AC 2012-4431: THE VALUE OF TRANSFER ACTIVITIES WHEN DEVELOPING TECHNOLOGICAL KNOWLEDGE AND SKILLS

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Patrick Rowsome's research areas/interests include the transfer of learning in technology education, pedagogical strategies within technology education, creativity and innovation within technology education, and social constructivism. At present, he is investigating the value of transfer activities in a workshop based context in developing skill and knowledge. This research area involves developing a strategy to facilitate transfer activities and how this can enhance the transfer from context to context. The research aims to identify the key elements needed to design and implement an efficient pedagogical strategy to promote design and innovation.

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The Value of Transfer Activities when Developing Technological Knowledge and Skills

Abstract

The heritage of many post-primary engineering curricula is grounded in the development of craft and vocational education. In recent years the consensus of policy makers and educators internationally has centred on developing a broader skill-set that includes design, innovation, and creativity. The need to understand the physical properties of materials, the ability to select and execute appropriate processes, and implement effective manufacturing systems still forms the core of engineering education. The nature and purpose of engineering education demands that students acquire specific technical content knowledge and develop practical skills in the context of a collaborative student centred environment applying knowledge and skills in an innovative and creative way.

This study attempted to elicit the critical variables that scaffold design and creativity by using the divergent nature of decorative metal craft to explore the relationship between the 'transfer' of newly acquired knowledge and skills with students' performance in a design based activity. In this study, 140 students in initial teacher education at the 'University of Limerick' completed four transfer activities. The pedagogical approach to the activities reflected the stages of Kolb's theoretical learning cycle [1], where students (n= 140) observed a demonstration of a skill (concrete experience), reviewed technical details (reflective observation), transferred information into a new design idea (abstract conceptualisation) and then produced an artefact (active experimentation). The degree of transfer from the demonstration to the student's new design was assessed by seven subject experts.

The findings showed that there was a diverse response to the activities. At first it was difficult to distinguish between the diverse responses so the expertise of the subject experts was employed to help decide the level of transfer for each artefact. However some students merely mimicked what they were shown while others pushed the level of their understanding and experimented to explore the boundaries of their capability. This aligns with the constructivist belief that knowledge is not transmitted but constructed through hands on activities or personal experience which generates knowledge. It was also found that certain activities allowed for a greater depth of experimentation than others. This has an impact on the pedagogical approach taken by educators and highlights the importance when allowing students to experiment when constructing new meaning.

Background

In the Republic of Ireland there has been a shift in technology education from traditional craft based approach to a design based approach. Irish technical education has been described as having a "craft-orientated approach" with a possible movement towards a "design approach" in some subjects [2]. This has come about in an effort to prepare second level students for the future with skills and knowledge that will be adaptable to the changing needs of Irish society. This sentiment is shared by policy makers and educators as their aim is to contribute to a balanced education, for students giving them a broad and challenging experience that will enable them to acquire a body of knowledge, understanding, problem solving skills and competencies and so prepare them to be creative participants in a technological world.

Design has become an essential aptitude for personal fulfilment and professional success [3]. With the recent introduction of two new syllabi in Leaving Certificate Technology Education (final year exam of second level) it shows a shift of emphasis to a more design based approach. Williams outlines that there are those who propose that a range of manipulative skills and materials understandings should be mastered by students before they proceed to engaging in design [4].At the core of engineering curricula are those key aspects. But in more recent times there has been a greater need for design and innovation. This paper examines the use of 'transfer activities' which allows for innovation and exploration while still developing the key skills and knowledge.

Transfer of Learning

Transfer of learning is widely known as the ultimate aim of education [5]. The 'transfer' of knowledge and skill is paramount to any design education student. The development of craft and processing skills are still upheld through the heritage of most second level engineering subjects. In Irish technical education, engineering based design manifests in the Leaving Certificate (final year exam of second level) subject 'Engineering'. Historically Ireland's technical education can be traced back to 1930, where the emphasis was on preparing students with the vocational skills required for an apprenticeship. Some commentators have remarked on the prevailing pedagogical practices of the past saying that the didactic tradition has inhibited more innovative, creative, problem-solving attitudes among school-leavers [6]. Such a focus on the transmission of knowledge meant there was no allowance for exploration and experimentation. Some would argue that this didactic transmission model of teaching still exists today [7]. Similarly in the US in 1917, the Vocational Act was the first time the federal government became involved in supporting training in fields relating to engineering education at secondary level [8]. The main aim of this intervention was to prepare students for a career in engineering. In New South Wales, Australia, the subject Engineering Studies '*develops knowledge and understanding of the profession of engineering*'[9].

Transfer of learning can be defined as the influence of previously learned skills on the learning and performance of other skills with common elements. It occurs when learning in one context or with one set of materials impacts on the performance in another context or with other related materials [10, 11]. Transfer includes *'near transfer'* (to closely related contexts and performances) and *'far transfer'* (to rather different contexts and performances). Transfer is crucial to education, which generally aspires to impact on contexts quite different from the context of learning. It entails connecting past learning to new situations, all transfer, therefore, entails transfer of learning. There is no defined scale of near and far transfer in the context of technical education. Also it would suggest that it is crucial to find the most suitable pedagogical approach which best enhances the transfer of learning. It is now known that our knowledge base plays a central role in our cognitive processes [12]. Researchers have demonstrated that the absence of an appropriate knowledge base, not their developmental stage, is primarily responsible for young children's failure to transfer [13]. Also, the learners become accustomed to using their newly acquired knowledge and skills in novel situations, thus encouraging transfer of learning to the task [14]. By nature of their applied interest, educationalists' main concern has been less with the question of how transfer takes place, and much more with under what conditions it happens, or if it happens at all. This study examines the impact of a wide variation of procedural tasks on student's ability to transfer skills and knowledge learned from tasks and the impact they have on tasks in a similar context.

Decorative metal craft

Decorative metal craft activities are divergent in nature and allow for quite a unique opportunity for exploration. It forms part of the Irish Junior Cycle Metalwork* curriculum [15]. The general consensus of educators is that we need to promote divergent thinking amongst students. This is what De Bono calls lateral thinking [16]. Divergent thinking is helped by exploration as it allows for more than one single possible solution. Current practices in Irish second level do not allow for tasks that are divergent or open ended. They are bound by the assessment criteria and pedagogical practices which are convergent by nature. They allow students the scope to investigate the strengths and limitations of materials and develop and hone key processing skills. This domain specific knowledge is vital along with the procedural knowledge to enhance the transfer of learning. The New York State Centre for Advanced Technology Education "proposes the development of prerequisite skills and knowledge before the design process is utilized" [17]. Petroski believes that design should be taught early in their engineering education to grasp an understanding of procedural knowledge [18]. It was deemed by the facilitators to front load students with the key skills and knowledge before engaging in the design project. Therefore, in the Irish context it is important to look at the use of transfer activities in a workshop setting. The next section will outline how the activities were designed and carried out in the workshop. As outlined above there is a need for students to be able to transfer knowledge and skill to new situations. With this students must first develop an appropriate declarative and procedural knowledge base to enhance their transfer ability.

Method

Approach

Based on the review of the literature and the deficiencies outlined the study was set up to examine the value of transfer activities when developing key skills and knowledge in decorative metal craft. A set of four transfer activities were set up and took place in a practical workshop setting. The activities were set up to elicit the key skills and knowledge needed to be developed by students in initial teacher education. The constructivist approach taken to the activities aimed to build on students' prior knowledge to help enhance their declarative and procedural knowledge and apply it to new situations.

Participants

A stratified sample [19] of the entire cohort was taken. This represented the selection of 25 students out of a total of 140. This was deemed as a representative sample of the group due to the artefacts completed from each participant.

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*Junior Cycle Metalwork take place from years 1-3 in second level. It is an optional subject. Pupils would range from ages 12 to 15.

The sample represents a proportional amount of mature students (over 23 year olds) and CAO entrants (students who came directly from second level).The participants were first year undergraduates in a four year concurrent Technology teacher education programme. These participants would have varying degrees of ability and knowledge in the area of decorative metal craft. Some would have studied Engineering subjects in second level education, others having not studied the subject at all. Although some may have studied other Technology subjects such as Materials Technology (Wood), Technical Graphics, Technology, etc.

Design of Transfer Activities

Participants were given a set of four practical activities covering a range of decorative metalwork processes (Figure 1). A workshop matrix was set up and the students were assigned to four different subgroups. An activity was completed by each subgroup each week over a three hour period and by the end of the fourth week all participants had completed all four activities. The activities were designed to develop fundamental knowledge and skill in the subject discipline. The development of specific manufacturing skills and knowledge about specific materials and the properties of such materials are fundamental topics in the syllabus. The skills employed cover the broad range of decorative metalwork skills as outlined in the Junior Cycle Metalwork syllabus [15]. This includes such processes as hot and cold forming of metals, i.e. scrolling and twisting, hollowing, planishing, etc. The transfer activities are described in Figure 1.

Conducting Activities

The transfer activities were set up to reflect Kolb's theoretical learning cycle where students observed a demonstration of a skill (concrete experience), reviewed technical details (reflective observation), transferred information into a new design idea (abstract conceptualisation) and then produce an artefact (active experimentation).

1. Each subgroup received a demonstration averaging ten minutes on each process.
2. After they were shown the processes they were then assigned the activity. Students were encouraged not copy or mimic what they have seen in the demonstration. Clear instruction was given to participants that these were specifically skills development tasks and no grades would be assigned, however they had to complete these tasks to progress on to the end of term project.
3. For the remainder of the three hour period the students were left to produce the artefact. They were encouraged to collaborate with their group members on their design ideas.

Evaluating Artefacts

The opinions of seven subject experts in the area of metal craft were considered on the assessment of the artefacts. These experts have an extensive depth of the knowledge and understanding in the skills involved in decorative metal craft. They are actively involved in teacher education of the subject area. Experts were exposed to a representative sample of the complete artefacts and they were asked to rate from one to ten the level of transfer away from what they were shown compared to the finished artefact. A consensus was drawn on the rating of the artefacts.

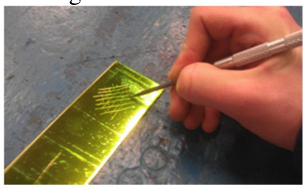
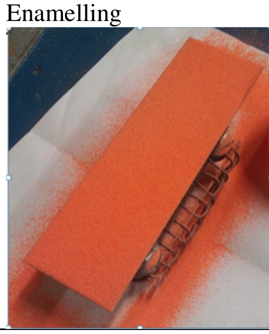
Activity	Processes Demonstrated	Materials	Description
Activity 1 Engraving	Etching 	Sheet copper and sheet brass	Etch a piece of copper of given dimension using the processes shown and etch to the desired depth using the etching bath.
Activity 2 Enamelling	Enamelling 	sheet copper	Enamel a piece of copper of a given dimension using the processes demonstrated
Activity 3 Candle Holder	Scrolling  Twisting 	Flat mild steel	Create a decorative candle holder capable of accommodating one or more candles, by using the process shown
Activity 4 Copper Wristband	Beaten metalwork 	sheet copper	Design a decorative wristband using the skills demonstrated.

Figure 1- Description of Transfer Activities

This was quite subjective as the experts were asked to rate the transfer away from what the student were shown, based on the criteria of one meaning near transfer (mimicry of what they were shown) or ten meaning far transfer.

A sample of 25 participants work was taken with four artefacts per student, resulting in one hundred artefacts being rated. The average rating for each artefact was recorded. The findings of this are discussed in detail in the next section.

Findings

The transfer activities were rated from one to ten by the seven subject experts and these data were subsequently analysed by the researcher. An average was calculated for each individual student and their artefact (Table 1). These averages were then sorted into categories of each activity, copper wristband, enamelling, etching and candle. The distributions of scores for each activity are presented in Figure 1. Table 2 shows the average rating across the seven experts given to each individual artefact and the mean score for each student across the four activities. The mean score of individuals will be looked at in more detail later in this section.

Table 1 - Student Transfer Ratings

Student	Etching	Enamelling	Candle	WB	Mean
1	3.7	3.6	4.6	4.7	4.1
2	3.6	2.1	4.9	5.9	4.1
3	7.7	5.1	6.4	3.0	5.6
4	7.3	4.7	4.9	3.7	5.1
5	4.1	4.4	4.7	6.7	5.0
6	6.6	5.0	5.3	6.9	5.9
7	5.4	3.9	4.6	4.1	4.5
8	4.0	5.6	4.7	6.0	5.1
9	6.7	3.3	4.7	6.7	5.4
10	6.9	5.3	4.7	5.6	5.6
11	5.9	5.4	5.0	6.1	5.6
12	3.7	4.5	5.1	4.1	4.4
13	5.7	3.3	4.1	5.0	4.5
14	7.4	4.9	5.3	4.4	5.5
15	4.4	3.3	4.6	8.3	5.1
16	6.0	5.9	6.0	4.9	5.7
17	6.4	5.1	5.4	5.3	5.6
18	2.7	3.1	3.9	3.3	3.3
19	4.6	5.3	4.7	5.1	4.9
20	5.3	3.7	4.4	3.9	4.3
21	5.6	4.9	5.4	4.1	5.0
22	7.4	6.3	5.6	4.3	5.9
23	5.4	2.9	3.7	4.0	4.0
24	5.4	4.3	4.3	7.1	5.3
25	4.0	5.0	3.4	3.9	4.1

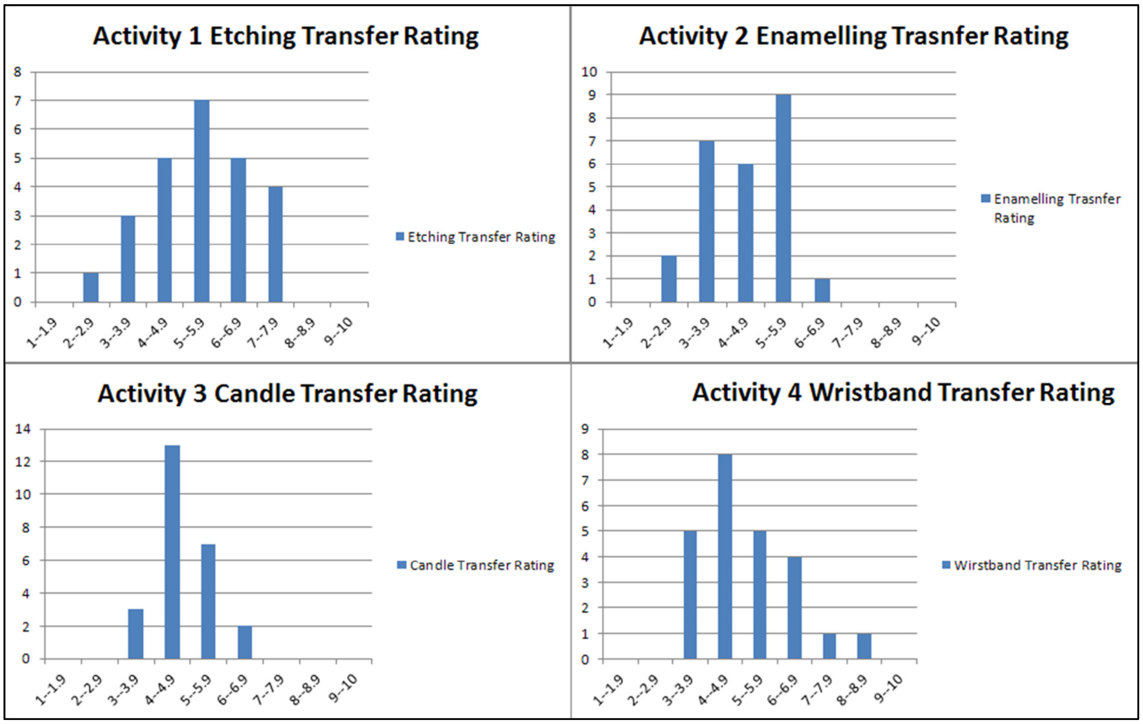


Figure 2 - Distribution of Ratings

Table 1 - Mean and Standard Deviation for each Transfer Activity

Transfer Activity	Activity 1	Activity 2	Activity 3	Activity 4
Mean (n=25)	4.43	5.43	4.82	5.09
StDev ±	1.05	1.41	0.68	1.34

In table 3, the lowest standard deviation was for the Activity 3 (0.68) compared to the Activity 2 (1.41). Activity 4 (1.34) had the second highest with Activity 1 the third highest (1.05). This suggests that there was a greater range of transfer in Activity 2 compared to the other activities. This can also be seen in figure 2 where more students transferred further away from what they were shown in the activity four with six students receiving a rating of 6 or higher compared to the two students in the Activity 3.

While investigating the individual students and their artefacts a qualitative approach was taken. Each activity was divided up into three categories (Table 4) and sample artefacts were examined from each. In the activities the ratings were broken up into three categories to show varying degrees of transfer.

Table 2 - Rating Categories

Transfer Categories	1	2	3
Transfer Ratings	1-3.9	4-6.9	7-10

Presented in Figures 2, 3 & 4 are the responses of three students across the four activities. Student 22 had one of the highest mean scores of 5.9 (Table 5) across the four activities. Student 13 rated 4.5 (Table 6) while student 18 had a mean of 3.3 (Table 7) over the four tasks. From the researchers observations during the activities his judgement of student's application would align with the subject experts' ratings. Student 22 appeared quite interested and very engaged during the activities. It appeared that he explored the potential of the processes learned and also tried to gauge the strengths and limitations of it. Transfer took place a across his four activities to a greater extent than Student 13 and 18.

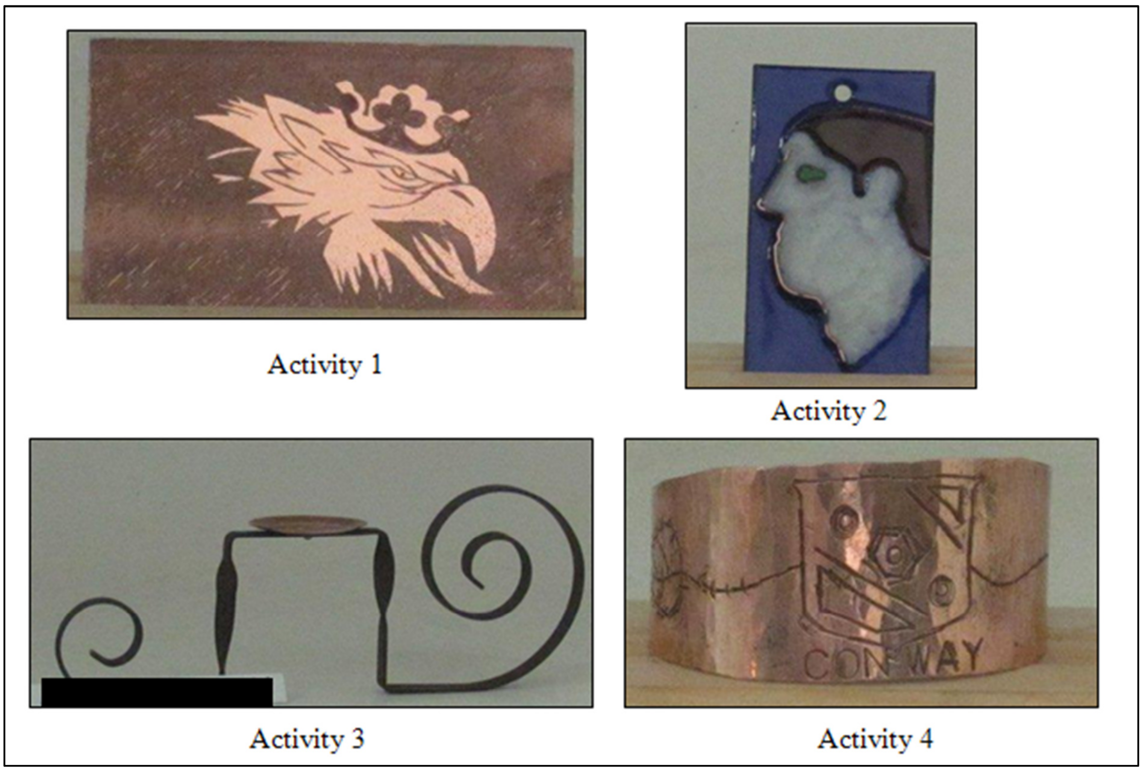


Figure 3 - Student 22 Transfer Activities

Table 3 - Student 22 Ratings

Name	Activity 1	Activity 2	Activity 3	Activity 4	Mean
Student 22	7.4	6.3	5.6	4.3	5.9

It cannot be definitively inferred if this was due to the individual's innate ability to transfer or was an effect of the activities. This will be discussed in greater detail in the discussion section of the paper. From the evidence presented for student 18 and the observations made in the workshop, it is clear that their transfer could be described as near. The observations made would suggest that while they may have engaged in the activity at the minimum level as possible to merely complete the tasks. It was clearly outlined to them that they would not be receiving any grade for the task, it was just required that the tasks be completed. This may have acted as a demotivating factor in the student to fully engaging.

Comparing the three students across individual activities, it is evident in the activity one that there is clear distinction of near and far transfer ratings from student 18 (2.7) to student 13 (5.7) and to student 22 (7.4). The same is evident across in the Activity two and three. Activity four was somehow different from the other three. Student 13 (5.0) performed more transfer than student 22 (4.3).

Figure 4 - Student 13 Transfer Activities

Table 4 - Student 13 Ratings

Name	Activity 1	Activity 2	Activity 3	Activity 4	Mean
Student 13	5.7	3.3	4.1	5.0	4.5

An inference is made that the other three activities lend themselves more to transfer than the wristband activity. It should also be noted that the etching activity was more open-ended than the wristband activity.

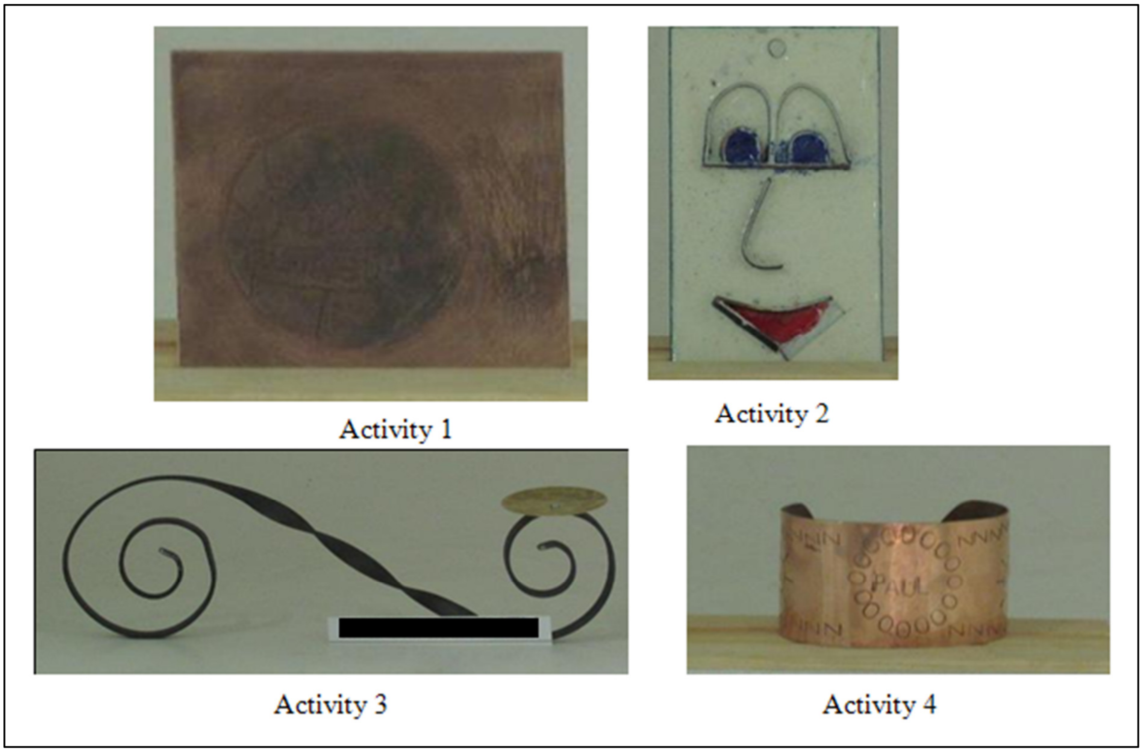


Figure 5 - Student 18 Transfer Activities

Table 5 - Student 18 Ratings

Name	Activity 1	Activity 2	Activity 3	Activity 4	Mean
Student 18	2.7	3.1	3.9	3.3	3.3

Discussion

With no rating scale of near and far transfer in technical education, it presents a problem in terms of exactly defining what is near or far. What is evident in the findings is exploration during the activities, where some students explored more than others resulted in a greater deal of 'transfer'. It was thought that the students who did explore more may have understood the materials unique properties which are important to any engineering student. The divergent nature of decorative transfer activities allows for a variety of responses and raises one of the key issues of this discussion. How exactly do we assess such divergent activities in a current education system which is convergent in nature? With current assessment practices the question of construct validity is raised. Are we measuring what we intended to measure? The convergent nature of current practice at second level does not lend itself to exploration and a deeper understanding of the knowledge and skills being taught. These activities, as evidenced, give students the opportunity to experience and internalise their learning. If we are to facilitate students to be creative participants in society there is a need to break the traditional practices. As outlined by Jackson, all post primary technological subjects were aimed towards the transmission of a practical skills set and knowledge to students rather than students engaging critically with the learning process [20]. Also the issue of what students value as good design in relation to decorative craft. Their perception of decorative craft could be influenced by their passed experience of the subject. Examining the activities individually some lend more towards transfer than others. Task variation [14] is important for students to practice their new skills and knowledge so that they can develop a deeper understanding hence enhances their transfer potential.

Current practices do not give opportunity to develop divergent thinking or problem solving skills. Student need to be able to solve problems and create problems of their own to hone these transferable skills. Lewis outlines that beyond the provision of domain knowledge, schools can enhance the creativity of students if classroom environments support and facilitate risk taking, problem solving, divergent and analytical thinking [21]. For students to engage in analytical thinking they must be allowed to elicit what they value most and in turn this presents a range of divergent responses. Students worked closely in an open collaborative environment which would have an impact on how their designs developed through the activities from suggestions from other group members.

Conclusion

This paper has highlighted key areas for further study. It is noted that transfer activities facilitate autonomous enquiry which is crucial if the future participants in society are to develop transferable skills. It is also important to eliminate the activities that inhibit creativity and innovation. Creating an environment that supports such enquiry is a key responsibility of all educators. This study has raised quite a few research questions. It is important to define and have a reliable rating scale to distinguish between near and far transfer. A further examination is needed to develop a pedagogical approach which best facilitates transfer. Also there is a need to examine whether a student's ability to transfer is innate or can be taught. It is hoped that a pedagogical framework will stem from this study which will outline the key approach needed to teach transferable skills in the future.

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