The Use of Learning Styles as a Tool for Curriculum and Personal Development

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Abstract

A broadening of the range of acceptable subjects for entrance to degree programs in the School of Mechanical & Aerospace Engineering (the School) at Queen's University Belfast (QUB) has led to an increasingly diverse academic background among the student intake. The recently introduced Product Design & Development (PDD) degree, in particular, is more diverse with significant numbers not having studied advanced level mathematics. Many also have art based qualifications on entry, rare among engineering undergraduates on the courses offered by the School. It can no longer be assumed that students entering the School possess the same fundamental knowledge, experience or approach to learning which has traditionally been the base from which to teach students on the Bachelor or Master of Engineering degree programs.

A better understanding of the student population was required and an investigation initiated. Part of this involved a survey of all stage 1 entrants to the School's degree programs. Measurements of learning style preferences were used to identify differences and trends among the various cohorts.

Individual learning style data then provided a focus for discussion with personal tutors as part of a pilot Personal Development Planning exercise with the PDD cohort. This structured and supported process helps students plan their personal, educational and career development. The emphasis was on raising awareness among the students of their own preferences and to encourage a balanced development across the range of learning styles.

Keywords: learning styles, student intake, personal development planning

Introduction

The four stages of Kolb's experiential learning cycle (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 [1] to identify how these preferences might vary across a group of students. Armed with the knowledge of how students prefer to learn, Kolb's objective was then to individualize instruction in order to produce students, competent in all four learning styles, who would be more balanced and integrated learners.

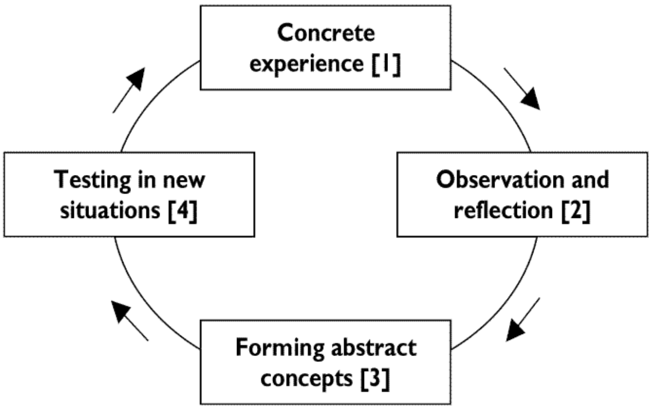

Figure 1: The four stages of the Kolb Experiential Learning Cycle

Others have developed and adapted Kolb's inventory to be more suitable for their discipline. Honey and Mumford [2] developed a Learning Style Questionnaire for managers which identifies four styles of learning and is closely aligned with the four modes of Kolb's cycle.

Felder and Silverman's study of engineering students [3] identified positive benefits gained from planning learning opportunities to take account of learning styles prevalent among engineering students. They too identified four dimensions of learning namely; Visual (verbal learners), Sensing (intuitive learners), Active (reflective learners) and Sequential (global learners). They proceeded to develop teaching techniques which address all learning styles by providing a variety and balance in content and delivery. Their methods also focus on improving motivation, attentiveness and attainment and as a result improving retention rates for students.

These and other methods of measuring learning style preferences have become popular and are widely used. A number of businesses have grown up, often involving the researchers who developed the theories. There is limited commonality between the competing methods / inventories / indices. The complex nature of an individual's learning, the vast number of other influencing factors that might have an effect and the still incomplete knowledge of how the human brain functions mean that no one metric is accepted objectively as being complete. Coffield *et al* [4] in their study of 13 models of learning styles found fault with many, including the most popular, and little evidence of benefit directly attributable to adoption of such methods. They found exaggerated claims from many practitioners and a conflict of interest, in terms of using their own data to validate claims made for the services being sold. They did, however, acknowledge that where the examination of learning styles of both student and lecturer had been carried out that there was clear evidence that the educational experience had been improved. Awareness of the existence of different learning styles and sensitive adjustment by the teacher as a consequence tended to change the teaching environment away from the traditional "chalk and talk" paradigm, thus creating an improvement. 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.
This meaningful dialogue also allows some negative effects and misconceptions of learning styles to be avoided. The fact that there are no right or wrong answers can be reinforced and

students can be reminded that the questions help identify preferences only. Students can confuse preference for a particular learning style with competence or expertise. Preferring to work in one mode does not mean that the student is necessarily better when working this way. It is also important to emphasize that these modes are not predetermined or innate; rather development of proficiency in the different modes can be acquired. It should be remembered however as Price & Richardson [5] have argued that "the validity of these learning style inventories is based on the assumption that learners can accurately and consistently reflect (a) how they process external stimuli and (b) what their internal cognitive process are". Another popular tool is the Myers-Briggs Type Indicator which focuses on personality types rather than learning styles. Coffield *et al* [4] concluded that there was little evidence to link values produced by this test with learning.

Learned patterns of behavior developed at secondary school are not what are required at university, or beyond. The A-Level examinations of the UK secondary education system, completed in small chunks over a two year period with the opportunity for retaking elements in order to boost overall grades, promote a surface or strategic learning approach with little of the reflection or criticality desired of learners within higher education. Students can become more interested in assessment than in learning and the modular organization of degree programs does little to suggest to a newly arrived student that anything different is required at university. An argument could be made for the inclusion of a Learning Styles Inventory questionnaire and discussion of learning strategies in an introductory course in stage 1 of a degree program in order to assist the desired transition in the learning practices of incoming students.

If it is accepted that there is benefit from both making students aware of the issue of learning styles and adapting curricula as suggested by Felder and Silverman [3] then an appropriate questionnaire should be used to access the learning styles profile of a student cohort, as a first step. CDIO structured degree programs which seek to develop students in all phases of the development of a product or system necessarily need to provide opportunities for this to take place. They also need to recognize which areas need most attention so that the curriculum can be adjusted to meet these needs. The measurement of learning style preferences is proposed as a method of contributing data which can be used as part of an ongoing analysis of program development. Honey and Mumford [2] contend that the most effective problem solvers are good all rounders who can adapt to a range of environments. With this objective in mind a knowledge of individual preferences can act as a focus for personal development.

Kolb [6] has suggested that individuals choose careers congruent with their learning style preferences and others such as Healy and Jenkins [7] have found Kolb inventory learning style profiles characteristic of geographers differ from those of other disciplines. A study by Harvey [8] of engineering students at Rowan University in New Jersey found an overwhelming, although not universal, preference for a "technical" learning style using a Learning Combination Inventory (LCI) instrument developed by Johnston and Dainton [9] at that university's Center for the Advancement of Learning. Having undergraduates on different degree pathways enrolled on the same module is resource efficient but may not meet the educational needs of all students if their learning style preferences differ.

Another issue of relevance here, and the subject of some debate in the published literature, is the "matching hypothesis" which suggests that learning is enriched when the style of teaching matches the preferences of the student. Kolb originally proposed such a model but later [10] concluded that there was merit in intentionally creating a mismatch so that students might in the longer term develop as a result of being stretched in areas which they might naturally chose to avoid. Reynolds [10] and others have found evidence of matching to be contradictory and inconclusive leading to debate over the validity of using learning styles as an indicator of learning strategies which might be adopted in various contexts. Sadler-Smith [15] in his reply to Reynolds critique emphasized the difference between learning styles and cognitive strategies which rather than being fixed can be adaptive to circumstance. He noted that self aware learners can develop strategies which enable them to effectively employ styles which are not their first preference. Rush and Moore [11] observed that matching styles does nothing to prepare students for situations where they are asked to operate outside of their "comfort zone". Messick [12] argued that an awareness of learning style preferences does at least serve to stimulate self reflection of what may have become unproductive learning habits or traits. Hayes and Allinson [13] concluded that although research failed to support some aspects of the matching hypothesis consideration of learning styles does have an important consequence for the efficiency and effectiveness of both training and development. On balance the potential for benefit was deemed sufficient for an investigation of the learning styles of the undergraduate intake to be carried out.

Learning Combination Inventory (LCI)

While accepting that none of the available tools for measuring learning styles is without its critics, or universally accepted as a de facto standard, it was however necessary to select one to begin the investigation. The Johnston & Dainton LCI tool [9] used was first introduced to the author during a Post Graduate Certificate in Higher Education Teaching. This is a compulsory Masters level program which all new academic staff must complete within 3 years of appointment at QUB. John Johnston, a former member of staff from the School of Education at QUB, who run the program, had co-authored a number of publications with one of the authors of the LCI (Christine Johnston) and existing staff from that School were also using the LCI tool as part of a "Centre for Excellence in Interprofessional Education" research program looking at improving team working practices and communication between different healthcare professions and services. Using the same tool also left open the option of comparing data between different disciplines at QUB.

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 Design Build Test (DBT) projects found in CDIO structured degrees. 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. 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 LCI totals represented by integer values between 7 and 35. John Johnston [14] describes the four learning styles in the following terms:

"A **sequential** processor is an individual who prefers clear and explicit directions/instructions in approaching learning tasks. Sequential processors need to be organised, to work neatly and methodically and to have the time necessary to complete tasks to their satisfaction.

A **precise** processor's predilection is for gathering, processing and utilising lots of data, and this gives rise to the asking and answering of many questions and to a preference for demonstrating learning through the writing of answers and factual reports.
A **technical** processor on the other hand is much less comfortable with writing, preferring hands-on experience with relevant materials and problem-solving tasks to which his or her own solution-forming strategies can be distinguished and applied. Technical processors tend to be challenged, independent and often private thinkers.
A **confluent** processor is creative and imaginative, has a strong preference for seeing 'the bigger picture' and enjoys finding and making the widest connections between ideas or phenomena."

Individual LCI totals in each of the 4 styles indicate whether a student is liable to avoid, use as needed or strongly favor each of the styles. (Table 1)

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 favor this action tendency. This is typically me'

Data Collection
All Stage 1 undergraduates in the School were asked to complete the LCI questionnaire during the first week of the first semester of the 2006/07 academic year. The author supervised the sessions to ensure consistency between the 3 cohorts. A short explanation of the rationale for the survey was given to each group and focused on the following key points:

- The LCI was not part of any assessment, rather for self awareness and personal development.
- Maximum benefit would be gained by answering honestly and not giving the answer you suspect your tutor would like you to give.
- There were no right or wrong answers to the questions.
- Knowledge that individual's preferences could be different should help understanding of why other group members might approach a task differently.

The LCI totals were then calculated and individual values emailed to each student along with descriptors of the four learning styles.

Results
Of concern from the outset was the retest reliability of any data. A group of 10 PDD students were entering Stage 1 having completed a foundation Stage 0 and had been asked to complete the LCI questionnaire at the end of that year. Their retested totals at the start of Stage 1 varied by

no more than ±1 and examination of how individual questions had been answered showed a high level of consistency. It is assumed in this that little change in learning style preferences would occur during the summer vacation and that scores should be reproduced in the retest.

Each vertical line of each graph in Figure 2 has four colored points which represent an individual student's LCI totals. The Technical style was the most dominant action tendency across all three subject cohorts The Mechanical Engineers in particular had a high proportion of students for whom this preference far exceeded the scores for the other styles. Aerospace Engineers scored lowest in this style and also had the lowest proportion of students for whom this tendency dominated. A first year introductory course with DBT and active and interactive content should therefore prove popular with many of the students since it matches their first preference learning style, particularly with the Mechanical Engineers where this style is more dominant.

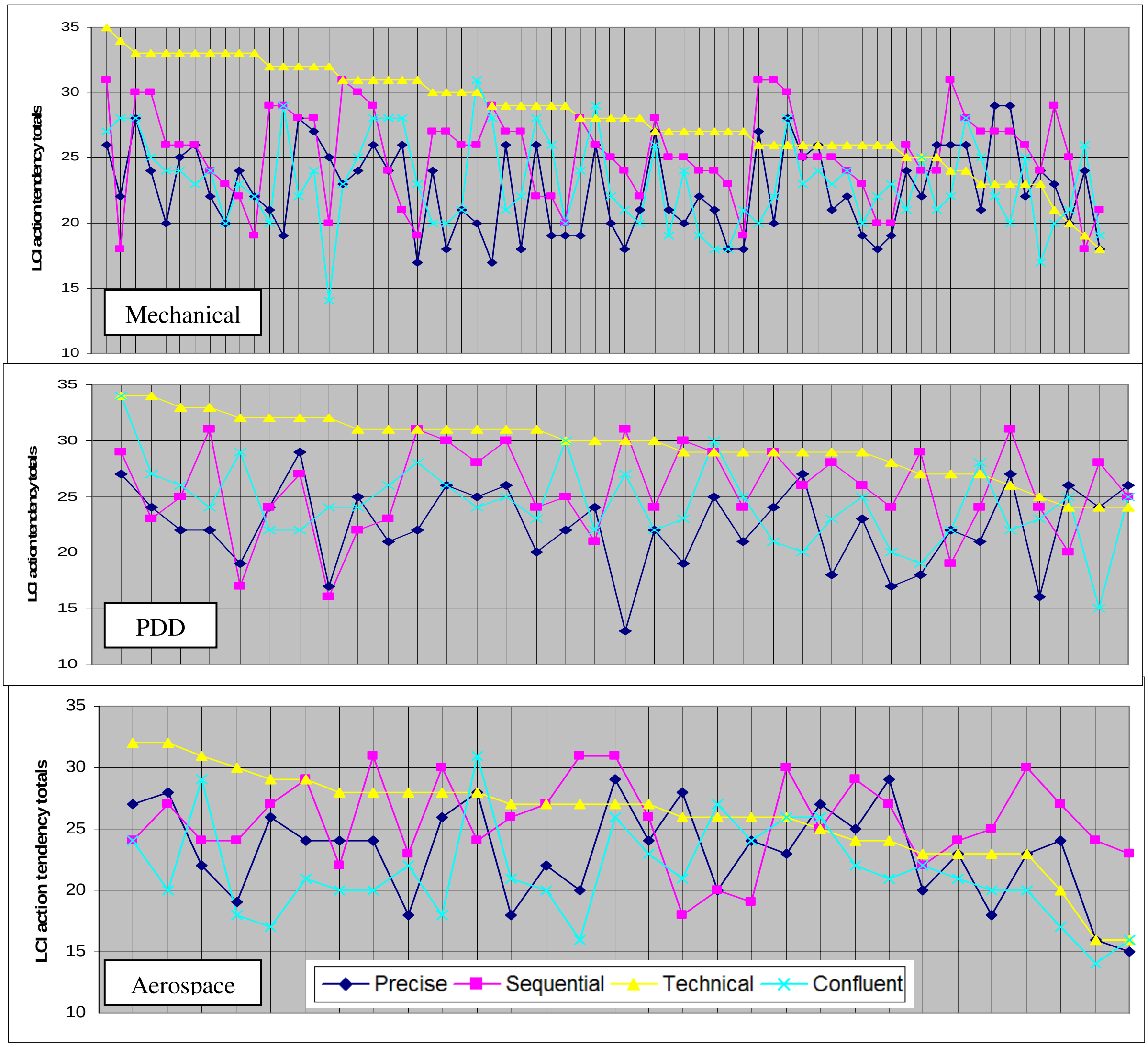

Figure 2: LCI profiles for academic year 0607 QUB stage 1 Mechanical Engineering, Product Design & Development and Aerospace Engineering students ranked by Technical style preference

The profiles ranked for the Precise processing style were very similar across the three disciplines. Very few of the students surveyed have this style as their first preference and a significant "tail" rate this as their least favored style. The PDD cohort shown in Figure 3 was typical and suggests a large percentage of students could benefit by improving their learning skills in this area.

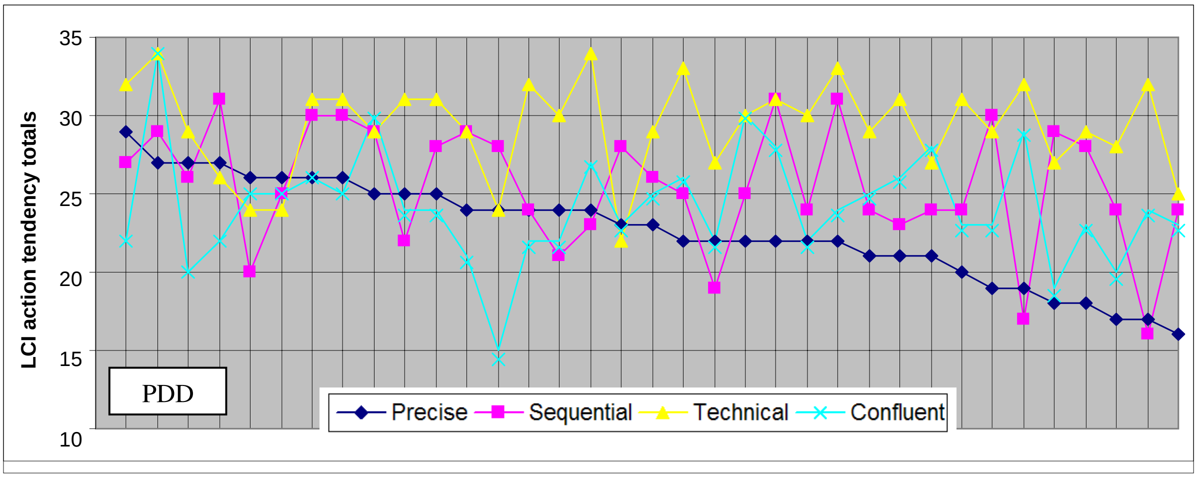

Figure 3: Product Design & Development students ranked by Precise style preference

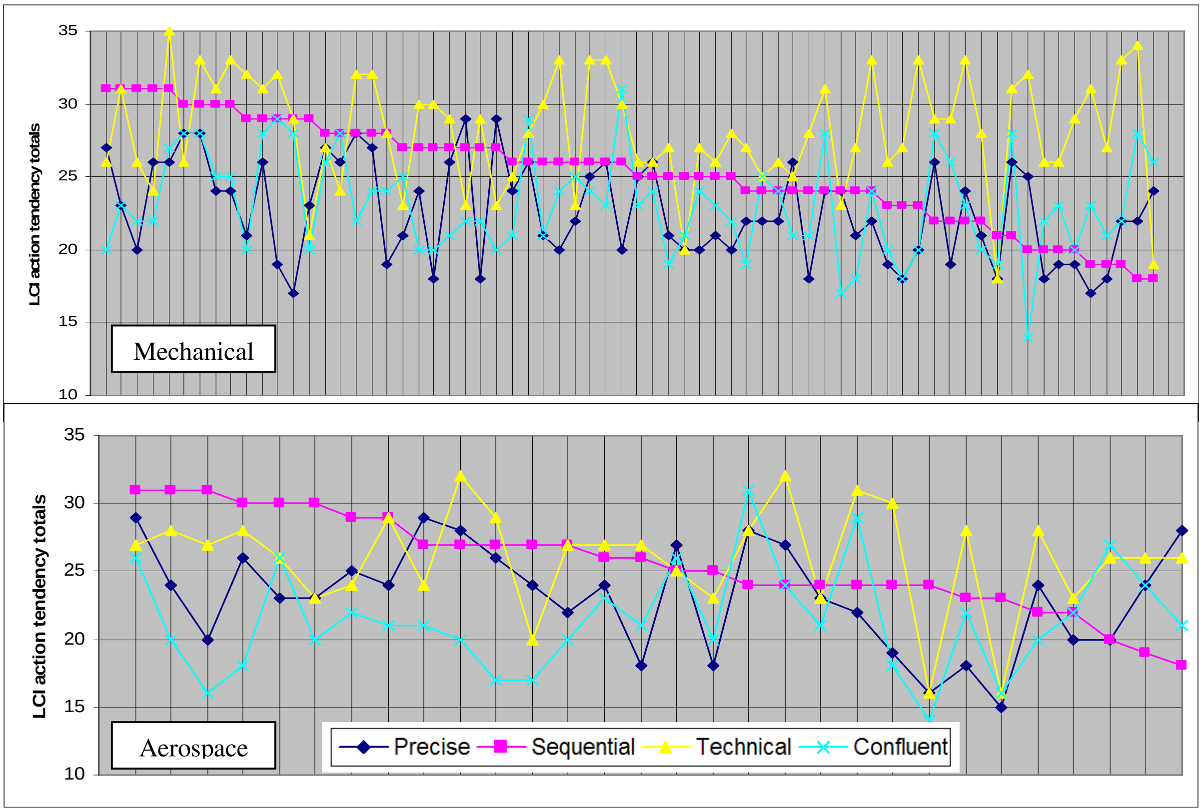

Figure 4: Mechanical and Aerospace Engineering students ranked by Sequential style

Despite the fact that entry requirements for the Mechanical and Aerospace degree programs require the same minimum grades in the same A-Level subjects the profiles for the two cohorts showed significant differences in learning style preference, most noticeably in the Sequential and Confluent processing styles.

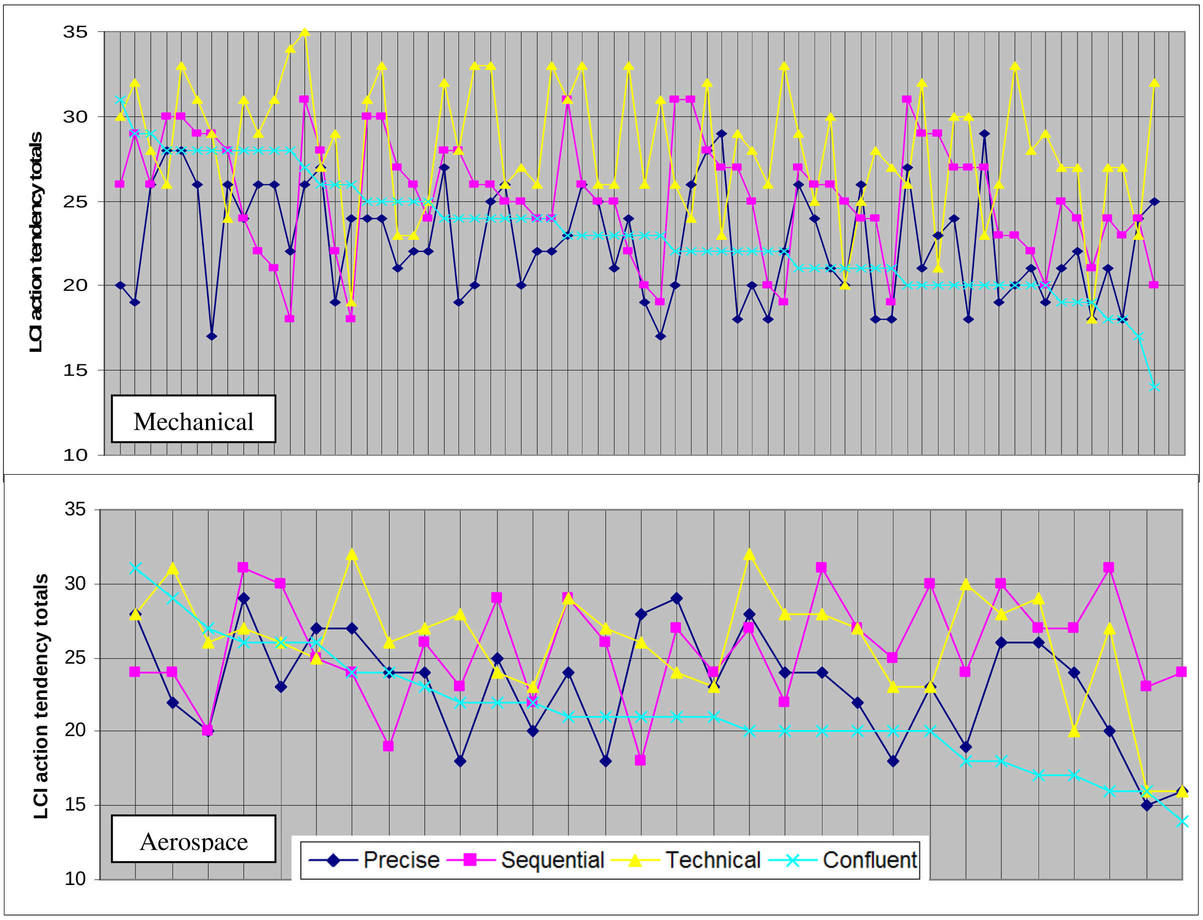

Figure 5: Mechanical and Aerospace Engineering students ranked by Confluent style

Figure 4 shows that a third of the Aerospace students are most comfortable with a Sequential style and Figure 5 shows that many of these students and half of all Aerospace students are least at ease with a Confluent style. Only a few students in each group favored the Confluent style above all others.

These students learning style combinations are evidently determined by more than A-Level subjects studied prior to university. The PDD students are in fact more like the Mechanical Engineering students across all four learning style preferences than the Aerospace group despite many having studied markedly different A-Level subjects. Consideration should be given regarding content, delivery and assessment methods for modules common to a number of degree pathways in order to meet the educational needs of all students if significant differences in learning style preference, as observed here, exist.

Table 2 shows that the Mechanical and PDD students have on average the same order of preferences. The PDD students typically rate higher in both the Technical and Confluent styles and with less variance among the group.

Table 2. QUB 0607 Stage 1 LCI Averages and (Standard Deviations)

	Mechanical	PDD	Aerospace
Precise	22.6 (3.3)	23.0 (3.5)	23.1 (3.9)
Sequential	25.3 (3.5)	25.8 (3.9)	25.6 (3.6)
Technical	28.1 (3.8)	29.5 (2.9)	26.0 (3.9)
Confluent	23.1 (3.4)	24.5 (3.1)	21.4 (3.9)

Table 3. QUB 0607 Stage 1 PDD Cohort LCI Scores Ranked by Preference for Technical Style

Gender	Precise	Sequential	Technical	Confluent	School
	27	29	34	34	
	24	23	34	27	
	22	25	33	26	
	22	31	33	24	
	19	17	32	29	
	24	24	32	22	
	29	27	32	22	
	17	16	32	24	
	25	22	31	24	
	21	23	31	26	
	22	31	31	28	
	26	30	31	26	
	25	28	31	24	
	26	30	31	25	
	20	24	31	23	
	22	25	30	30	
	24	21	30	22	
	13	31	30	27	
	22	24	30	22	
	19	30	29	23	
	25	29	29	30	
	21	24	29	25	
	24	29	29	21	
	27	26	29	20	
	18	28	29	23	
	23	26	29	25	
	17	24	28	20	
	18	29	27	19	
	22	19	27	22	
	21	24	27	28	
	27	31	26	22	
	16	24	25	23	
	26	20	24	25	
	24	28	24	15	
	26	25	24	25	
	23	28	22	23	

The central 4 columns of Table 3 correspond to the LCI scores in the order Precise, Sequential, Technical, Confluent for the 36 stage 1 PDD students surveyed. A green box indicates a score in the “strongly favor” category while a red box indicates an “avoidance” tendency. A pink square in the left hand column indicates that the data on that row belongs to a female student. A pink box in the right hand column indicates that student attended an all girls secondary school and a blue box signifies attendance at an all boys school. Reading across in rows students with both a dominating (green) and avoidance (red) tendency can be easily identified. (student names have been removed).

Since a higher percentage of female students are enrolled on the PDD degree (typically 20 – 25%) than on the traditional engineering programs run by the School, the LCI scores were examined to see if any gender specific differences were apparent. It was observed that females in the PDD group were less dominated by a Technical preference. The lowest scores were generally only just below the “strongly favor” category however and several had desirably close scores across all 4 styles. Those who had attended all girls schools were lowest among the group. A similar pattern appeared for girls in all 3 disciplines with the bottom half of scores being overwhelmingly from girls who had attended single sex schools. In the other 3 learning styles the female students were comparatively evenly distributed throughout the range of LCI values as shown in Figure 6.

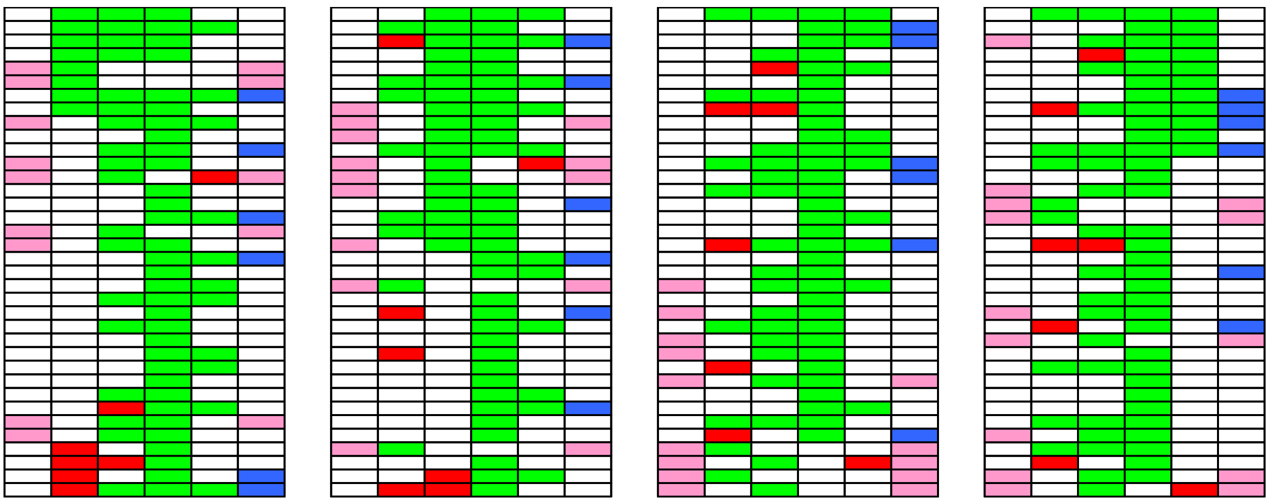

Figure 6: 0607 Stage 1 PDD LCI Profiles Ranked by Precise, Sequential, Technical & Confluent Preference

A more detailed examination of the PDD cohort was carried out in preparation for the pilot Personal Development Planning (PDP) exercise which was to follow. Design and Technology is a common A-Level for all students on this program. Approximately one quarter will additionally have studied Mathematics and another quarter Art or Art and Design. None in this cohort had studied both Mathematics and Art. Table 4 shows that the “Art” students typically had lower Sequential scores while scores for the Precise processing style varied to a much greater extent than the “Maths” students who were similarly more varied in the Confluent style.

Table 4. QUB 0607 Stage 1 PDD Students with A-Level Art or Mathematics, Ranked by Overall Average LCI

	22	31	31	28		Maths
	22	25	30	30		Maths
	21	24	27	28		Maths
	18	28	29	23		Maths
	23	28	22	23		Maths
	18	29	27	19		Maths
	24	28	24	15		Maths
	22	19	27	22		Maths
Average	21.25	26.50	27.13	23.50		
S.D.	2.19	3.74	3.00	5.04		

	26	30	31	25		Art
	24	23	34	27		Art
	22	25	33	26		Art
	24	24	32	22		Art
	27	26	29	20		Art
	26	20	24	25		Art
	17	16	32	24		Art
	16	24	25	23		Art
Average	22.75	23.50	30.00	24.00		
S.D.	4.17	4.14	3.70	2.27		

PDD Average	22.42	25.69	29.33	24.28
PDD S.D.	3.65	4.02	2.86	3.2

To enable an assessment of the level of "matching" between student and tutor learning preferences all faculty staff involved in teaching Stage 1 PDD students were asked to complete an LCI questionnaire under similar conditions to those of the student cohorts. LCI totals for the tutors of the PDD students are more balanced than their students and significantly higher in the Precise processing style (Table 5).

The first 14 students enrolled on the PDD program in 2004 showed an average increase of 3.1 points in the Precise processing style between university entry and the end of Stage 2. (Sequential +0.9, Technical +0.0, Confluent +1.6). A similar change in the 0607 intake would be desirable, particularly with the third of students who favor this style least.

The results of the LCI survey proved useful both in profiling the student body but also in identifying areas in which to focus attention during the PDP discussions.

Table 5. QUB 0607 Stage 1 PDD Student and Tutor LCI Averages

	PDD Students	PDD Tutors
Precise	23.0	27.7
Sequential	25.8	25.2
Technical	29.5	27.8
Confluent	24.5	24.5

Personal Development Planning (PDP)

Keeping a PDP file has recently been made a mandatory requirement for all students at QUB. Academic staff within the various Schools are charged with supporting the students in this practice. The aim is to help each individual become more responsible for their own learning and career development and to gain a better understanding of their own skills. The personal tutor system already in place in the School of Mechanical and Aerospace Engineering has been built upon to provide the required support for the PDP exercise. In academic year 2006/07 the PDD cohort was selected as a pilot group and four additional meetings with personal tutors were scheduled with a specific focus of discussing each tutee's PDP. One of these meetings, at the end of the second semester, concentrated on a discussion of learning styles. Each tutee was asked to look again at their completed LCI questionnaire and to change any of the scores on the basis of their experience of Stage 1. They were advised that they could move scores up or down, or indeed keep their original choices if they considered no change had taken place.
If any alteration was made the student was asked if they could identify any classes, tasks, assignments or other events which contributed to this change.

The benefits of being conscious of their learning styles were discussed at these meetings as follows:

- Eliminate "avoidance tendencies"
- Aim to produce a more balanced profile (i.e. LCI totals closer together).
- A strong preference for one style may result in a reluctance to use all others and this could be worse that having one style which is avoided.
- Raise awareness of responsibility for independent learning and awareness of individual learning style preferences. (cognitive strategy)
- Decathlon not sprint analogy, need to be a good all rounder.
- C,D,I & O phases of New Product Development cycle requiring different skills and aptitudes at different times.
- Students challenged to take on tasks outside of their comfort zone to assist with their longer term personal development.

The opportunity was also taken during these meetings to discuss a number of other issues which had been identified by the LCI analysis, for example the lower Technical scores from girls at single sex secondary schools and lower Sequential scores for students who had studied A-Level Art. The numbers of students for whom these circumstances apply is currently low but considered worth monitoring.

Future Work

The next stage is to collate the LCI totals from the amended questionnaires and map the changes in student preferences to their observations of related events. It is planned to continue measuring all new incoming students for all programs offered by the School and to repeat the testing at the end of each academic year to monitor the effect of any curriculum or teaching method changes that are made. An investigation looking for correlations between learning style preference values, or combinations, and attainment in modules assessed by terminal examinations and those assessed by continual assessment will be carried out with the 0607 Mechanical, Aerospace and PDD cohorts. A basic examination of the 0506 Stage 2 PDD class suggested a stronger positive correlation between LCI values and continually assessed modules than with modules assessed by the more traditional time limited written examination.

References

[1] Kolb, D. A. (1985). The Kolb Learning Style Inventory

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

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

[4] 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/)

[5] Price, L & Richardson, J.T.E. (2003). Meeting the challenge of diversity: a cautionary tale about learning styles; Oxford Centre for Staff and Learning Development, Oxford Brookes University

[6] Kolb, D.A. (2000). Facilitator's guide to learning. Boston: Hay/McBer

[7] Healy, M. & Jenkins, A. (2000). Kolb's Experiential Learning Theory and Its Application in Geography in Higher Education – *Journal of Geography* 99:185-195

[8] Harvey, R. (2004). Beyond Styles and Intelligences: Understanding the Learning Processes of Engineering Students - 2004 ASEE Annual Conference

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

[10] KOLB, D.A. (1984) Experiential Learning: Experience as the Source of Learning and Development. (New Jersey, Prentice-Hall Inc.).

[11] Rush, D.M. and Moore, D.M. (1991). Effect of Restructuring Training and Cognitive Style, *Educational Psychology*, 11(3), 309-321

[12] Messick, S. (1984). "The Nature of Cognitive Styles: Problems and Promise in Educational Practice", *Educational Psychologist* 19(2): 59-74.

[13] Hayes, J. & Allinson, C.W. (1996). "The Implications of Learning Styles for Training and Development: A Discussion of the Matching Hypothesis", *British Journal of Management* 6(1): 63-73

[14] Johnston, J. Q. (1996). Many Voices - One Message: A Cross-Cultural Study of Student Learning Processes with Implications for Learners, Teachers and Reformers: Will the Real Learner Raise a Hand? *American Educational Research Association's Annual Meeting*, April 1996

[15] Sadler-Smith, E. (2001). A Reply to Reynolds's Critique of Learning Style, *Journal of Management Learning* 32(3), 291-304

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