident that the model of assessment would value what they presented as capability. The consensus of the group was that generating their own assessment criteria through their engagement in the task had a positive effect on their learning. They also agreed that this had a positive impact on them determining what was of value in the subject domain. The significant finding in relation to the assessment issue is the nature of the student engagement in the learning process. The removal of explicit criteria and the introduction of democratic peer assessment were the catalysts for the natural propagation of a social-constructivist approach to learning. The evolution of collegiality among the class group was in contrast to prescribed traditionally focused approach used in these modules in years previous to the study. The elephant in the room (for the module leaders) was that they were all going to be compared to one another (normatively) through the comparative pairs assessment, but this was not an issue for the students. One hypothesis for the students’ supportiveness is that no student
felt as if they were trying to compete on predefined areas of the brief as their interpretation and engagement in the task was uniquely personal.

The emergence of the community of learning within the groups highlights the positive interdependence that was created by the democratic approach to assessment with non-explicit criteria. What was observed was that students engaged in dialogue with peers and teaching staff in an effort to establish the value of their actions among the classroom community. This sharing of ideas and experiences was observed to reassure and give confidence to students trying to navigate their way to developing their concept of capability and criteria for assessment. Over 60% of the students agreed that being peer assessed encouraged them to interact more with their peers during the task activity. The consensus amongst the group was that the purpose of these discussions related to more conceptual issues of clarifying their thinking or problem solving than with sourcing information and getting help with procedural aspects of manufacture. An average of 52% of students agreed and 36% strongly agreed that discussions with peers were mutually beneficial. Boud (2005) identifies this reciprocal nature as critical for peer learning to be developed and valued in the culture of the learning environment. Students found benefit in discussing other students work and that their learning did not always happen in the context of their own project. A further indication of the level of peer support that developed in the classroom is indicated by 88% of students reporting that they initiated communication to help peers with their work. It was noted that student strengths and weaknesses were shared for development. Students with strong IT skills for example were often observed helping the less capable, who generally reciprocated with help or advice from their area of strength.

The peer to peer collaboration was clearly a means for the students to externalise and validate their thoughts and ideas in relation to the task. This is a critical feature of the constructivist approach. Establishing what was of value within the group was relevant to the student as this closed group were ultimately going to be responsible for the assessment of capability. So finding out what your peer was doing was not the only focus, finding out why they were doing it was now becoming important in making meaning of the value of the subject domain and establishing a common frame of reference for capability in the design task. Students identified that peer assessment had an impact on how they approached the communication of their design task through the
electronic portfolio with an average of 80% of students agreeing that they wanted to impress the person assessing their work. This finding is an indicator of confidence and self-esteem which Craft (2005) says must be nourished in order to be creative. It is also an indicator of the student developing a relationship with the assessor working out what was critical in their performance and presenting it as their capability. Overall the latent integration of the assessment into the learning activity had a positive impact on the students’ experience. The removal of explicit criteria did not stifle students’ progression but rather promoted dialogue and interaction that was valued more than the normative comparison that would ultimately decide on quality.

6.5.3 Motivation to Learn

Implementing design activities within an unstructured educational paradigm is a challenge, but can be achieved if the learner is given a proactive part and not a spectator’s role in their own learning. With this comes responsibility on the students’ part for their learning and development. Motivation for engagement is then critical with this approach. The nature of the task played a central role in intrinsically motivating students to engage. The personalised nature of the brief coupled with the freedom from explicit assessment criteria were observed as key to this aspect of learning. Learning developed from a paradigm of ‘have to know’ to ‘need to know’, as students were not only creating their own solutions but also their own problems. The essential transferability of new knowledge and skills fostered a deep engagement in the learning activity. The autonomy gained during the design task and the absence of external criterion-referenced assessment reduced the anxiety of having to produce what is perceived to be required. The natural propagation of the student peer engagement was stimulated by the removal of the assessment criteria. In an effort to establish their personal value and range of criteria students engaged and discussed what was of value in their work in a sub-conscious effort to develop their conceptualisation of standards and quality. This indicates the success of the methods integration of learning and assessment for self-actualisation.

The findings from the study revealed that the students regularly engaged in experimental activities to develop their understanding and inform their design decisions.
The qualitative feedback through the student questionnaire revealed that the majority of students saw value in trying things with unsure outcomes and 91% of students placed value on learning from mistakes. Students also indicated that they were confident that presenting evidence of mistakes could be valued as evidence of learning in their electronic portfolios. The willingness to take such risks in the task was supported by the democratic nature of assessment where the student was confident that what they presented as capability could be valued by the broad range of assessors.

### 6.5.4 Students’ Design Approach

Figure 5.26 illustrates the engagement of the students in the design based activity as evidenced by their personal tagging of their portfolio contents. What is presented in this graph is highly significant. The literature review outlined the problematic issue of the structured approach to student engagement in design based activities, and the resultant negative conformist, linear impact it can have on student learning and meaningful engagement. The evidence provided by the tagging tells a significantly different story.

The portfolios were not necessarily presented in chronological order of task execution but rather in an order that students’ perceived as being of value in communicating their design story. Therefore the order of the portfolio represented the critical milestones of their “thought in action” (Kimbell et al. 1991) ultimately what the student felt was of value in demonstrating their capability. The data show the idea generation and conceptual development not to be confined to any particular stage of designerly activity. Instead it can be seen that students were generating, developing and proving ideas throughout the whole activity in the pursuit of a solution to their brief. When the success of the students work in demonstrating capability in the study is considered, the application of linear approaches to design based tasks comes into question. The data show that the concentration of the idea generation to the beginning of the portfolio indicating the value students placed on this activity in the context of their design evolution. It is clear, as the portfolio progresses through the design story, that idea generation becomes less frequent but still important to their personal design process. The inverse is true of the idea proving function of their design process.
Growing of ideas is seen to occur more uniformly throughout the activity with the graph showing a relationship that suggests that growing ideas is the link between “thought” and “action” presented by Kimbell et al. (1991). This provides evidence of the effectiveness of the study methodology in engaging students in learning through design in a meaningful way. With the generally high quality of diverse and creative work produced and the positive experiences of the student body evident, this study reports the success of the assessment strategy employed in creating meaningful learning.

### 6.5.5 Relevance to ITE

The study has shown the reliability and validity of students holistic judgments based on a personal construct of capability developed through a design based learning task. The positive impact on motivation and learning has been outlined as well as the high levels of performance achieved by the students.

Assessment is an integral part of teaching and judgement is an integral part of assessment. This is evident from the many writings and discourse in the review of the literature. With this being accepted it is therefore critical that Initial Teacher Education programmes develop student’s professional judgement. Laming (2004) states that judgement in assessment is not absolute and is based on comparisons of a variety of different elements. The critical issue for ITE is developing a broad and sound basis for future practitioners to inform their judgements in the education domain. At the heart of this study students developed the capacity to holistically judge quality of performance based on a personal construct of capability derived from experience based learning. Their skills of identification and appraisal of qualities of capability are fundamental skills for the classroom practitioner. The model of personal subject construct outlined by Banks et al. (2004) Figure 2.5 identifies three critical areas for development in ITE students which were addressed by the implementation of this study. Through the removal of the explicit assessment criteria students were required to identify, value and reflect on qualities of capability revealed through their engagement in the learning task. This resulted in students developing their personal construct of capability which is fundamental to their future role as teachers. Sadler (2009) identifies this as developing a “conceptualisation of what constitutes quality”, and indicates that this is critical in
achieving consistently high levels of performance. The catalyst of democratic assessment encouraged the broadening of this learning experience in a bid to establish the consensus of values within the developing culture of the student group. This was facilitated by peer collaboration as the learning task evolved over the six week period. The value and standards of the group, on domain capability, was then revealed through the consensus of the peer assessment using the ACJ process. The values exemplified by the students through the ACJ process indicate students embracing a post-modern approach to learning and assessment. This is important for the implementation and development of the Irish technology curriculum to achieve the outcomes of the contemporary design based approach.

The experience of holistic judging provides students with context for reflection and discourse on the role of assessment in learning as they progress along the continuum of professional development. Sadler (2009) presents the judgement of quality as having benefits in the development of evaluative knowledge and skills that are valued in the field of educational practice. The requirement to use personally constructed criteria for the basis of individual judgement initiates an internal debate to establish what constitutes good or bad and what is of value or not in the context of learning, as a critical element of teachers’ professional knowledge.

The study highlights the critical need for assessment to be embraced as part of the learning process, empowering students to think, act and reflect in an effort to make sense of it all.
7 CONCLUSION
7.1 CONCLUDING REFLECTION

Research in technology education in Ireland (or until recently ‘technical’ education) is for the most part embryonic. The more traditional view of ‘craft’ education with purely vocational ideologies, aligned with a singular view of enquiry. The subsequent introduction of ‘design’ as a vehicle to support abstract thinking and reasoning skills within technology education has changed the nature of enquiry, that is only now beginning to gain traction. Recognising the intertwining of education, educational researchers, policy makers and politics contributes to the ambiguity surrounding the epistemological understanding of technological education in definition.

In addition to the definition of Technology education, navigating the complexities of educational research is a significant challenge, when considering the potential impact of individual viewpoints and concepts on the research outcomes. Considering the merits of positivist and naturalistic approaches highlights the relationship between epistemological assumptions, methodological considerations and issues of data collection and instrumentation. Even further complexity is added when considering the context of educational research where the very act of engaging in evaluative educational research has potentially already changed the nature of what it is that is determined to be data.

It is quite apparent why Buchanan (1995) described the research task as frequently ‘wicked’, with the real issues hidden by the complexities of content, context and subjectivity. On reflection this study considers the three core interrelated research issues. The resolution of variance between idealism and realism within action based research, the importance of beliefs and values defending the research lens that they dictate and finally the dichotomy of distance as the research evolves.

Resolving the variance between idealism and realism, and ultimately evolving the research agenda was a recurring theme across the three years of the longitudinal study. Cohen et al (2007 pg. 78) identifies that there is no single blueprint for planning research and suggests that research design is governed by the notion of ‘fitness for purpose’. The interpretation of this notion is inexplicitly linked to the values and beliefs of the researcher. This research benefited for the philosophical position of the researcher being the kernel of the approach to the research design. The lack of external
funding created pragmatic challenges for the study, but significant philosophical advantages. The absence of mandated outcomes which are generally the modus operandi of funded evaluative educational research projects allowed for a more ideological approach to the research, supporting the authentic and natural propagation of student reaction and response.

Having the capacity to take and develop a philosophical position is a great place to start. The clarity of beliefs and values held by the researcher underpin the definition of what constitutes capability. This supports the appraisal of quality ensuring a clear focus and intend, which easily translates into the research questions. Clear focus and questions in-turn aid the methodological design converging on a ‘fit for purpose’ approach. The strength of having unambiguous beliefs and values that are not clouded or compromised by external considerations supports the clarity of problem, approach and method. While respecting the subjective nature of educational research, it should also be noted that a strong philosophical position magnifies the risk of subjective interpretation of the research data. In particularly when dealing with holistic judgement, the risk of interpreting capability by inference raises validity issues. The evidence each student presents as capability may in fact be perceived as being of greater or lesser value depending on the perspective and values of the researcher. Although, there is no defined method to incorporate particular philosophical positions, it does not mean that we can assume a licence to be dilettante (Kimbell and Stables 2008 pg. 287).

Acknowledgement and recognition of this risk enabled the research design to ensure a responsible and reasonable accommodation of the researcher’s values, beliefs and experiences when developing the data analysis and allowing the research to be intuitively and validly managed to ensure the integrity of this data.

On reflection, the dichotomy of acting as both a researcher and pedagogist created a challenging undercurrent throughout the study. Protecting the study form research bias, particularly were responses could be contrived to support the students perception of what they thought the module leader was looking for was a significant consideration within the research approach. The distance between the role of a researcher and pedagogist often presented a Sophie’s Choice style scenario amid the methodological approach and the capture of authentic student behaviours/responses/reactions. As with most action research, this study balanced the primary objective (acquisition of learning
outcomes as defined by the module of study) with the research objectives (as defined in section 1.5.1). But more importantly the study attempted to balance the ethical dilemma of being close enough as a pedagogist to support meaningful learning/attainment and yet far enough way as a researcher to allow for an authentic measure of performance and capability. This dichotomy of distance was also bi-directional. With the contemporary view of technological education requiring less emphasis on prescribed approaches, and more facilitation of exploratory and experiential learning opportunities, supports the idea of mentoring and not teaching and thus a distance from the learner. Alternatively from a research perspective, it was essential to maintain a distance from the students for fear of research bias, yet ensure the capture of performance indicators that were essential and meaningful.

The research study was conducted to finely balance the experiences, beliefs, and values of the researcher in the context of a complex, evolving method in an attempt to capture authentic performance indicators of participant students, with the objective of contributing to the body of knowledge within technological education.

7.2 CONCLUDING COMMENTS

At the outset this study aimed to evaluate the impact of assessment on student performance and engagement in design based learning. The following conclusions were drawn from the research:

- This study highlights the positive affect of the integration of assessment learning. Students reacted positively to the removal of explicit assessment criteria and indicated that this empowered them to be innovative and creative in their learning. The uncertainty and risk introduced by this approach saw the development of autonomous and collaborative learning creating a rich and supportive educational setting. The outcome is an authentic communication of student capability defined by their personal construct providing evidence of qualities for a valid assessment of student performance.

- Developing a personal construct of capability and value in the subject domain was empowering for the students. The success of the approach is highlighted in the diversity and quality of the outcomes of the learning and assessment activity. The validity of the student learning is evidenced through their capacity to
establish and communicate qualities of capability through the electronic portfolios.

- The high reliability of the ACJ assessments indicates that as a group the students reached consensus on the qualities of capability. The alignment of the student assessment with that of module leaders and expert assessors presents the validity of the construct of assessment generated by the group as a whole.

- The study presents the efficacy of the ACJ model of assessment in developing sophisticated levels of skills in appraisal to validly discriminate quality of capability in the subject domain. The emergence of latent and ‘delta’ criteria in the judging process present potential as vehicles for learning, contributing to the broadening and development of students’ construct of capability. This is a sophisticated approach to valuing both implicit and explicit characteristics of learning that students engaged in through the design based activity.
8 FUTURE WORK
8.1 FUTURE WORK

Areas of future work stemming from the conclusions of this study are now outlined.

- This study outlines the positive impact that the approach to assessment had on students of technology education on two Initial Teacher Education programmes. Further research is required to investigate if the method can be successfully deployed in the second level schools.

- The findings of this research present the effectiveness of the ACJ assessment model in broadening and developing the personal construct of domain capability. This prompts the need for further research on the potential of the ACJ process to support the continuous professional development of teachers in both the learning and assessment domains.

- The tagging process deployed in this study presents the potential of the holistic interface to provide insight into the cognitive process of the students. Further research and development on the role of the interface in the learning and assessment process should be conducted to optimise the potential to evidence and value student capability.
9 REFERENCES


Bonser, F. G. (1928). "‘The Most Outstanding Next Steps for Curriculum Makers in the United States: A Response by Frederick Gordon Bonser’

" Teachers College Record 30(3): 200 - 204.


Australia Curriculum Studies Association Biennial Conference. University of the Sunshine Coast, Queensland.


McLellan, R. and Nicholl, B. (2009). "'If I was going to design a chair, the last thing I would look at is a chair’: product analysis and the causes of fixation in students’ design work 11–16 years." International Journal of Design and Technology Education.


Robinson, K. (1999). All our futures: Creativity, culture and education, National Advisory Committee on Creative and Cultural Education, DfES.


10 APPENDICES
Outline of lecture discussion topics for WT4302 and PN4012 modules.

Materials

- Material Properties
- Material Selection
- Material Processing

Processing

- Principles of material processing
- Process selection
- Processing technique and best practice
- Health and Safety

Skills

- Physical skills (mastery of craft)
- Intellectual skills
- Communication skills

Design approach

- Process outcomes
- Product outcomes
- Knowledge, Values and Skills
- Technology subject domain
- Technological capability

Assessment

- Purpose and role of assessment
- Impact of assessment on learning
- Developing assessment constructs
- Role of judgement and appraisal
- Valuing quality
- Value of formative feedback

Learning

- Collaboration
- Autonomy
- Problem solving
- Active experimentation
Focus group schedule and topic guide. Outcomes of the focus group discussions were used to inform the structure and content of the research questionnaire.

Statement of Intent:

Project work activity for modules WT4302 and PN4102 employed a comparative pairs assessment methodology where peers self-assessed and ranked the work submitted by the class group. This focus group sets out to examine the factors that may have influenced the response and engagement of students in the activity.

1. Motivation: Can you outline your thoughts on motivation to engage in this activity.
   - The brief (Personalised)
   - Assessment (Holistic)
   - Paired comparison
   - Peer viewing your work

2. Diversity of Response: As a group of students your solutions were diverse. Can you comment on this?
   - Brief
     - Semi-open
     - Holistic criteria
     - Student structured portfolio
   - Confidence
     - Skills building
     - Value of activity
     - Value of your contribution
   - Inspiration
     - Personal theme
     - Ownership
     - Beyond the classroom
3. Confidence in Assessment: The assessment method used holistic comparative pairs assessment. Can you comment on this?
   - Peer assessment
   - Value your contribution
   - Holistic assessment
   - Comparison
   - Aggregation
   - Subjectivity
   - Capability

4. Norm Referenced Assessment: Paired assessment compares you to others. Can you comment on this? How did comparing your work to others impact on you?
   - Personal standards
   - Observed peers
   - Helped peers
   - Learned from peers
   - Fear of losing
   - Desire to win

The focus group discussion can be accessed in Appendix 2 on the accompanying CD.
Thank you for taking the time to complete this questionnaire. The following questions are related to the modules PN4102 and WT4302 that you studied in the second semester of first year. The survey is particularly focused on the design project work activity (flower and scene) that you completed and your engagement in the peer assessment activity that you engaged with using the comparative pairs method of assessment. You will see some images throughout the survey to remind you of the nature of the work produced in the modules. Then you will be presented with a series of questions to be answered. Please answer the questions as honestly as you can based on your personal experience from the modules. All information submitted will only be accessed by the module leaders.

Outline of the infrastructure supporting the capture and communication of your work during the modules

Mobile Phone → Conversion Server → Digital Repository
Some examples of the student work presented at the end of the modules

Please answer the following questions relating to your experiences during the modules PN4102 and WT4102. Comment boxes are provided with each question. If you would like to clarify your response or leave a comment in relation to the content of the question please do so.

1. When working during this project did you initiate discussion/interactions with your peers about your work?

<table>
<thead>
<tr>
<th>Initiating peer discussion</th>
<th>Never</th>
<th>On occasion</th>
<th>Regularly</th>
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**2. From your experience in the project please rate why these discussions/interactions may have occurred.**

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree or disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
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<tbody>
<tr>
<td>To clarify my thinking</td>
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<tr>
<td>To solve a problem</td>
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<td>To find out information</td>
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<tr>
<td>To get help when manufacturing</td>
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<tr>
<td>To help capturing data</td>
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<td>To see if I was going in the right direction</td>
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<tr>
<td>To see what other people were doing</td>
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<tr>
<td>To help me generate some ideas of my own</td>
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<tr>
<td>Other</td>
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<tr>
<td>Other (please specify)</td>
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**3. These discussions/interactions helped me with my progress in the following areas:**

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree or disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
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<tbody>
<tr>
<td>Generating ideas for your project</td>
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<tr>
<td>Deciding on my finished design</td>
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<td>Reporting my project</td>
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<tr>
<td>Research and investigation</td>
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<tr>
<td>Manufacturing stage</td>
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<tr>
<td>Comment if necessary</td>
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</table>

**4. I was confident that discussing my project with my peers was mutually beneficial. (Please rate)**

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutually beneficial</td>
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Please give a reason for your answer


5. Rate the level of peer discussion/interaction relating to the task that took place at the following stages of your project?

<table>
<thead>
<tr>
<th>Stage</th>
<th>Low</th>
<th>Low-Med</th>
<th>Medium</th>
<th>Med-high</th>
<th>High</th>
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</thead>
<tbody>
<tr>
<td>Generating ideas for your project</td>
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<tr>
<td>Agreeing on your finished design</td>
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<td>Reporting your project</td>
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<tr>
<td>Manufacturing stage</td>
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</table>

Please comment if necessary

6. Did you initiate communication with any of your peers to help them with their work?

- Yes
- No

Please explain why you did or did not initiate discussions with your peers about their project work.

7. When I encountered difficulty during my project I found the following approach worked best:

<table>
<thead>
<tr>
<th>Approach</th>
<th>No value</th>
<th>Little value</th>
<th>Not sure</th>
<th>Some value</th>
<th>Very beneficial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solving the problem independently</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussing issues with peers in my lab group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussing issues with peers in my class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussing issues with teaching staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussing issues with friends/family members</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussing issues with others not engaged in the task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please comment if necessary
8. Please rate the value you placed on the following when developing your design solution.

| I experimented with materials and processes based on the principles I was taught. | No value | Little value | Not sure | Some value | Very beneficial |
| I modified a process that I had learned to suit the needs of my project. | | | | | |
| I generally executed the processes I was shown to ensure high quality of output. | | | | | |
| I tried things where I was unsure of their outcomes during the project | | | | | |
| I made mistakes during this design task. | | | | | |
| I learned from making these mistakes. | | | | | |
| I learned from mistakes that were made by my peers during the project. | | | | | |

Please comment if necessary
9. Rate the activity or resource that best supported you in your learning during the project.

<table>
<thead>
<tr>
<th>Activity</th>
<th>No Value</th>
<th>Little Value</th>
<th>Not Sure</th>
<th>Some Value</th>
<th>Very Beneficial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture notes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture discussions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction with teaching assistants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction with technical support staff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab demonstrations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By making mistakes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In class and error</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By taking risks with ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modelling/prototyping my design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discussions with peers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observing other peoples work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finding relevant information on my own</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please comment if necessary

10. I was confident that presenting evidence of mistakes made during the project could show that I had learned during the process.

<table>
<thead>
<tr>
<th>Confidence</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

11. Having completed the modules, rate what you feel is the increase in your level of capability in the following areas.

<table>
<thead>
<tr>
<th>Capability</th>
<th>Small Increase</th>
<th>Small to Moderate</th>
<th>Moderate Increase</th>
<th>Moderate to Significant</th>
<th>Significant Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of materials and processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craft skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem solving ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand the value of craft based education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please comment if necessary
**12. Rate the following based on your experience throughout the project**

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel that the project brief was appropriate to allow me to present my capability in the task.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I developed my processing skills to meet the demands of my project design.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I designed my project to cater for the skill levels I had developed.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I developed my subject knowledge to meet the demands of my project design.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I designed my project around the subject knowledge I had developed in the modules.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please comment if necessary

**13. Rate the following statements based on your experience throughout the project.**

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I was confident that the assessment model would value what I presented as my capability and learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Having to establish my own criteria for what would be assessed in my project had a positive impact on my learning.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was confident that the pair assessment model used in this task would value my work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was confident that as a judge I could make valid judgements on the quality of other students work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would prefer to be given explicit criteria for assessment to guide me during my project.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I was happy that the assessment model for the task would compare my work to other peoples work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Example of the Paired Comparison Judging Interface

**Comparison Info**

Here is where you can add notes about each portfolio. This is also where you decide which is the winner.

<table>
<thead>
<tr>
<th>Portfolio A</th>
<th>Portfolio B</th>
</tr>
</thead>
</table>

**Select Winner**

- Portfolio A is the winner
- Portfolio B is the winner

To return to the current comparison you can:
- Click here
- Press the “Esc” key
- Or click anywhere in the dark border region outside this dialogue

*14. From your experience rate the following comments on the impact of the paired comparison method of assessment on your work during the course of the project*

<table>
<thead>
<tr>
<th>Comment</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>It wasn't the most important thing for me</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It encouraged me to share my ideas</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It made me want to find out what others were doing</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It created competition within my peer group</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It motivated me to demonstrate high levels of skill</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It motivated me to work hard</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It made me clarify my thinking about my work and capability.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It motivated me to come up with something unique in my project</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It influenced how I communicated my work in my portfolio</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
**15. Rate the impact that being assessed by your peers had on you during the project**

<table>
<thead>
<tr>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>It changed the way I thought about my approach to the task.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It made me interact more with peers during the task activity.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It made me think about how best to communicate my work through the electronic portfolio.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It motivated me to come up with something new and innovative in my project.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It motivated me to impress the person assessing my portfolio.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It created a relaxed atmosphere in the module.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>I was confident that my work would be valued by the group of judges.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It was important to me that the person(s) judging my work had gone through the same process as me and could empathise with my situation.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>It made me feel part of a group.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>

Please comment if necessary

---

285
16. Explicit assessment criteria or reporting guidelines were not given to you for this task.
Rate the following statements relating to assessment criteria for the modules:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>This allowed me to be free to explore a wide range of solutions to the brief</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>It made me think about what capability in this subject is.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>It made me take responsibility for my learning</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>It made me focus on the key elements of my work that should be presented in my design portfolio</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>It made me question what I was thinking and doing</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Please comment if necessary
17. Rate the following statements that relate to the democratic assessment model used in these modules.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large groups of assessors will give a more accurate assessment of the quality of my work.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I would prefer if only one person assessed my work.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Having a large group of assessors allowed me more freedom to be creative.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Having a large group of assessors made me feel confident that what I valued in my design solution would be recognised and rewarded.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I was confident that class group could produce a valid assessment of the work produced.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>It was important that the system was capable of monitoring the performance of the judges assessing the portfolios.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I was confident that module leaders would fairly apply the grade boundaries once the rank order of work was produced by the paired judging session.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Please comment if necessary
**18.** Having completed your judgements in the paired judging session please rate the following statements:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>This broadened my understanding or capability</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have learned about my strength and weaknesses</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have re-evaluated my own performance in the module as a result of judging other peoples work</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I always used the same criteria to judge the portfolios</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>My criteria for judging a portfolio depended on the portfolio it was up against</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Completing the judging session was a valuable educational experience</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Please comment if necessary

Example of the tagging process used in the electronic portfolios:  

![Image of a tagging process in an electronic portfolio]

- Pane Number
- Pane Title
- Tagging Bar
- Post text
- Posted Image
- Posted Sketch
- Posted Video
- Rating: Rating, Growing, Proving
19. Rate the following in relation to the tagging process used in the electronic portfolio

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tagging made me think about what I was doing throughout the task</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Tagging helped me structure my portfolio at the end</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Tagging helped me focus when making judgements in the paired comparison</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>session</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Tagging helped me see the value in my work</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

20. Rate the following statements in relation to these modules

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The design task was appropriate for the development of the skills that are relevant to teaching in second level schools.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Engaging in this design task was beneficial to me.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>This task made me think about my subject area in a new light.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>The overall approach to these modules helped me develop my own personal value for this subject area.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Please comment if necessary
21. Which of the following categories would best describe your theme and inspiration for your design project? (You can select more than one box if necessary)

<table>
<thead>
<tr>
<th>Your theme</th>
<th>Your inspiration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Something that was conceived from personal experience</td>
<td></td>
</tr>
<tr>
<td>Something that related to personal interest, hobby etc</td>
<td></td>
</tr>
<tr>
<td>Used an external reference that evoked a feeling or emotion (personal connection)</td>
<td></td>
</tr>
<tr>
<td>External inspiration from an object, graphic, situation etc.</td>
<td></td>
</tr>
<tr>
<td>(no personal connection)</td>
<td></td>
</tr>
</tbody>
</table>

Describe the theme/focus of your project

22. Please rate the following comments based on your experience during the project

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I was able to be creative in this project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I took ownership of this project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I enjoyed learning during this project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I learned a lot about myself during this project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am proud of the work I created during this project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>This project changed my views on teaching in this subject area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My confidence in my ability is higher as a result of this project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My ideas were not restricted in this project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

23. Identify and comment on the most significant aspect of the approach taken with this project that impacted on your learning

24. ID Number
25. Please select the year in which you completed these modules

- 2009 (4th Years)
- 2010 (3rd Years)
- 2011 (2nd Years)

Year of participation in modules

Thank you for taking the time to complete this questionnaire.
Your contribution is valued and appreciated.
The following graphs present the portfolio parameter value error plots for the Rank 1 (Architectural) judging session from round 19 to round 1 of the judging session.
(ROUND 17)

Parameter value error plot

(round 16)

Parameter value error plot

(round 15)

Parameter value error plot
Parameter value error plot

(ROUND 14)

Parameter value error plot

(ROUND 13)

Parameter value error plot
Parameter value error plot

(ROUND 1)
The following graphs present the parameter value error plots for the Rank 2 (Engineering) judging session Round 1 to Round 16.
APPENDIX 6

Descriptive statistics for Rank 1 and Rank 2 from Year 1 of the study can be located in the Appendix 6 folder on the accompanying CD.
APPENDIX 7

The parameter value error plots for Year 2 rank can be located on the e-scape data base using the following guide.

Web link: http://escape.maps-ict.com/exec/eab/login/

Username: Contact Principal Investigator

Password: Contact Principal Investigator

Complete the following actions to access the parameter value error plots for the Year 2 rank.

On the top toolbar click on “specs”

Then in Spec Options click on **judgement sessions**

Click on select this series on the right hand side (click on the top series)

Scroll to the following judging session: Flower Task 2010

Click on **19 rounds concluded** on the right hand side:

Click on **show graphs** for round 19 at the top of the judging list:

Scroll to view the parameter value error plots for the 19 estimation rounds
APPENDIX 8

Descriptive statistics for the Year 2 rank can be located in the Appendix 8 folder on the accompanying CD.
APPENDIX 9

Judging history of the top 8 portfolios on the Year 2 rank can be located on the e-scape data base using the following guide.

Web link:  http://escape.maps-ict.com/exec/eab/login/

Username:  Contact Principal Investigator

Password:  Contact Principal Investigator

Complete the following actions to access the parameter value error plots for the Year 2 rank.

On the top toolbar click on “specs”

Then in Spec Options click on judgement sessions

Click on select this series on the right hand side (click on the top series)

Scroll to the following judging sessions: Flower Task 2010

Click on 19 rounds concluded

Then click on full details for round 19
This interface has the portfolios listed in the rank order of that judging session.

Click on the portfolio link to access the portfolio.

Click on the judge history to view the judging comments.

Click on the rank order history to follow the portfolio rank order movement throughout the judging sessions.

Video and audio files in the student portfolios are best played using the Firefox web browser and Flash Player 10 or updated equivalent.
APPENDIX 10

Descriptive statistics for Rank A, Rank B and Rank C from Year 3 of the study can be located in the Appendix 10 folder on the accompanying CD.
APPENDIX 11

The parameter value error plots for Year 3 Rank A, Rank B and Rank C can be located on the e-scape data base using the following guide.

Web link: http://escape.maps-ict.com/exec/eab/login/

Username: Contact Principal Investigator

Password: Contact Principal Investigator

Complete the following actions to access the parameter value error plots for the Year 2 rank.

On the top toolbar click on “specs”

Then in Spec Options click on judgement sessions

Click on select this series on the right hand side (click on the top series)

Scroll to the following judging sessions:

- Flower Test 2011 (Group 1) gives details of Year 3 Group A
- Flower Test 2011 (Group 2) gives details of Year 3 Group B
- Flower Test 2011 (Group 3) gives details of Year 3 Group C

Click on the rounds concluded for the judging session on the right hand side:

Click on show graphs for the round at the top of the judging list:

Scroll to view the parameter value error plots for the estimation rounds.
Descriptive statistics for the Expert judging session can be located in the Appendix 12 folder on the accompanying CD.
APPENDIX 13

Graphs of responses to the ACJ qualitative questionnaire.

Q.1 When working during this project did you initiate discussion/interactions with your peers about your work?

Q.2 From your experience in the project please rate why these discussions/interactions may have occurred.

(a) To Clarify My Thinking

(b) To Solve a problem
Q.2 From your experience in the project please rate why these discussions/interactions may have occurred.

(c) To Find out Information

(d) Get help when manufacturing

(e) To get help capturing data
Q.2 From your experience in the project please rate why these discussions/interactions may have occurred.

(h) To help generate ideas

Q.4 I was confident that discussing my project with my peers was mutually beneficial. (Please rate)

(a) Peer discussion mutually beneficial

Q.6 Did you initiate communication with any of your peers to help them with their work? (1=Yes 2=No)

Discussion initiation to help peers
Q.11 Having completed the modules, rate what you feel is the increase in your level of capability in the following areas.

(a) Knowledge of materials and processing

(b) Craft skills

(c) Design skills
Q.11 Having completed the modules, rate what you feel is the increase in your level of capability in the following areas.

(d) Problem solving ability

(e) Understand the value of craft based education

Q.12 Rate the following based on your experience throughout the project

(d) I developed my subject knowledge to meet the demands of my project design
Q. 13 Rate the following statements based on your experience throughout the project.

(b) Having to establish my own criteria for what would be assessed in my project had a positive impact on my learning

Q. 14 From your experience rate the following comments on the impact of the paired comparison method of assessment on your work during the course of the project

(a) It wasn’t the most important thing for me

Q. 14 From your experience rate the following comments on the impact of the paired comparison method of assessment on your work during the course of the project

(e) It motivated me to demonstrate high levels of skill
Q. 14 From your experience rate the following comments on the impact of the paired comparison method of assessment on your work during the course of the project

(f) I motivated me to work hard

Q. 15 Rate the impact that being assessed by your peers had on you during the project

(b) It made me interact more with peers during the task activity

Q. 16 Explicit assessment criteria or reporting guidelines were not given to you for this task. Rate the following statements relating to assessment criteria for the modules:

(a) This allowed me to be free to explore a wide range of solutions to the brief
Q.16 Explicit assessment criteria or reporting guidelines were not given to you for this task. Rate the following statements relating to assessment criteria for the modules:

(b) It made me think about what capability in this subject is

Q.16 Explicit assessment criteria or reporting guidelines were not given to you for this task. Rate the following statements relating to assessment criteria for the modules:

(c) It made me take responsibility for my learning

Q.17 Rate the following statements that relate to the democratic assessment model used in these modules.

(a) Large groups of assessors will give a more accurate assessment of the quality of my work
Q.17 Rate the following statements that relate to the democratic assessment model used in these modules.

(b) I would prefer if only one person assessed my work

Q.18 Having completed your judgements in the paired judging session please rate the following statements:

(a) This broadened my understanding of capability

Q.18 Having completed your judgements in the paired judging session please rate the following statements:

(c) I have re-evaluated my own performance in the module as a result of judging other peoples work
Q. 18 Having completed your judgements in the paired judging session please rate the following statements:

(f) Completing the judging session was a valuable educational experience

Q. 20 Rate the following statements in relation to these modules

(c) This task made me think about my subject area in a new light

Q. 20 Rate the following statements in relation to these modules

(d) The overall approach to these modules helped me develop my own personal value for this subject area
For a full range of graphs for all question responses to the questionnaire please refer to the Appendix 13 file on the accompanying CD.
Mean Score response to question 8 from qualitative questionnaire

**Student Value of Active Experimentation**

- Experimented
- Modified Processes
- Used what I was shown
- Took risks with ideas
- I made mistakes
- Learned from Mistakes
- Learned from Peer Mistakes

**Question Categories**

**Category Score**

1. 0
2. 1
3. 2
4. 3
5. 4
6. 5

**Mean Score**
The following is an excerpt taken from the national assessment of Junior Certificate Technology 2011. This is presented in the “Instructions to candidates” section of the design task assessment document.

**Technology - Design Tasks**

Information for examination candidates:

A simple model of a design process is shown below. It is recommended that you follow the logical sequence of this design process and that evidence of each stage is reflected in your design folder. Shading and colour (pencils etc.) should be used where appropriate in your design folder.

(Source: SEC 2011)
The following is copy of the national assessment of Leaving Certificate Technology 2012.

Leaving Certificate Examination 2012

Technology

Coursework Briefs

Ordinary Level and Higher Level

200 marks

The Thematic Briefs for the Leaving Certificate Examination 2012 are given overleaf.

The Coursework must be available for assessment by Friday 30th March 2012.
Leaving Certificate Technology

Ordinary Level and Higher Level 2012

Instructions to candidates:

1. The coursework submitted for assessment must consist of two components:
   • a design folio and
   • an artefact.

2. If either assessment component (written examination or coursework) is submitted at Ordinary Level, the subject is graded at Ordinary Level.

3. All coursework submitted for assessment must be clearly identified with your examination number.

4. The coursework submitted for assessment must be your own individual work and must be completed in school under the supervision of the class teacher.

5. The design folio should record all stages of your work and should document how the artefact meets the stated thematic brief.

6. When using research sources, including the Internet, the sources must be acknowledged. Research material copied directly from the Internet or from other sources and presented as your own work will not receive any marks.

7. The coursework should display knowledge and skills developed through your study of the core and chosen options.

8. All important operating features of the artefact must be clearly visible and be easily accessible without dismantling.

9. Where an electrical supply is used to operate the artefact, it should be of low voltage output. Where specialised equipment is required, it must be set up by you, have clear operating instructions and be ready to use.

10. The coursework presented for assessment must be displayed in an attractive manner. Multimedia presentations, where submitted, must be of maximum 3 minutes duration, must be set up by the candidate and must be ready for viewing.

The coursework must be available for assessment by Friday 30th March 2012.
**Thematic Brief:**

Many factors influence our choice of destination when going on holiday. These include value for money, climate, landscape, hospitality, culture and an awareness of the local attractions on offer. Following the downturn in the Irish economy in recent years, there is an increasing need to promote Ireland as a tourism destination to both the domestic market and to foreign visitors. Many economists suggest that tourism will be a vital component in Ireland’s economic recovery into the future.

*In this context, design and make a model of an interactive advertisement display which promotes a local tourism destination of your choice. Dynamic in design, this display should stimulate interest and encourage tourists to visit your chosen attraction. The display should be attractive, incorporate a mechanical and/or electronic system and should also be well presented.*

**Note:** The maximum dimension of the artefact you present for assessment should not exceed 500 mm. If multimedia presentations are used to *enhance* your display, a hardcopy printout and a CD must be included in your portfolio.

Coursework at Ordinary Level is weighted as follows:

- Design Folio - 40% of marks
- Artefact - 60% of marks

**Total - 200 marks**
### Design Folio - Ordinary Level - 30 marks

<table>
<thead>
<tr>
<th>No.</th>
<th>Heading</th>
<th>Description</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analysis, research and investigation</td>
<td>Analysis of thematic brief. Research into chosen area. Analysis of existing solutions.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Overall management of the project</td>
<td>Analysis of available resources, time and budget constraints; proposed timeframe etc.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Environmental impact</td>
<td>Impact of materials and production processes; product use; suitability for reuse/recycling</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>Design ideas and selection of optimum solution</td>
<td>Annotated sketches and drawings outlining three possible solutions. Optimum solution identified and justified.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sketches and drawings for manufacture</td>
<td>Detailed annotated sketches and drawings including all elements/aspects of solution; circuit diagrams/flowcharts/models/prototypes/dimensions/scale/assembly details.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Production planning</td>
<td>Materials and component lists; scheduling, work breakdown, structure, costing.</td>
<td>40</td>
</tr>
<tr>
<td>7</td>
<td>Product realization</td>
<td>Sequence of manufacture including photographic record.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Evaluation and testing</td>
<td>Testing against chosen brief. Evaluation of final artefact. Comparison of planned schedules and actual schedules. Suggested modifications with justification.</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>Presentation and ICT</td>
<td>Correct sequence of presentation. Quality of material presented. ICT skills in production of folio.</td>
<td></td>
</tr>
</tbody>
</table>

### Artefact - Ordinary Level - 120 marks

<table>
<thead>
<tr>
<th>No.</th>
<th>Heading</th>
<th>Description</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Artefact meets theme &amp; specification</td>
<td>Solution presented meets the thematic brief and specifications.</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>Creativity</td>
<td>Creativity in design, aesthetics &amp; ergonomics.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creativity in use of material.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Production skills</td>
<td>Processing of materials. Assembly of materials and components. Range and depth of skills.</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>Functionality</td>
<td>Artefact works well. Appropriate limited use of commercial components/solutions.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Quality and finish</td>
<td>High quality manufacture. Artefact well finished. Due regard for health and safety.</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>Presentation</td>
<td>Coursework well presented. Parts well integrated and labelled where appropriate.</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** While the general headings and marks above will largely remain the same, breakdowns may vary depending on the actual brief for any given year.
Leaving Certificate 2012 - Higher Level

Thematic Brief:

“Over a billion people, about 15% of the world's population, have some form of disability” (World Health Organisation, Fact Sheet No. 352, June 2011).

Disability is an umbrella term, covering impairments, activity limitations, and participation restrictions. An impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations. Thus disability is a complex phenomenon, reflecting an interaction between features of a person’s body and features of the society in which he or she lives.

Society has a duty to ensure that people with disabilities are given the best quality of life possible through enhanced independence and dignity. Advancements in assistive technologies have helped to minimise the effects of disability for many people. In this context, design and make a model of a technical aid or appliance that could help a person with a disability to live independently in the home, workplace, public area or other context of your choice. Your solution should include electro-mechanical movement in operation and should also be well presented.

Note:

- The maximum dimension of the artefact you present for assessment should not exceed 500 mm.

Coursework at Higher Level is weighted as follows:

- Design Folio - 50% of marks
- Artefact - 50% of marks

Total - 200 marks
### Design Folio - Higher Level - 100 marks

<table>
<thead>
<tr>
<th>No.</th>
<th>Heading</th>
<th>Description</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Analysis of thematic brief</td>
<td>Evidence of research of the broader context of the theme. Specification of chosen parameters.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Overall management of the project</td>
<td>Analysis of available resources, time and budget constraints, proposed timeframe/Gantt chart, etc.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Environmental impact</td>
<td>Demonstration of environmental awareness during design and realisation. Analysis of materials chosen for manufacture. Consideration of energy requirements, reuse/recycling etc.</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>Research, investigation and specifications of brief</td>
<td>Further research into chosen area. Analysis of existing solutions. A statement outlining the candidate's final brief and related specifications.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Design ideas and selection of optimum solution</td>
<td>Annotated sketches and drawings outlining three possible solutions. Optimum solution identified and justified.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Sketches and drawings for manufacture</td>
<td>Detailed annotated sketches and drawings including all elements/aspects of solution, circuit diagrams/flowcharts/models/prototypes/dimensions/scale/assembly details.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Production planning</td>
<td>Materials and component lists; costing; scheduling; work breakdown structure, Gantt charts, critical path diagrams.</td>
<td>35</td>
</tr>
<tr>
<td>8</td>
<td>Product realisation</td>
<td>Sequence of manufacture including photographic record.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Presentation and ICT</td>
<td>Correct sequence of presentation. Quality of material presented. ICT skills in production and presentation of folio.</td>
<td>15</td>
</tr>
</tbody>
</table>

### Artefact - Higher Level - 100 marks

<table>
<thead>
<tr>
<th>No.</th>
<th>Heading</th>
<th>Description</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Artefact meets theme and specifications</td>
<td>Solution presented meets the thematic brief and specifications as identified by the candidate</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Originality and creativity</td>
<td>Originality and creativity in design, aesthetics and ergonomics. Creativity in use of materials.</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>Production skills</td>
<td>Processing of materials. Assembly of materials. Range and depth of skills.</td>
<td>45</td>
</tr>
<tr>
<td>4</td>
<td>Functionality</td>
<td>Artefact works well. Appropriate/limited use of commercial components/solutions.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Quality and finish</td>
<td>High quality manufacture. Artefact well finished. Due regard for health and safety.</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>Presentation</td>
<td>Coursework well presented. Parts well integrated and labelled where appropriate.</td>
<td></td>
</tr>
</tbody>
</table>

Note: While the general headings and marks above will largely remain the same, breakdowns may vary depending on the actual brief for any given year.