The Use of Learning Styles as a Guide for Project Group Formation and Methods of Assessment

Paper Title:

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Abstract

Since the introduction of a new degree programme in Product Design and Development (PDD) in 2004 a study of student learning style preferences has been undertaken to profile the first year intake on the three different degree programmes within the School of Mechanical and Aerospace Engineering at Queen's University Belfast. A broadening of the range of acceptable subjects for entry and the acceptance of students without A-Level mathematics onto the PDD programme suggested that these students might prefer to study in a manner different to previous "generations" of engineering undergraduates. As well as identifying characteristic differences between disciplines the study provided information which is used across the degree programmes to enhance student learning and improve students' self awareness of learning style preferences and strategies.
With the objective of improving the range of student skills and abilities, required of professionally competent engineers, individual learning style preferences have been used in the formation of project groups. The profiling of learning styles within student cohorts has also provided information that has been used to adjust the methods of assessment and target areas where students require most development in order to achieve a more balanced learning style combination.
The paper also discusses the experience of forming groups with both balanced and unbalanced learning style preferences, student reflections on their experiences of working in such groups and measured changes in student learning style preferences as a result of the changes in teaching and assessment methods.

Context

The Product Design & Development (PDD) degree at Queen's University Belfast aims to produce BEng and MEng graduates professionally competent in all phases of new product development from conception through design, implementation and operation. Working as part of the conceive, design, implement, operate (CDIO) Initiative (www.cdio.org) the School of Mechanical and Aerospace Engineering has undergone a process of reforming its existing engineering degree programmes which now include more group based projects and more active and interactive learning. In the case of the PDD degree a new programme has been built with CDIO standards at the core. The first MEng cohort from this degree will graduate in 2008

Introduction

The four stages of the experiential learning cycle defined by Kolb (1983) (Figure 1) led him to propose that students have a dominant phase in which they prefer to learn. He subsequently developed a Learning Style Inventory to identify how these preferences might vary across a group of students. Knowing how students prefer to learn, Kolb's objective was to individualise instruction to produce students competent in all four of these learning styles, who would be balanced and integrated learners. Others such as Felder and Silverman (1988) have identified positive benefits gained from planning learning opportunities to take account of the broad ranges of learning styles found among engineering undergraduates.

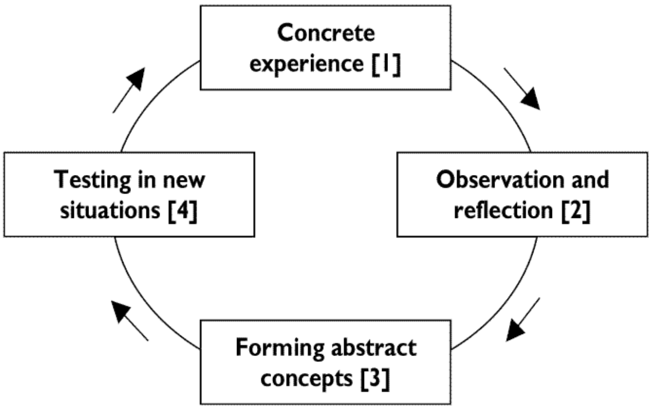


Figure 1: The four stages of the Kolb Experiential Learning Cycle

Kolb's and other methods of measuring learning style preferences have become popular and are widely used but there is limited commonality between the competing methods. In a study of thirteen different models (Coffield *et al,* 2004) found fault with many, including the most popular, and little evidence of benefit directly attributable to adoption of such methods and exaggerated claims from many practitioners. They did, however, acknowledge that where the examination of learning styles of both student and lecturer had been carried out there was clear evidence that the educational experience overall had been improved. They concluded that the development of a "lexicon of learning" facilitated productive discussion between teachers and students and that this self-awareness and metacognition enabled students to improve how they learnt.

Preferring to work in one mode does not mean that the student is necessarily better when working this way. It is a level of preference not competence which is being measured. It is also important to emphasise that these modes are not predetermined or innate and that development of proficiency in the different modes can be acquired.

A CDIO structured degree programme (Crawley *et al,* 2007) seeks to produce students who are professionally competent in all phases of the development of a product or system and necessarily needs to provide opportunities for this development to take place. It was proposed that profiling of student cohorts by measuring learning style preferences could be used to identify areas needing most development so that both curriculum and assessment could be planned to provide sufficient opportunity for this to take place. From Stage 1 the PDD students undertake a number of group Design Build Test (DBT) projects. The intention here is to mimic professional practice where product design and development is carried out in heterogeneous groups. These group projects also facilitate the acquisition of personal and interpersonal skills such as team working, project management and leadership which are much prized by employers but which have not traditionally been part of the disciplinary knowledge taught in purely engineering science modules. Set in the CDIO context of conceiving, designing, implementing and operating a product the group needs to perform well in all phases of the project to meet all the intended learning outcomes. Halstead & Martin (2002) and others have found that students allocated to groups on the basis of learning style preference can perform at a higher level than those placed randomly or allowed to self select their project group. To assist in the objective of maximising performance and development the learning outcomes and assessment methods are constructively aligned (Biggs, 1999) and tasks best suited to each of the preferences are present among the assessed elements. Honey and Mumford (1986) contend that the most effective problem solvers are good all rounders who can adapt to a range of environments. The DBT projects facilitate an engaged and motivated student to take control of their own learning. Each student has the opportunity to work on tasks at which they are most comfortable and to improve their abilities in other less preferred areas to become more rounded learners.

Characteristic Profiles of Degree Programme Cohorts

The study conducted first set out to measure the learning style preferences of the student cohort. An ongoing process of measuring the learning style preferences of students in all three degree programmes offered by the School of Mechanical and Aerospace Engineering when they first enrol in stage 1 is followed up by subsequent retests of the same students in later years of their degree to measure any changes in preference which have occurred.

The Learning Combination Inventory (LCI) tool used was devised by Johnston & Dainton (1997) at the Rowan University, New Jersey. The LCI has twenty eight Likert scale (5 point), forced answer, tick box questions which are well matched to the learning objectives of the group based DBT projects and takes 10 to 15 minutes to complete. The questions focus on identifying preference in specific circumstances; for example “I would rather draw or build a model than read or write about a subject”. The questions relating to the different learning styles are not obvious to the student as they are irregularly mixed throughout the questionnaire and the students are not given prior information about the definitions of the different styles. Totals are calculated using a separate guide sheet which the students do not see beforehand. Preference between four learning styles; Precise, Sequential, Technical & Confluent processor, can be identified by four integer totals between 7 and 35.

Table 1: Interpretation of Learning Combination Inventory Totals

LCI Total	Interpretation
7 - 17	'I avoid this action tendency wherever possible. This is not really me'
18 - 25	'I use this as needed'
26 - 35	'I strongly favour this action tendency. This is typically me'

A **precise** processor prefers to gather, process and use data and to demonstrate their understanding through the writing of answers and factual reports.
A **sequential** processor prefers clear and explicit instructions. They need to be organised and to have the time necessary to complete tasks to their satisfaction.
A **technical** processor is much less comfortable with writing, preferring hands on practical experiences and problem solving tasks.
A **confluent** processor is creative and imaginative and enjoys finding and making the widest connections between ideas.

It should also be noted that the tool used focuses strongly on how a student prefers to carry out tasks and that there can be a distinct difference between how individuals choose to give and receive information. Carrizosa and Sheppard (2000) for instance found that engineering design students much preferred to receive visual information but rarely used this medium when working within their groups. This study concentrates on how the groups operated and not on how information has been provided or presented to the students.

The study has proved consistent over three years and shows that there are significantly large numbers of students dominated by a preference for practical, hands-on learning. Many have avoidance tendencies for learning that requires precise data collection, manipulation and presentation. There is a significant minority of students most comfortable when working to a detailed plan and others who feel out of their comfort zone when required to generate original ideas or concepts. Among the three degree programmes characteristic cohort profiles can be identified. This is consistent with the notion proposed by Kolb (2000) that individuals choose careers congruent with their learning style preferences. The Aerospace and Mechanical Engineering programmes for instance have the same entry requirement prerequisites but produce a consistently different LCI profile for the two cohorts (Figure 2).

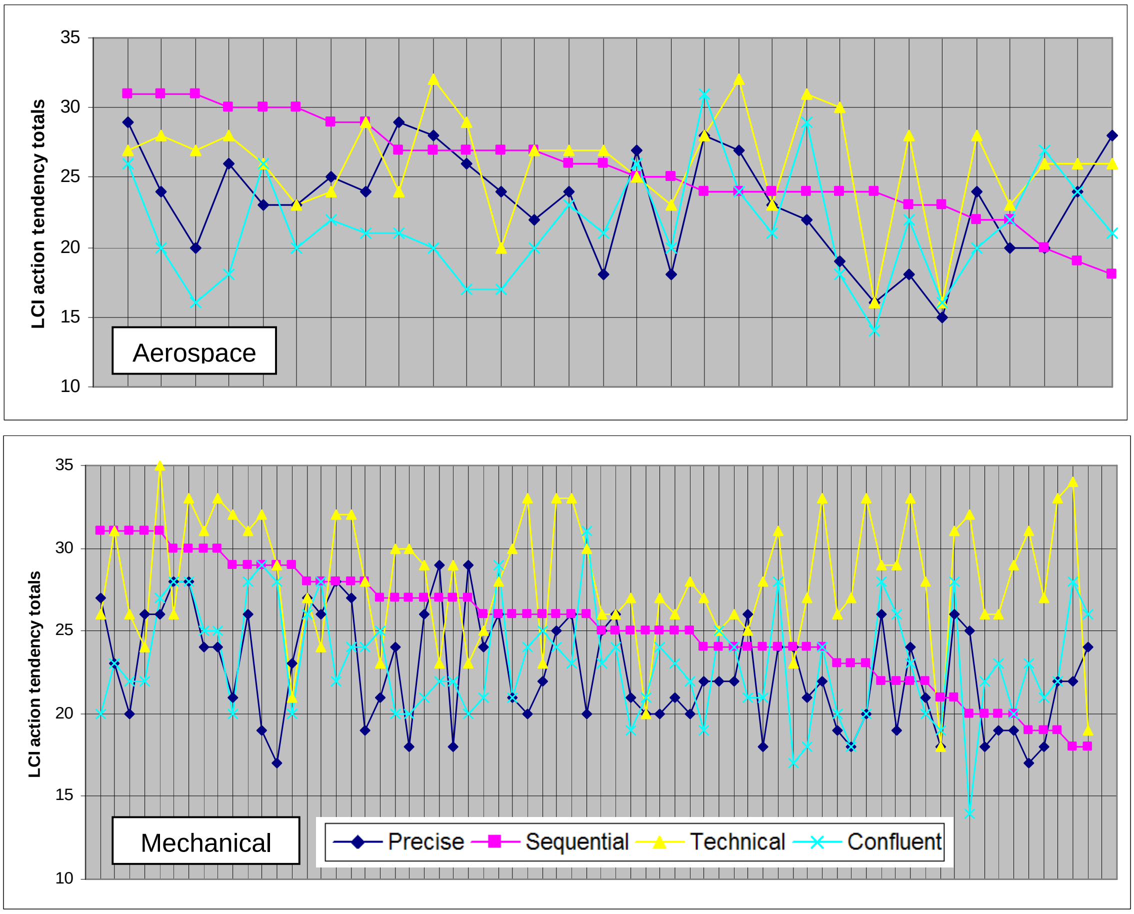
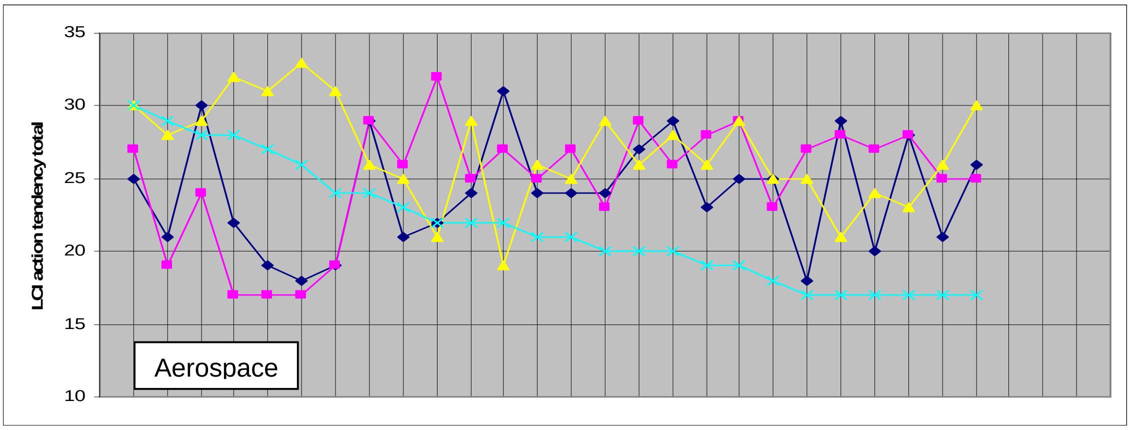


Figure 2 – Characteristic Sequential Processor ranked cohort profiles for 1st year Mechanical and Aerospace Engineering students

Each vertical line of each graph in Figure 2 has four coloured points which represent an individual student's LCI totals. Typically a much higher proportion of Aerospace students have a preference for sequential processing than the Mechanical students where noticeably some of the lowest scores coincide with some of the highest scores for technical processing. In the DBT projects these students can often be identified as the ones who are most eager to get on with building a model or prototype rather than plan or schedule tasks within the project. It has also been noted that it is more typical for female students to have a dominant tendency for sequential processing.



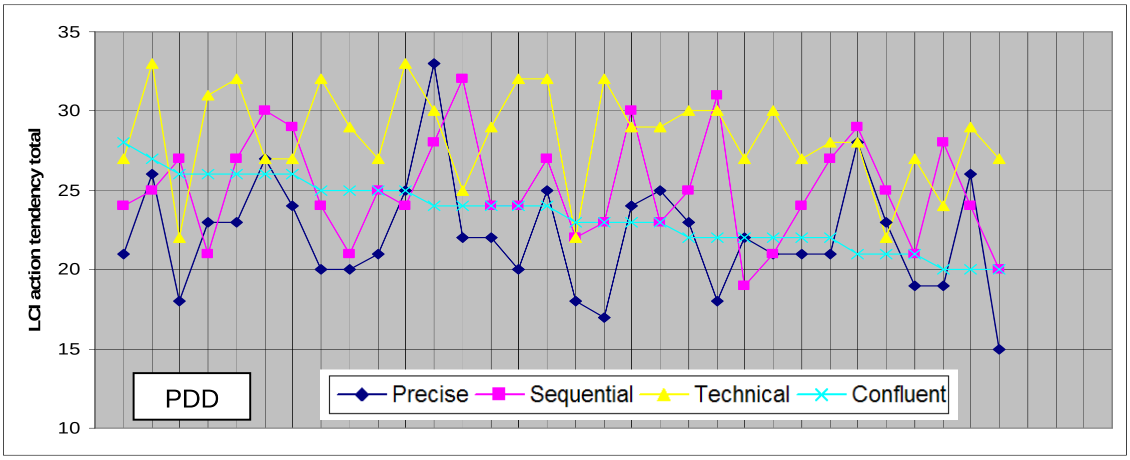


Figure 3 – Characteristic Confluent Processor ranked cohort profiles for 1st year Aerospace Engineering and Product Design and Development students

First year Aerospace Engineering students typically have lower LCI values for confluent processing than the PDD students and for about half this is their least favoured style. Prior knowledge of these profiles assists in planning project activities and also in understanding why students have difficulty or show a reluctance to take on particular tasks. Projects requiring ideas to be generated and evaluated are likely to require more tutor support and feedback with a group of Aerospace than PDD students on the basis of these cohort profiles. Awareness of their own LCI combinations by students can have a positive effect in situations where students are being asked to operate outside of their comfort zone. Discussions explaining that a learning outcome of such a task is to stretch and develop the student's ability in an area they would naturally avoid have in the majority of cases been well received and assisted the student in taking an interest and responsibility for the way in which they learn. This supports the benefit to the learning process identified by Coffield et al (2004) that self awareness of learning styles provides.

Pilot Study

An initial pilot study was carried out on thirty Stage 2 PDD students undertaking an eight week DBT project. Groups were drawn at random, LCI values were calculated and group profile graphs plotted. Students were not initially made aware of the LCI values of other group members. On completion of the project reflective comments were gathered in two ways. Each student was asked to write a 1000 word critique of how the project operated from their perspective and also to complete a peer assessment spreadsheet. The spreadsheet asks each student to confidentially score their own and all other members of the team for their contribution in each of fifteen categories which are closely aligned to the assessed elements and learning outcomes of the project. Each category must have a zero mean score and any non zero marks for individuals must be collaborated by supporting comments. Table 2 shows selected comments collated for one such group. The four columns labelled P,S,T and C give the LCI totals for Precise, Sequential, Technical and Confluent learning styles for each student in the group. Boxes coloured green indicate a strongly favoured tendency by a student for that learning style.

Table 2: Group A Stage 2 PDD reflective comments

	P	S	T	C	Reflective comments
Male A	22	25	33	26	1. Personally the reason I enjoyed the project was that it was realistic. 2. I have been told I have a leadership attitude… …and tend to assume this role. 3. Everyone had many initial ideas. 4. Female A was brilliant at collating the report. 5. Male C seemed to lack drive for the writing of the report.
Male B	19	17	32	29	1. At the start we were all very enthusiastic and bounced ideas off each other well. 2. We experienced difficulty in making major decisions, due to multiple leader types in the group. 3. I enjoy hands-on and informal classes much more. 4. Male D's research was much more detailed and in-depth.
Male C	21	23	31	26	1. The most valuable outcome of the project was gaining experience with the rapid prototyping equipment. 2. Halfway through we still had 5 different concepts which were all still being developed further.
Female A	26	25	24	25	1. I found that our downfall was decision making. 2. My perfectionism means that I feel I cannot trust others to produce work of a standard that I would hand in. 3. Male C seemed uninterested in sourcing data. 4. Male A submitted work late for the report which resulted in more stress for me as compiler. 5. I found that to keep the project flowing I had to organise the team entirely
Male D	24	23	34	27	1. As I continued through the project the more problems I encountered and realised it wasn't as easy as I had initially thought. 2. During our first meeting we came up with loads of interesting, diverse and somewhat unorthodox ideas to take forward.

It is most noticeable that four members of the group have very similar LCI profiles and strongly favour both technical and confluent learning styles. These tendencies are backed up by a number of the comments (Male A.3, Male B.1, Male B.3 & Male D.2) as well as comments suggesting that they avoided some tasks requiring the use of other styles (Male A.5, Female A.3, 4, 5). None of the group has a strong sequential processing tendency which would lead them to naturally adopt the organising role and this comes through in other comments which show an inability to make decisions and progress the project on schedule (Male B.2, Male C.2 & Female A.1). Female A has the highest precise processing score and adopted the role of report collator (Male A.4, Female A.2). Overall the comments correlate positively with how each individual would be expected to operate based solely on the LCI combinations. Interestingly if using overall performance in Stage 1 as a guide Group A should have easily outperformed all others given that several students were among the top ranked in the class. In the event they underachieved primarily due to their lack or organisation and inability to make decisions.

Table 3: Group B Stage 2 PDD reflective comments

	P	S	T	C	
Male X	21	24	29	25	1. I think that in order for a group to perform to the best of their ability some organisation is needed but too much organizing and not enough actual design work can hold the design process back. 2. I like to get a more hands on approach down in the workshops. 3. Male Y was helpful at recognising good ideas
Female Y	24	29	29	21	1. At one stage I feared we were going to fall far behind the intermediate deadlines we had set. 2. Female Z and I chased up each member for their contribution to the report.
Female Z	23	28	22	23	1. I took on the role of team leader. 2. Males X and Z worked well on CAD design which is their strength. 3. I have learnt that I like to be organised and have a plan
Male Y	22	25	30	30	1. Female Z took control of the project at the start and started to delegate responsibilities. 2. Female Y wanted to make the design too complicated. 3. The write up was the most difficult part of the project. 4. Female Z had the idea of making the deadline to complete the write up week 7 (of 8)
Male Z	17	16	32	24	1. After our initial brainstorm we quickly came up with our final idea. 2. I found the write up the least enjoyable part of the project as I much prefer doing the design and manufacturing side of things where I feel I can do a better job.

Table 3 shows the collated comments for a second Group B who undertook the same project. Boxes coloured red in the table indicate an avoidance tendency for a particular learning style. In this case there were two group members with high sequential processor values who effectively managed the project organisation (Female Y.1, Female Y.2, Female Z.3, Male Y.1, Male Y.4). Other comments again show traits characteristic of the LCI totals (Male X.2, Female Z.2, Male Y.3, Male Z.2). This group decided on a final concept early and ended up with more time than other teams to produce and test iterations of their design. This resulted in a final submission which was both aesthetically and functionally refined.

After the projects were completed and assessed each group was given a debriefing session and an open discussion took place on the relevance of the learning style preferences, combinations and shortfalls within each group that impacted on performance. This reflective practice is seen as an important part of student development and provides an opportunity for the tutor to explain the objective of attaining a high and balanced LCI combination. The issue of learning strategies distinct from learning style preferences (Sadler-Smith, 2001) can also be explained in such sessions to further assist in student self awareness of their own learning.

Using assessment methods to effect changes in LCI Totals

A previous study (Hermon, 2007) showed that the precise processing LCI totals for PDD students changed more than the other three styles, from an average of 20.3 to 23.4 over a period of two years. Subsequent analysis of curriculum content and interviews with the students concerned resulted in this change being attributed in large part to the repeated task of compiling technical reports detailing several DBT projects over the period. This is a desirable change since a large percentage of PDD students typically have this as their least favourite style (Figure 4) and as a result many students' LCI combinations became more balanced and the cohort profile more homogenised. This development of a behavioural style relevant to the discipline is also consistent with the findings of others such as Nulty and Barrett (1995) who observed less variance in students learning styles in the later years of their courses and also discipline specific learning style profiles.

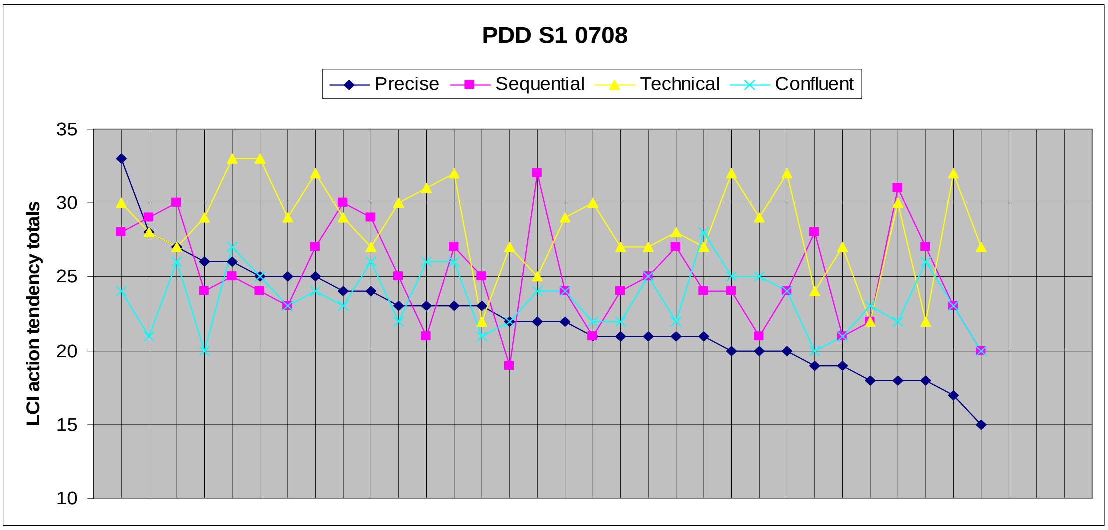


Figure 4 – Precise Processor ranked LCI totals for 1st year Product Design and Development students – academic year 0708

It is reasonable to assume that since the PDD students studied over the last three years show a consistent and characteristic cohort profile that the same reporting task and assessment regime will continue to produce the same desirable effect.

To date groups have not been formed with LCI totals in mind. A variety of methods have been employed including random selection, self selection, distribution of high achievers among groups and tutor selection to ensure students work with new partners. Retrospective analysis of the LCI profiles of such groups has shown that all conceivable combinations have been created including; all LCI combinations similar, all different, no dominant styles, all with dominant styles. Combined with a lack of self awareness or an awareness of the preferences of others in the group there is a chance that not all students will avail of the opportunity to improve the areas in which they are weakest. As can be seen from the pilot study the natural tendency among group members when tasks are being allocated is to volunteer for those they feel most comfortable doing. It is possible therefore that if groups are deliberately formed so that at least one member is strongest in one of the four styles that this could in fact inhibit the desired balancing of

LCI totals as students choose to perform tasks that will in fact only serve to strengthen their dominant preferences. Despite this risk the evidence suggests that this has not been the case regarding the observed increases in precise processing. The group report is a major part of the project and can account for up to 40% of the marks available. As such no group member is able to avoid doing their share, whether they are comfortable doing it or not. A number of the peer assessment categories also relate to the contribution to the report and failure to do an average amount within the group in this area will lead to a lower grade as peer marks contribute to the adjustment of individual grades about the group mean.

Other tasks related to other learning styles however do not carry the same weight of marks and are therefore more easily avoided. To encourage engagement in these areas by all group members other means must be employed. By building into the learning outcomes the acquisition of skills such as leadership and management it is possible to encourage students to mentor others in areas in which they are strong and the others weak. It had been observed that only some of the students in Stage 4 had continued to develop their CAD skills beyond what had been taught in formal classes in the early years of the degree. Interviews revealed that the students who are better at CAD inevitably ended up carrying out this part of the project with the common belief that the group performance would be better by adopting this approach. To reinforce this culture of peer learning it also helps to place a strong emphasis, and allocation of assessed marks, on the process of how the project is conducted as well as the product produced.

Further Work

As a result of the pilot study Stage 2 groups are now routinely constructed so that there is a balanced mix of learning style preferences represented. Some of the original objectives regarding distribution of abilities based on previous performance and giving students the opportunity to work with different people are accommodated as far as is possible but these are now secondary considerations. Careful construction of project tasks and assessment methods continues with the objective of balancing all students LCI totals. Ongoing monitoring of the effectiveness of these changes is taking place and students will retake the LCI questionnaire at the end of the academic year to measure any changes in their preferences which have occurred. Additional discussions will also be carried out in an attempt to identify events or circumstances which the students recognise as contributing to changes in their learning styles or strategies. A parallel study across the three degree programs in the School with Stage 1 group projects is also under way in which some deliberately unbalanced (in terms of LCI profile) groups have been constructed to allow observation of how students cope when asked to operate outside their comfort zone.

Conclusions

- LCI profiles are consistent and characteristic of different degree pathways.
- Prior knowledge of cohort learning style preferences can be used to structure group projects to improve the learning experience.
- Individual LCI totals can change over time as a result of curriculum and assessment methods.
- Left to their own devices students will tend to chose tasks within a group project at which they feel most comfortable.
- Combined with assessment methods the objective of balancing learning styles can be used as a reason to encourage students to take on tasks they might otherwise avoid.

References

Biggs, J.B. (1999) Teaching for Quality Learning at University: What the Student Does

Carrizosa, K. & Sheppard, S. (2000) The Importance of Learning Styles in Group Design Work; *30th ASEE/IEEE Frontiers in Education Conference*

Coffield, F. et al (2004) Should we be using learning styles? What research has to say to practice (Learning & Skills Network; https://www.lsneducation.org.uk/)

Crawley, E.F., Malmqvist, J., Östlund, S., Brodeur, D.R. (2007) Rethinking Engineering Education – The CDIO Approach: Springer, ISBN 978-0-387-38287-6

Felder, R.M. & Silverman, L.K. (1988). Learning and Teaching Styles in Engineering Education: *Engr. Education* 78(7), 674-681

Halstead, A. & Martin, L. (2002) Learning Styles: a tool for selecting students for group work; *International Journal of Electrical Engineering Education* 39(3) p 245-252

Hermon, J.P. (2007) The Use of Learning Styles as a Tool for Curriculum and Personal Development; *3rd International CDIO Conference*

Honey, P. & Mumford, A. (1986). Using Your Learning Styles, Honey – Maidenhead UK

Johnston, C. & Dainton, G. (1997). The learning combination inventory (Manual). Thousand Oaks, CA: Corwin.

Kolb, D. A. (1983). Experential Learning: Experience as the Source of Learning and Development

Kolb, D.A. (2000). Facilitator’s guide to learning. Boston: Hay/McBer

Nulty, D.D. & Barrett, M.A. (1995) Transitions in Students' Learning Styles, *Inaugural Pacific Rim - First Year Experience Conference*

Sadler-Smith, E. (2001). A Reply to Reynolds’s Critique of Learning Styles, *Journal of Management Learning* 32(3), 291-304

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