

Preferential Learning Styles as an Influencing Factor in Design Pedagogy

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Abstract

Design is a discipline which involves many domains, skills and professions. Design practice in Technology education¹ in the Irish second level (high school) context is not a representation of the professional realm of design. Design education in the Irish second level system is generally structured on a linear design process and associated assessment criteria. Both the linear process and assessment criteria are stifling creative design outcomes. In an attempt to improve design teaching and learning, and thus students design ability, consideration of students preferred mode of learning has been investigated. Educators have attempted to improve instruction through the influential adaptation of pedagogy intervention in the context of learning and cognitive styles of students (Cook 2008). This paper addresses the need for a strategic approach to design pedagogy to be established within the Irish second level education system, with reference to student's preferential learning styles (PLS). The findings of the study identify the test cohort's preferential learning styles. It also reveals significant differences in school types and contrary to initial hypotheses some surprising findings. The preferential learning styles will be one of the prime considerations in meeting the requirement of best practice design pedagogy, where there is a *"compatibility of his or her learning style and the instructor's teaching style"* (Felder and Silverman, 1988, p.674).

Key words

Preferential Learning Style (PLS), Pedagogy, Strategy, Design.

Introduction

Background to the current Irish education system

In Ireland, compulsory education exists from six years of age up to sixteen years of age or three years of second level education (Education Welfare Act, 2000). Compulsory education includes primary and secondary level. An additional, optional level of schooling exists, known as third level. The focus group for this paper is second level students.

Second level education caters for approximately 360,000 students in over 750 schools. Second level education, also

known as post primary education, is divided into two main cycles; junior and senior. Junior cycle involves three years of education, which is completed by a state examination, the Junior Certificate Examination, previously known as the Intermediate certificate. The age of junior cycle students ranges from approximately 12 years old to 15 years old. Students study a minimum of eight subjects in junior cycle (Department of Education and Science 2005). The range of core and optional subjects is outlined in Table 1. The level of study for junior cycle subjects ranges from higher level, ordinary level and foundation level.

The final two years of second level schools is known as senior cycle, which consists of a choice of three programmes – the established Leaving Certificate, the Leaving Certificate Vocational Programme or the Leaving Certificate Applied. Students must participate in one of the senior cycle programmes. Senior cycle students' age ranges approximately from 15 years old to 18 years old. Prior to the commencement of senior cycle students may partake in an additional optional year of schooling, known as the Transition Year Programme, if it is available in their school. Transition year serves the prime purpose of broadening students' development on an educational, social and work-based experience.

Students must study a minimum of five subjects in senior cycle, however to achieve entry to third level a minimum of six subjects must be undertaken. The Irish third level 'points system' has a benchmark of 600 points. Senior cycle subjects are divided into subject departments as outlined in Table 2. The subjects available vary greatly between second level school types due to differing academic foci and socio-economic factors. The three main categories of school types and their characteristics are outlined in Table 3. On completion of senior cycle students complete the Leaving Certificate Examination.

In terms of the management of curriculum and assessment for second level, four main bodies exist:

- *Minister of Education*: responsibility and ratification of educational policy and direction.
- *The Department of Education and Science (DES)*: provides the subject syllabus and oversees its implementation.

¹ In the Irish context, Technology education includes Materials Technology Wood, Systems Technology, Technical Graphics and Metalwork. For the purpose of the paper, 'Technology education' refer to Materials Technology (Wood & Metal) and Systems Technology.

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- *The National Council for Curriculum and Assessment (NCCA)*: under the delegation from the Department of Education and Science (DES), oversee curriculum development, teacher guidelines, and syllabus production.
- *The State Examinations Commissions (SEC)*: responsible for examinations in terms of preparing examination scripts, assessment material, corrections and publishing results and statistical data related to second level education. The SEC is a non-departmental body under the guidance of the DES.

On a non-governmental level there are three main associations representing the teachers of technology education subjects:

- Association of Technology Teachers (Lattu).
- Techno Teachers Association (TTA).
- Engineering Technology Teachers Association (ETTA).

Description of Technology education in the Irish context. Technology education, in an Irish second level educational context, deals with eight subjects (Table 4).

Initially technology education was only available in junior cycle. However with the change in the junior cycle subjects from industrial practices to a design driven approach, the design thread has followed through to senior cycle to contextualise the materials and processes through the activities of design. Both junior and senior cycle technology education subjects are available in two levels for assessment purposes; higher level (HL) and ordinary level (OL), and some at foundation level (FL).

Outlining the study.

This paper discusses a study which sets out to determine students' preferred learning styles in establishing a design pedagogy in Technology education in the Irish context. Design is an activity which requires a higher cognition skill set. Creative design is only possible if the designer is 'thinking' and applying the skill set to the issue under enquiry. Ability and style, both of which can be nurtured, (Owen-Jackson 2002) are two crucial factors which affect one's design ability and creativity. As Sternberg noted "[Teachers] are failing to recognise the variety of thinking and learning styles they [students] bring to the classroom,

Core subjects (all must be studied)	Irish (sanctions can be made not to study)
	English
	Mathematics
	History
	Geography
	Civic, social, political education (CSPE)
Optional subjects sample (at least two)	Materials technology wood
	Metalwork
	Technical drawing
	Technology
	Art, craft and design
	Home economics
	Social, physical and health education (SPHE)
	Science
	Religion
	Foreign language (French / German / Spanish etc)
	Computers
	Physical education
	Music
	Etc...

Table 1: Junior cycle subjects

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Subject department	Subject
Applied Science	Architectural technology
	Engineering technology
	Technology
	Design and Communication graphics
	Agricultural Science
	Home Economics
Languages	English (compulsory pass)
	Irish
	Foreign language (French, German, Spanish, etc)
Business	Economics
	Accountancy
	Business studies
Sciences	Mathematics
	Applied mathematics
	Physics
	Chemistry
	Biology
	Physics and Chemistry
Social studies	History
	Geography
	Classical studies
	Music
	Art
	Home Economics

Table 2: Senior cycle subjects

and teaching them in ways that don't fit them well" (Sternberg, 1999, p.17). The issue also exists that many believe design ability cannot be taught, however Nigel Cross outlines that *"all of us possess the ability to design, at some level, and that this can be developed through education"* (Owen-Jackson, 2002 p.124).

This paper examines the preferential learning style of 525 students (age bracket 12-16 years) within Technology education or design subjects from a range of nine second level schools. To determine the subjects' preferential learning style the Felder-Silverman *Index of Learning Styles*

(ILS) (Felder 2005) was the preferred tool applied to the project. The ILS was created in 1991 by Richard M. Felder and Barbara A. Soloman. The four learning style dimensions (comprised of 44-sub items) of the instrument were adapted from a model developed in 1987 by Felder and Silverman. The ILS was proven for reliability and validity in 2005 (Zywno 2003; Felder and Spurlin 2005)

Change in education through the eras

Schools should reflect the culture and values of its society (Vygotsky and Cole 1978). It is one's culture that provides

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Subject type	Characteristics
Secondary schools	Most popular, providing for 55% of students. State-subsidised but usually owned by religious groups, organisations or privately owned. Small numbers of secondary schools are fee paying. Traditionally provide a more 'academic' education. In recent years they have introduced practical and technical subjects.
Vocational schools/community colleges	Cater for approximately 34% of student population. Owned by the local authorities and run by vocational education committees or authorities, which are statutory bodies. Main focus was in terms of the development of practical skills and vocational training. However, the full range of second-level subjects is available.
Comprehensive/community schools	Cater for approximately 12% of the student population. Established by the State and are owned by partnership boards of trustees. A board of management representative of the diocesan religious authority, the Vocational Education Committee of the area and the Minister for Education and Science manages these schools. Financed entirely by the Department of Education and Science. Set up to give recognition to a compromise between Secondary and Vocational Schools. Offer a broad curriculum embracing both practical and academic subjects.

Table 3: Second level school types and characteristics (OECD and Gallagher 2003)

the tools to develop what to think and how to think (Kristinsdóttir 2000). Technological changes have progressed through society however the educational system to a large extent remains unchanged (Kristinsdóttir 2000).

Design activity involves both procedural and conceptual activity, requiring innovative thinking skills, which the current Irish education system does not sufficiently facilitate. The acquisition of technical and manipulative skills is important for design activity, however conceptual skills are important in the development of students innovative thinking skills which is currently not occurring in the current education system (Kimbell 1982).

A shift needs to occur in the current second level education from an 'information era' of knowledge acquisition, a lower cognition activity, to knowledge application, a higher cognition activity. It is not sufficient to store knowledge; one must know when, how and why this knowledge is relevant for design activity (Caban and Wilson 2004; Atman, Kilgore et al. 2008) as we are progressing into a 'conceptual era' (Pink 2006). Applying knowledge correctly is a critical factor of design activity, especially when broad sources of information are readily available. Another obstacle is that "most current approaches to curriculum, instruction, and assessment are based on theories and models that have not kept pace with modern knowledge of how people learn" (Redish and Smith, 2008, p.3).

Junior cycle	Senior cycle
Materials technology wood	Architectural technology
Metalwork	Engineering technology
Technology	Technology
Technical drawing	Design and communication graphics

Table 4: Technology education subjects

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The use of computer technology in education

In a society which is dominated by technology this trend should also exist in the second level education system. There is a progression from the information age, where there is a reform from knowledge acquisition to knowledge application. The use of technology in education will aid design activity through a greater use of presentation media thus appealing to a greater range of students. From a motivational perspective, the use of computers improves the climate for learning especially in subjects that use computers (Valdez et al., 1999). Technology aids the learner in a conceptual era through the availability of knowledge, transmission of knowledge and the production of new knowledge. With access to knowledge, at the touch of a button, it is becoming less important to build up knowledge, and more important to know where to find and how to use the information (Salomon, 2000). Computer technology allows easy access to information. How a student uses and transforms this information is under their command.

However not all schools and students have sufficient access to computer technology thus it should not be the sole means of providing students with information. Though, if used there are some important factors which must be considered (Kristinsdóttir 2000);

- Suit student's learning style.
- Adaptive to the needs of each student (levels and abilities).
- Interactive.
- Subject specific.
- Apply current knowledge for creative learning.
- Learning material structured on first thought and problem solving.

- Develops flexible learning: can occur anywhere and any time.
- Peer learning will be encouraged.

In second level education the use of computer technology should be used to promote students information, which can be further applied to a specific context (Suh 1990). Information acquisition is no longer sufficient in today's society. To meet the needs of students in Technology education, a context must be established in developing student's conceptual skills. To better meet student's needs, student styles for learning should to be investigated.

Student styles

Learning, thinking and cognitive styles are all important characteristics of a student in terms of education. A learning style is how a student *prefers* to learn, for example by actively doing. A thinking style is the way a student thinks about the information they had learned. Cognitive style is the application or joining of the information learned in various ways. Thinking and learning styles can often be taken as one style. For the purpose of this paper the focus is on preferential learning styles (PLS).

Practices in design activity

Design activity is multi-faceted activity, evident in many disciplines, which is causing ad hoc practices in a second level context. For example, there is a concentration of focus on assessment criteria for design activity, due to a misunderstanding of design activity, which was due to the fact that the goals for Technology education differed from the assessment criteria (Kimbell and Perry 2001; Barlex 2002). Thus education has become greatly dependant on assessment. This is resulting in pupils focusing on a

Aspect	Engineering Versus Design
Activity	<ul style="list-style-type: none"> • Engineering: the application of scientific theory in the design, creation, and maintenance of technology. • Design: as a process can take many forms depending on the object being designed and the individual or individuals participating.
Types	<ul style="list-style-type: none"> • All engineering disciplines will involve some aspects of design. There are many types of engineering such as electrical engineering, mechanical engineering, civil engineering, and biomedical engineering. • Similarly there are many types of design such as product design, interior design, furniture design, urban design, fashion design, to name a few.
Strategy	<ul style="list-style-type: none"> • Design activity is primarily carried out to fulfil a human need. • Engineering applies to advances in technology very often to fulfil a human need.
Design processes	Both disciplines make use of design processes; however, engineering design processes are more clearly structured (Jones 1980).

Table 5: Engineering versus Design

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“single, best, ‘correct’ answer to a standard problem in the shortest time” rather than encouraging divergent, creative thinking (Fry, 2006, p.3). The aim should be to achieve examination success along with creative thinking abilities. Creative thinking abilities though, can cause difficulty for teachers as they involve students carrying out activities in a ‘legislative’ nature, which primarily represents sovereignty and self-choice with respect to doing things (Sternberg 1999; Coffield, Moseley et al. 2004). Students will have a style preference established after their first year in second level education. However the school environment may not be facilitating or promoting students style necessary to achieve to the best of their ability.

Also the cause for the hindrance in the effectiveness of practicing design is due to preferential learning styles (PLS) not being accommodated or even considered in most education systems’ pedagogies. Nor are ‘universal design practices’ in place, which are adaptable to industry, education and other professions. In comparing design and engineering there are many similarities (Table 5). Design activity is carried out in both disciplines in varying degrees of complexity. However practices in engineering are far more documented and researched, especially in the context of learning styles, which have proven to aid students (Felder, Felder et al. 1995; Seery, Gaughran et al. 2003).

Preferential Learning Styles

Everyone has their own preferred way of learning, it could be by reading, listening, acting or watching to suggest a few modes. The way in which one learns, receives information, uses it and retains it, is known as a learning style. Table 6 outlines definitions for learning styles from a number of theorists.

Awareness to learning styles is beneficial in education systems for many reasons. One important reason is that if the learning and teaching styles are not compatible, it usually results in unproductive learning. This is highlighted by Felder *“how much a student learns in class in governed in part... by the compatibility of the students attributes as a learner and the instructor’s teaching style”* (Felder and Brent, 2005, p.57). Another important reason is that students are not being shown how to learn effectively. Recognising how to learn effectively can be achieved by understanding learning styles, as highlighted by Caban and Wilson in the statement *“to become independent and effective learners is to help them [students] to understand their own learning styles”* (Caban and Wilson, 2004, p.131). However it is important not to highlight individual students’ personal preferential learning style as this may result in students concentrating their learning environment solely to this domain.

Theorist	Meaning	Reference
Keefe	Characteristic cognitive, affective and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with and respond to the learning environments.	(Keefe 1979)
James and Gardner	The complex manner in which, and conditions under which, learners most efficiently and most effectively perceive, process, store and recall what they are attempting to learn.	(James and Gardner 1995)
Sarasin	The preference or predisposition of an individual to perceive and process information in a particular way or a combination of ways.	(Sarasin 1998)
Sternberg	How an individual prefers to learn, by reading for instance.	(Sternberg 1999)
Atkinson	It is a distinct and consistent way of encoding, storing and performing, and one that is mainly independent of intelligence.	(Atkinson 2004)
Felder	The type of information the student preferentially perceives.	(Felder and Silverman 1988)
Gregorc	Consisting of distinctive behaviours which serve as indicators of how a person learns from and adapts to his environment.	(Gregorc 1979) (Henson and Borthwick 1984)
Hunt	Describes a student in terms of those educational conditions under which he is most likely to learn. Learning style describes how a student learns, not what he has learned.	(Hunt 1979) (Henson and Borthwick 1984)

Table 6: Preferential Learning Styles meaning

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There are almost fifty different theories regarding learning and teaching styles. Many learning and teaching styles practiced and tested for years have proven reliable and victorious. However, are these teaching and learning styles compatible with design pedagogy? One problem with the subject matter of design is that there is no 'universal learning theory' associated with the activity. Unfortunately the same theory is not present for design practice within second level schools. A "universal design theory" (Lossack and Grabowski, 2000, p.1) is fundamentally required within our education system. A universal design theory is one which can be adaptable to the various design circumstances. It should also suit the various PLS's of design students insofar as creativity and 'designerly ways of thinking' can be developed and nurtured in students.

Relevance of learning styles for design activity

At regular intervals a teacher will carry out assessment to determine the level of understanding by students. This should consequently, if required, result in adjustments in teaching style by the teacher to meet the needs of their students. Students, as a group, can be informed of learning styles, thus increasing their ability to develop skills which will improve and increase their learning. Much research has occurred in the area of learning styles over the past four decades. Learning style research has broadened to a variety of disciplines. However design activity is one area that learning styles are quite novel. Similarly design activity in Technology education is a relatively new area. Engineering is a discipline in which design activity may be a major element and has been greatly researched (Cross 1989; Seery, Gaughran et al. 2003; Atman, Kilgore et al. 2008). Engineering disciplines in third level institutions have gained many developments due to the discovery of the learning style profiles of its students (Felder and Spurlin 2005; Seery 2005). This benefit could be applied to developing design activity in the Irish second level education system through the development of a strategic approach to education and training with reference to preferential learning styles. Thus the main reason is to improve understanding and learning of students participating in design activity in Technology education.

Investigating and identifying learning styles provides the opportunity for the teacher to match the design activity instruction to the preferred style of learning of the student, thus enriching the learning experience.

Selecting the optimum learning style inventory

Consequently what do schools have that will promote the required skills for successful design? Primarily, knowledge is a necessity and schools are the best facility to obtain

and access knowledge, provided it is presented correctly. However, in attempting to increase knowledge and understanding, different learning styles are not being facilitated. This is highlighted by Zywno et al, when it was stated "It is also generally agreed that the conventional teaching style prevalent in schools and universities does not accommodate the preferences of all students equally" (Zywno and Waalen, 2002, p.36). Studies have shown that greater than fifty-percent of knowledge is lost immediately after a lesson unless some action is occurring using this new knowledge. This is reinforced by Cubitt, Hodgson and Norman; "The proportion of key information which students remember immediately after a lecture [lesson] vary from about 50% downwards" (Cubitt, Hodgson and Norman, 1993, p.172).

Information is also lost if the learning style is not compatible with the methods by which the information is presented. As Felder described "information routinely comes in both forms, [visual and verbal] and much of it will be lost to someone who cannot function well in both of these modes" (Felder, 1996, p.18). The best way something can be presented is to ensure it appeals to all the audience, which in a school situation is to ensure the knowledge, is presented via the dominant teaching styles, which will reach all students and their multiple learning styles. All of the learning style models have the aspect of giving a positive affirmation of the learning potential of students, based on the belief that anyone can benefit from education if their preferences are catered for. As there is not sufficient research in terms of learning style models within the technology education, Table 7 distinguishes the characteristics and suitability of some popular learning style models.

Numerous studies of the learning style inventories have occurred, however there is no general consensus in terms of the inventory best suited to web based learning. Web based learning along with design activity requires adaptability to various design activity, learner differences and individual needs (Kuljis and Liu 2005). Thus it may be observed from the analysis of the various learning style tools/models, the Felder-Silverman model is the only model which has been tried and testing in a cognate activity. Therefore for the purpose of this research the Felder-Silverman model was adopted.

Current Pedagogy

Felder and others have shown that when and if the teaching style is harmonised with the corresponding learning style, improvement in learning and understanding for the student at all levels is evident (Felder, Felder et al. 1995). To further aid learning, it was outlined by Kolb, that

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Model	Main purpose. Situation implemented	Suitability in design education?
Gregorc Style Delineator. (Ballone & Czerniak, 2001)	To identify and quantify the mind qualities and their respective style characteristics. Used for helping individuals gain a better understanding of self and others.	Not suitable <i>Reason:</i> Instrument for adults.
Sternberg's thinking styles inventory (TSI) (Sternberg 2001)	Derived from the theory of self-government. Not a theory of thinking and learning styles but a metaphor, undergoing research stimulating research and in changing practice.	Not suitable <i>Reason:</i> In need of independent evaluation.
Herrmann's Brain Dominance Instrument (HBDI)	To promote change and growth by identifying mental preference or thinking styles. Personal, interpersonal, staff and organisational implementation.	Not suitable <i>Reason:</i> Well established in the 'business' world. Pedagogical implications of the 'whole brain' model have not yet been fully explored and tested.
Dunn and Dunn (Dunn 2003 ^b)	To improve attainment through matching instruction, environment and resources to students' high preferences; many of which a teacher has little control over. Some of the sub-domains are not supported by scientific evidence.	Not suitable <i>Reason:</i> Promotes self-limiting behaviour and beliefs by students working only with their strong preferences rather than openness to new styles and preferences.
Myers-Briggs Type Indicator	Provides a view of the whole personality including learning, though not specifically about learning. Often used in career counselling to steer students toward appropriate areas of study.	Not suitable <i>Reason:</i> It is still not clear which of the personality types of the MBTI are relevant for education
Carl Jung's Psychological Topology	From these ones preferential learning style or cognitive style can be determined. The Jung types (dichotomies) were used in the Myers-Briggs Type Indicator which differs from standardised tests and others measuring traits, such as intelligence, instead classifying people's preferred types.	Not suitable. <i>Reason:</i> More suited to determining traits such as intelligence
Felder-Silverman Index of Learning Styles model	To establish a persons preferred learning style. Used in engineering and computer based subjects.	Suitable <i>Reason:</i> Engineering has a sub-structure similar to design. This instrument has been successfully implemented and proven in reliability and validity. ILS often used in technology enhanced learning.

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Model	Main purpose. Situation implemented	Suitability in design education?
Kolb's Learning style inventory (LSI)	Can be used as introduction to how people learn.	Not wholly suitable <i>Reason:</i> Based on an explicit theory. Problems about reliability, validity and the learning cycle are still areas of concern with this model.
Honey and Mumford's Learning styles questionnaire	Probes the attitudes and behaviours which determine preferences with regard to learning. Used for organisational and personal development. Based on Kolb's model.	Not suitable <i>Reason:</i> No pedagogical association. Suited to a business environment.
Entwistles' Approaches and Study skills inventory for students	To encompass approaches to learning, study strategies, intellectual development skills and attitudes.	Not suitable <i>Reason:</i> Still undergoing development. Little connection between intervention and pedagogical improvements.
Vermunt's Inventory of Learning Styles (ILS)	To discover the thinking and learning styles of (university) students.	Not suitable <i>Reason:</i> For use where text-based learning is important.

Table 7: Characteristics of learning style models (Coffield^a, Moseley et al. 2004; Coffield^b, Moseley et al. 2004)

it is effective to start with one's dominant learning style (Thieme and Boeijen 2008). Similarly Felder has also outlined that the use of any learning style model should result in a similar style of teaching; *"which model educators choose is almost immaterial"* (Felder, 1996, p.23). Varying the teaching style, aids students development of additional learning styles, that should benefit them further on in life.

"Students whose learning styles are compatible with the teaching style of a course instructor tend to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject." (Felder, 1993, p.286)

A PLS approach in teaching design within Technology education would not only benefit the students acquisition of design capabilities, but would also enhance their technological literacy.

Design of Experiment

Rationale-PLS ILS

Motivation for investigating PLS:

- Students have unique needs especially in the practical design subjects of the technologies.
- Students may have difficulty learning when the learning style does not match the teaching style implemented.
- Learning style has a significant role in second level education as students are still developing and also being exposed to a greater range of interactive presentation media, such as drawing programs, internet and interactive board.
- Understanding learning styles aids learning and improves retention.

Participants-PLS

For validity, in relation to the second level cohort, an initial pilot test and pre-pilot test were carried out for the ILS survey. The initial pilot test was carried out on postgraduate students, most of who graduated with Materials and Technology Engineering/Construction Education Degrees, and the remainder completed Engineering based degree courses. Undergraduate

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	N	Minimum	Maximum	Mean	Std. Deviation
Age		12	16	13.65	1.004
Valid N	525				

Table 8: Student participants PLS and Design impression survey

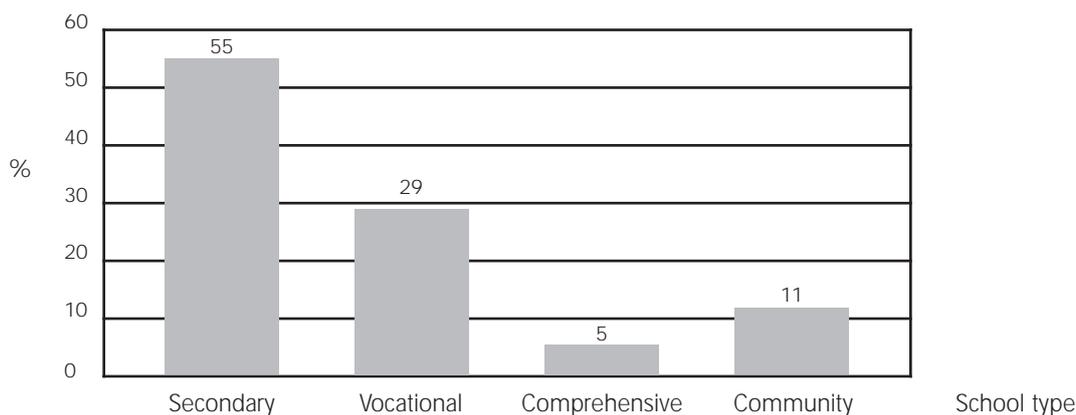


Figure 1: Second level school type breakdown

Bachelor of Technology Courses and BSc, Product Design students participated in the pre-test of the amended surveys. The aspiring teachers served the purpose of checking the survey for soundness of language for second level students. The ILS tool was finally tested with a small cohort (15) of second level students.

The main focus group participants consisted of approximately 530 students from the technologies, consisting of 146 female and 379 male. The students' age ranged from 12-16 with a mean age of 13.65 and standard deviation of 1.004 (Table 8)

Two criteria determined the mechanism for school selection:

- *Geographical location*: Schools were selected from urban, suburban and rural regions throughout Ireland.
- *School type*: was an influential factor. The schools selected comprised of a Vocational School, Secondary School, Community College/School, and Comprehensive, which are a representational sample of the four types of second level schools in the Irish education system as illustrated in Figure 1.

School type	Demographics	Gender	Percent of total (n=525) study participants
Secondary school	Sub Urban town	Female	8.7% (n=46)
Secondary school	Sub Urban town	Male	8.7% (n=46)
Secondary school	Sub Urban town	Co-educational	54.6% (n=287)
Secondary school	Rural village	Co-educational	
Secondary school	Sub Urban town	Co-educational	
Secondary school	Sub Urban town	Co-educational	
Comprehensive school	Sub Urban city	Co-educational	12.6% (n=66)
Vocational school	Sub Urban town	Co-educational	13.2% (n=69)
Community school	Rural village	Co-educational	2% (n=11)

Table 9: Gender distribution from the various school types

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Style	Semantic group	ILS questions (answer a)	Style	Semantic group	ILS questions (answer b)
Active	trying something out	1, 17, 25, 29	Reflective	think about material	1, 5, 17, 25, 29
	social oriented	5, 9, 13, 21, 33, 37, 41		impersonal oriented	9, 13, 21, 33, 41, 37
Sensing	existing ways	2, 30, 34	Intuitive	new ways	2, 14, 22, 26, 30, 34
	concrete material	6, 10, 14, 18, 26, 38		abstract material	6, 10, 18, 38
	careful with details	22, 42		not careful with details	42
Visual	pictures	3, 7, 11, 15, 19, 23, 27, 31, 35, 39, 43	Verbal	spoken words	3, 7, 15, 19, 27, 35
				written words	3, 7, 11, 23, 31, 39
				difficulty with visual style	43
Sequential	detail oriented	4, 28, 40	Global	overall picture	4, 8, 12, 16, 28, 40
	sequential progress	20, 24, 32, 36, 44		non-sequential progress	24, 32
	From parts to the whole	8, 12, 16		relations/connections	20, 36, 44

Figure 2: PLS Dimension's meaning representation (Graf, Viola et al. 2007)

The gender profile of the school cohort being surveyed was also divided (Table 9). One school was single sex-male, another single sex-female and the remainder were co-educational. One of the schools is fee-paying private. All these factors would affect the individual student learning styles. However the PLS was determined as a whole group rather than on an individual level. Informing students of individual learning style may result in sole concentration on their personal learning style rather than developing a greater range of learning styles.

Design-PLS

Preferential learning styles were assessed using the Felder-Silverman Index of Learning Styles. Initially Felder and Soloman devised an indicator to try and establish ones preferential learning style. Felder and Silverman designed the Index of Learning Styles (ILS), which has now been proven in relation to the four dimensions of the Felder-Silverman learning style model in a third level context in engineering education (Felder et al, 2005). The Felder Silverman ILS was used to determine the PLS for second level students in technology education. The Index of Learning Styles is broken up so that every fourth question is related to one of the four learning styles: Active-Reflective, Sensing-Intuitive, Visual-Verbal, and Sequential-Global.

Overview of the ILS:

- 44 questions.
- 11 questions for each dimension.
- Each question allows two possible answers indicating a preference for either the one or the other pole of the learning style dimension (Figure 2); e.g. active (+1) or reflective (-1).
- Result: a value between +11 and -11 for each dimension (Figure 3).

Procedure-PLS

For the ILS survey each question was read aloud to ensure no ambiguities in relation to word diction or meaning, along with a supporting keyword meaning sheet. The following instructions were given to all participants before commencing:

- All questions must be answered.
- If both answers apply select the one that applies most frequently.
- Clearly tick one selected answer.
- Each question was then read aloud and repeated.
- Ten minutes of additional time was then allocated on completion, to allow each student read over and contemplate selected answers.

-11	-9	-7	-5	-3	-1	0	1	3	5	7	9	11
Very Strong	Strong	Moderate		Mild		Neutral	Mild		Moderate		Strong	Very Strong

Figure 3: ILS scale

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Scale	Active/Reflective		Sensing/Intuitive		Visual/Verbal		Sequential/Global	
1	99	88	67	88	60	29	87	106
2	106	59	67	86	81	21	57	125
3	73	21	42	48	97	12	32	73
4	54	6	31	45	104	3	16	24
5	20	2	14	30	90	1	3	5
6	4	0	8	6	34	0	2	2

Table 10: Learning Style Data

Results

Raw Data

All questionnaires were collected and firstly screened for signs of apathetic participation; those questionnaires (approximately one-percent) were eliminated after consultation with each class teacher. The raw data was then tabulated trends and practices began to emerge.

For the ILS survey the results were recorded against a six point scale (Figure 3) where '1' represents a mild preference while '11' of the scale represents a very strong preference for each particular style mode. All test scores were recorded (Table 10) and subjected to statistical analyses. The data was checked to see if it was normally distributed, the normality tests used where the Kolmogorov-Smirnov and the Shapiro-Wilk. Both tests indicated that the data was not normal.

The raw data displayed in Table 10 clearly illustrates a strong preference for *Active*, *Visual* which is illustrated in Figure 4.

However the results for *Sensing* (11%)/*Intuitive* (13%) and *Sequential* (10%)/*Global* (16%) are not significant enough to draw any real conclusions and therefore warrant further investigation (Figure 4, Figure 5).

Table 11 (abridged), composed by Felder and Brent, (Felder et al, 2005) consists of all the reported PLS studies. Table 11 is used as a comparison for the results gained as a result of the study (Table 12). Approximately 530 students participated and Table 12 represents the findings from the study completed in May 2006, where A is active (reflective), S is sensing (intuitive), Vs is visual (verbal) and Sq is sequential (global).

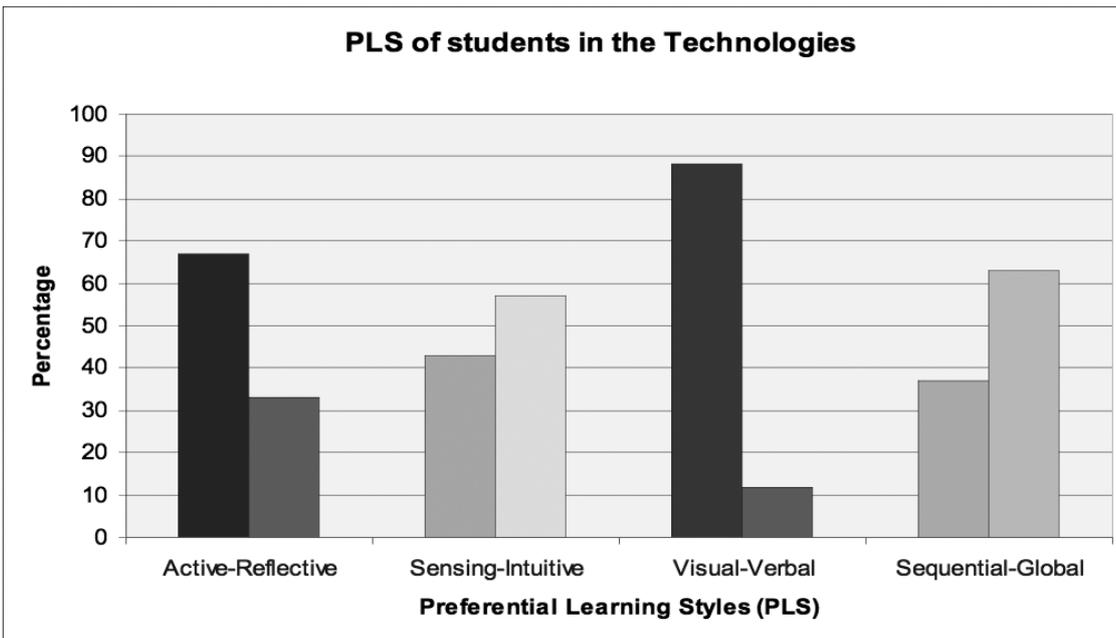


Figure 4: PLS of students in the Irish Second Level Technology education system

Preferential Learning Styles as an Influencing Factor in Design Pedagogy

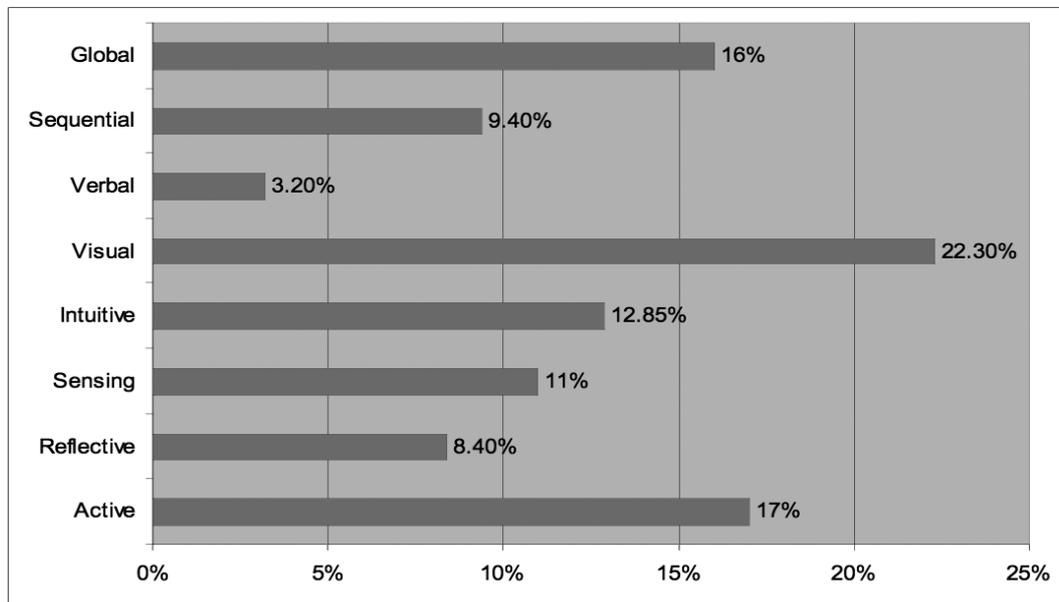


Figure 5: Learning Style Preference in Technology/Design Education

Population	A	S	Vs	Sq	Reference
Iowa State Materials Engr.	63%	67%	85%	58%	Constant (1997)
Michigan Tech, Env, Engr	56%	63%	74%	53%	Paterson (1999)
Ryanson Univ., Elec. Engr.	53%	66%	86%	72%	Zywno (2001) Zywno (2002) Zywno (2003)
Students (2000)	60%	66%	89%	59%	
Students (2001)	63%	63%	89%	58%	
Students (2002)	38%	42%	94%	35%	
Tulane, Engr.					Livestay (2002)
Second Year Students	62%	60%	88%	48%	
First Year Students	56%	46%	83%	56%	
Univ. of Limerick, Mfg. Engr.	70%	78%	91%	58%	Seery (2003)
Univ. of Michigan, Chem. Engr.	67%	57%	69%	71%	Montgomery (1995)
Univ. of Sao Paulo, Engr. ^a	60%	74%	79%	50%	Kuri (2002)
Civil Engr.	69%	86%	76%	54%	
Elec. Engr.	57%	68%	80%	51%	
Mech. Engr.	53%	67%	84%	45%	
Indust. Engr.	66%	70%	73%	50%	
Univ. of Technology Kingston, Jamaica	55%	60%	70%	55%	Smith (2002)
^a Data collected with Version 1 of the ILS (All other studies used Version 2.)					

Table 11: Reported Learning Style Preferences (abridged) (Felder et al, 2005)

Preferential Learning Styles as an Influencing Factor in Design Pedagogy

Population	Active-Reflective	Sensing-Intuitive	Visual-Verbal	Global-Sequential
Irish second level technologies	67% (A)	43% (S)	88% (Vs)	37% (Sq)

Table 12: PLS of students in Technology education

From comparing the findings on Table 10 and the results from Table 12, (the identified PLS), and as illustrated in Figure 4, it may be concluded that students in Technology education conform to the other engineering studies. In terms of the test cohort average (Table 12) two figures do not conform to the "norm". However, the students involved have yet to complete their post-primary education, which should cause further developments and advancements in their present PLS (Price 1980; Dunn and Griggs 1995).

Reading the PLS graphs further

From the active – reflective table and graphs, it can be indicated that the students are mainly active with a stronger percentile on this side of the graph (Figure 6, Figure 7, Table 13).

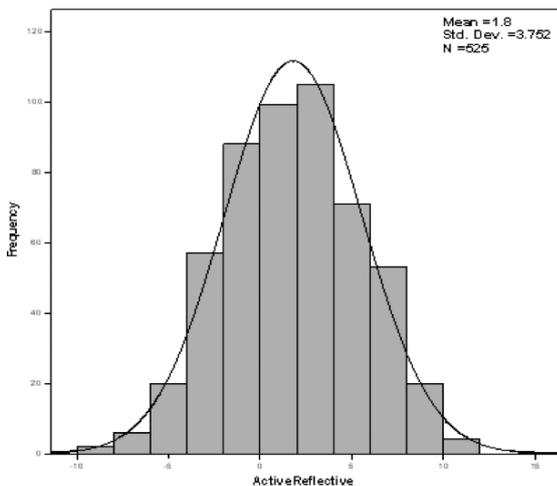


Figure 6: Reflective Active Histogram and Normal curve

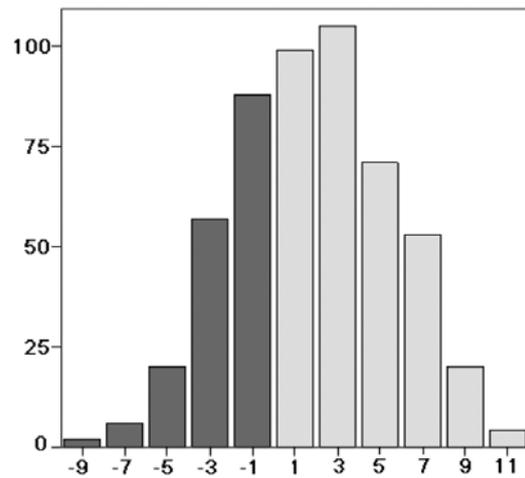


Figure 7: Reflective Active Style Frequencies Distribution.

This finding correlates with the assumption that the majority of students in the technologies are more inclined to learn by trying things out and enjoy working in groups. According to Felder and Silverman "active participation is the best teaching style for both types of learners. With active participation probably affecting the entire classroom experience and hence, the other three dimensions, it is not unfound to surmise that active participation is superior to passive, regardless of the preferential learning style." (Abdelhamid, 2003, p.139)

From the sensing – intuitive graph there is a slight difference in the percentile between sensing and intuitive learners. (Figure 8, Figure 9, Table 14)

	-9	-7	-5	-3	-1	0	1	3	5	7	9	11
	Strong Reflective	Moderate Reflective	Very moderate Reflective	Mild Reflective	Very mild Reflective	Neutral	Very Mild Active	Mild Active	Very Moderate Active	Moderate Active	Strong Active	Very Strong Active
N	2	6	20	57	88	0	99	105	71	53	20	4

Table 13: Active Reflective Distribution

Preferential Learning Styles as an Influencing Factor in Design Pedagogy

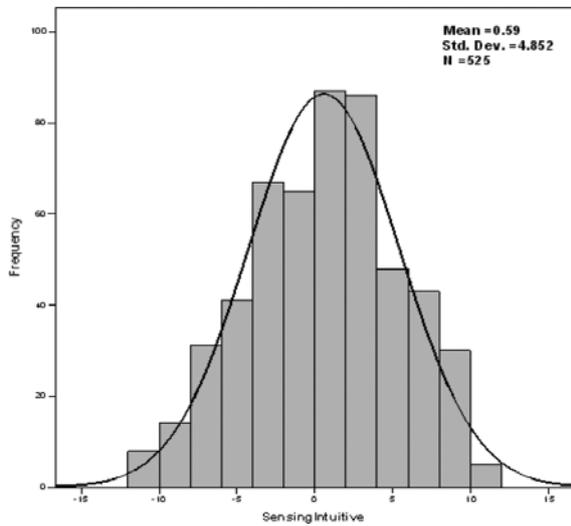


Figure 8: Sensing-Intuitive Histogram and Normal curve

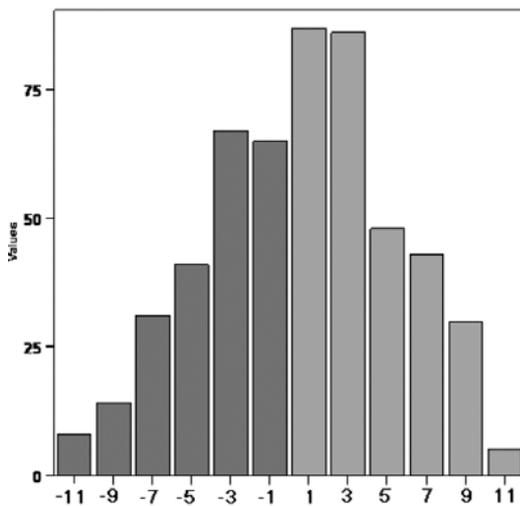


Figure 9: Sensing Intuitive Style Frequencies Distribution

However the slight difference is seen in terms of the greater number of mild intuitive learners, which are more abstract thinkers, innovative and oriented toward theories

and underlying meanings. As noted by Felder "that sensors are likely to think sequentially while intuitors may favour either sequential learning or global learning (if they are perceivers)." (Richard M. Felder, 2005, p.109).

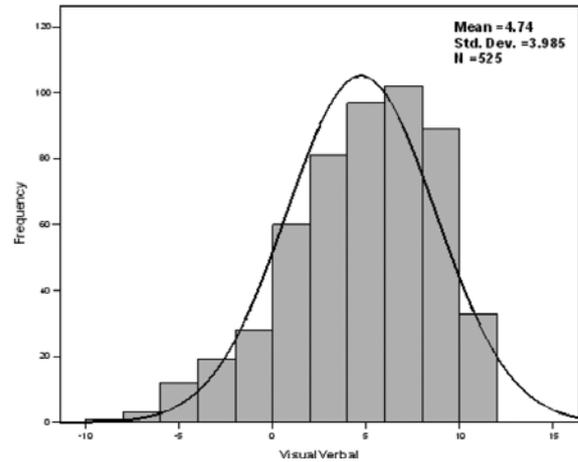


Figure 10: Verbal-Visual Histogram and Normal curve

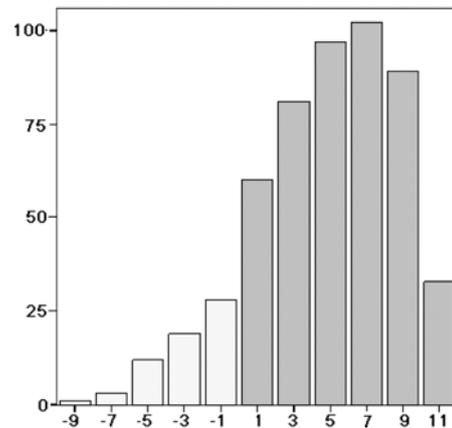


Figure 11: Verbal Visual Style Frequencies

There is a very clear distinction in terms of the difference between verbal – visual learners. (Figure 10, Figure 11, Table 15)

	-11	-9	-7	-5	-3	-1	0	1	3	5	7	9	11
	Very strong Sensing	Strong Sensing	Moderate Sensing	Very moderate Sensing	Mild Sensing	Very mild Sensing	Neutral	Very Mild Intuitive	Mild Intuitive	Very Moderate Intuitive	Moderate Intuitive	Strong Intuitive	Very Strong Intuitive
N	8	14	31	41	67	65	0	87	86	48	43	30	5

Table 14: Sensing Intuitive Distribution

Preferential Learning Styles as an Influencing Factor in Design Pedagogy

	-9	-7	-5	-3	-1	0	1	3	5	7	9	11
	Strong Verbal	Moderate Verbal	Very Moderate Verbal	Mild Verbal	Very mild Verbal	Neutral	Very Mild Visual	Mild Visual	Very Moderate Visual	Moderate Visual	Strong Visual	Very Strong Visual
N	1	3	12	19	28	0	60	81	97	102	89	33

Table 15: Verbal Visual Distribution

Visual learners are the stronger of the two domains as illustrated by the high peak and the presence of "very strong visual" learners.

The sequential – global learners are linked to the visual – verbal learners in the fact that sequential learners are more inclined to be verbal processors and global learners are more inclined to be visual processors.

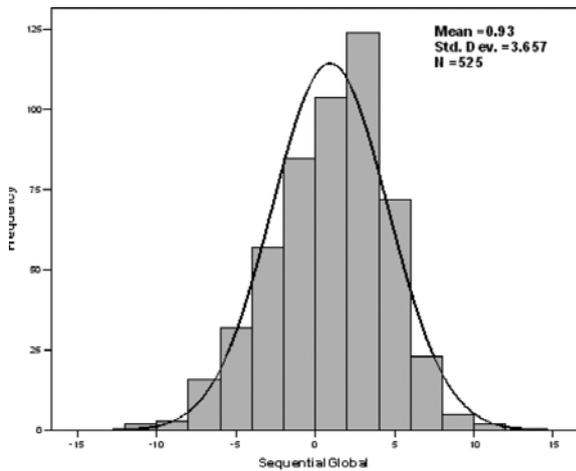


Figure 12: Sequential Global Histogram and Normal curve.

Graphically (Figure 12, Figure 13, Table 16) the cohort is globally stronger, which also correlates with the previous

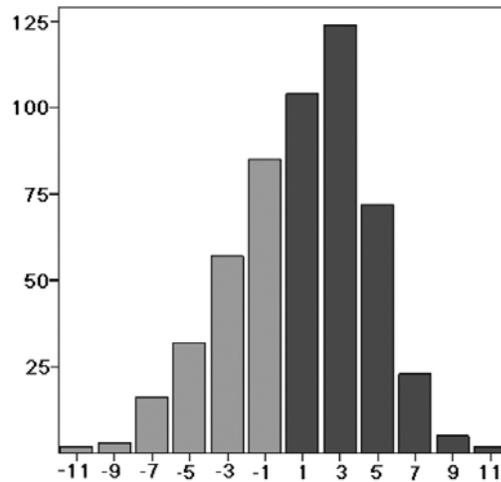


Figure 13: Sequential Global Style Frequencies

visual-verbal graph. Global learners should also be more intuitive perceivers. Global learners normally have a non-linear thinking process and acquire understanding.

Overall the findings correlate with Felder when he noted "that the active-reflective, sensing-intuitive, and visual – verbal scales may be considered independent but the sequential-global and sensing-intuitive scales show a moderate degree of association, confirming the conclusion drawn from the interscale correlations" (Felder, 2005, p.108).

	-11	-9	-7	-5	-3	-1	0	1	3	5	7	9	11
	Very strong Sequential	Strong Sequential	Moderate Sequential	Very moderate Sequential	Mild Sequential	Very mild Sequential	Neutral	Very Mild Global	Mild Global	Very Moderate Global	Moderate Global	Strong Global	Very Strong Global
N	2	3	16	32	57	85	0	104	124	72	23	5	2

Table 16: Sequential Global Distribution

Preferential Learning Styles as an Influencing Factor in Design Pedagogy

From the findings, in relation to PLS, one can observe the preferential learning style of students in the technologies is primarily active and visual. Also there is evidence of a correlation between sequential-global and sensing-intuitive. These findings show corresponding reinforcement with findings of Felder et al when he noted *“factor analyses conducted as part of the same studies supported the conclusion that the active-reflective, sensing – intuitive, and visual-verbal scales are orthogonal but the sequential-global and sensing-intuitive scales show some association. That association is consistent with the theory that underlies the Index of Learning Styles and does not compromise that validity of the instrument for its principal intended purpose of designing balanced instruction”* (Felder, 2005, p.110).

The findings of Richard M. Felder show a mismatch occurring between learning styles and teaching styles, *“a mismatch thus exists between the learning styles of most engineering students and the teaching style to which they are almost invariably exposed”* (Richard, M. Felder, 1988, p.677). This is either a disadvantage for the weak student or an advantage for the stronger student as they are getting a more diverse education. However *“irrespective of the extent of the mismatch, presentations that use both visual and auditory modalities reinforce learning for all students”* (Richard, M. Felder, 1988, p.677). In addition Felder and Silverman suggest *“that instructors can effectively engage students in the learning process by adopting a multi-style approach in instruction such that no one dimension of learning and teaching is favoured”* (Abdelhamid, 2003, p.127).

Another aspect to look at it is the environment and conditions one is learning in. As Felder once said *“a student’s preference on a given scale may be strong, moderate or almost non existent may change from one subject or learning environment to another”* (Felder, 1993, p.286).

Analysis of Disparity in PLS

According to Petroski *“numerous other factors (that) affect design including aesthetics, cultural, economics, egotistical, ethical, historical, political and psychological”* (Petroski, 2006, p.9). Similarly these factors can affect ones learning style(s). The influential factors affecting a students learning

style must be taken into consideration to determine the consequential affects. Determining the affects is important as they must be taken into consideration in developing a strategic approach to design pedagogy.

The main factors selected for analysis were school type, school gender and student gender (Table 17). As the data was proven to be of non-parametric nature and the experimental design was unrelated, the Mann-Whitney U Test and Kruskal-Wallis H Test were chosen to analyse the differences between the independent and dependent variables. Table 17 illustrates the influence between student gender, school type and school gender for each learning style domain.

For the Mann-Whitney Test results (P-values) which are not less than or equal to 0.05 are not significant. Therefore there is no significant difference in the PLS of males and females from the ‘Student Gender’ (Table 17). However for the Kruskal-Wallis Test, if the significance level is a value less than 0.05 then one can conclude that there is a statistically significant difference in the continuous variable (PLS) across the groups for ‘School Gender’.

In the Kruskal-Wallis Test for the significant difference between PLS and School Type, two PLS showed a significant difference (Table 17). These PLS were ‘A’ and ‘S’ and inspecting the mean ranks for the school types suggests that the Community School had the highest ‘A’ scores, which signifies the preference for the *active* and *sensing* style of learning. Whereas the Vocational School reporting the lowest ranking shows its significant preference for the *reflective* and *intuitive* learning styles, which runs contrary to expectations for this type of school which has a technical or practical based ethos. In the other PLS there is no significant difference in the PLS of the Comprehensive School and the Secondary School. The significant difference between PLS and school gender, three PLS showed no significant difference and ‘A’ showed a significant difference (Table 17). In terms of the mean ranking the female school showed the highest ‘A’ scores, which shows the significant preference for the reflective style of learning. On the other hand the co-educational school reporting the lowest mean ranking, highlighting the significant preference for the *active* learning style.

	Active/Reflective	Sensing/Intuitive	Visual/Verbal	Sequential/Global
Student Gender ^A	0.84	0.237	.054	0.925
School Type ^B	0.032	0.043	0.258	0.509
School Gender ^B	0.011	0.097	0.285	0.291

^A Mann-Whitney U Test
^B Kruskal-Wallis H Test

Table 17: Influence of Student Gender, School Type and School Gender on PLS

Preferential Learning Styles as an Influencing Factor in Design Pedagogy

PLS	Difference in values for PLS				
	Male & Female	School Gender	Co-ed & single sex male	Co-ed & Single sex female	School Type
A-R	No Difference	Difference	No Difference	Difference	Difference
S-I	No Difference	No Difference	No Difference	No Difference	Difference
V-V	Difference	No Difference	Difference	Difference	No Difference
S-G	No Difference	No Difference	No Difference	No Difference	No Difference

Table 18: Differences between various variables and PLS

Discussion.

As the findings of the study shows that learning style differences are evident between the various school types and gender. As a result the need for varied strategies in terms of the implementation of suitable design pedagogies further highlights the need for reform in order to redress the current pedagogical practices of design education in Technology education with respect to the PLS.

The PLS study has revealed that:

- The predominant preferential learning styles of students in Technology education are active and visual, which correlate with other studies (Felder and Spurlin 2005). This finding provides a further similarity between engineering and design in terms of similar learning preference of students. The other two domains; sensing-intuitive and sequential-global are not significant in difference. Therefore this warrants further research which was similarly discovered by Felder.

"The correlation between the sensing-intuitive and sequential-global scales is not unexpected." (Richard M. Felder, 2005, p.108)

- PLS were analysed from a series of perspectives; gender and school type (Table 18).
- There was no significant difference between males and females in terms of PLS.
- In terms of the school type differences did occur. These differences contradict the 'norm' stereotype for the various school types.
- There was a difference also between gender for the various types; single sex male, single sex female and co-educational.

Conclusion

In the context of an improved pedagogy for design activity in relation to technology education in the Irish second level education system a number of impacting factors were considered. For the cognate area of engineering

practical and theoretical, at third level, consideration of preferential learning styles proves to be beneficial. Design of instructional media which catered for preferential learning styles at this level reflected a significant improvement in students performance (Felder, Felder et al. 1995; Seery, Gaughran et al. 2003). As part of devising an appropriate design activities pedagogy it was felt that establishing the dominant PLS of the student cohort could contribute significantly to an improved pedagogy. The findings revealed that for a representative cross-section of participants in design activity in technology education that a dominant style has emerged. This learning style, active and visual, is now being used to inform the development of a best-practice pedagogy in the context of design problem solving and creative activity, where compatibility between instructional media and methodologies, and how the participating students prefer to learn is a prime consideration. The development and application of the strategic tutorial intervention tool is expected to significantly enhance the learning experience of the participants, particularly in the cognitive processing associated with 'designerly ways of thinking'.

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