

## PEER-ASSISTED TUTORING IN CHEMICAL ENGINEERING - DEVELOPMENT OF A TUTOR-ORIENTED MODULE

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**Abstract:** A system of peer-assisted tutoring was introduced to the curriculum for a 4-year, professionally-accredited degree programme in Chemical Engineering. The system involves small-group, peer-assisted tutorials (PATs) associated with specific modules. PATs were initially developed to support a core 3rd Year module in Unit Operations. For the initial pilot series of PATs, Tutors (4th Year Chemical Engineering students) were remunerated for their efforts. The PATs provided Tutees (3rd Year students) with structured opportunities to work together, solving lecturer-defined, course-related problems, facilitated by slightly senior (4th Year) students. Tutors received training in directed-questioning and group facilitation and were supported with the relevant course material. The pilot series of PATs was positively received by Tutors and Tutees, with definable benefits for both groups. Based on the success of the initiative, a 5-credit elective module (CHEN40430: 'Peer-Assisted Tutoring in Chemical Engineering') has been developed for 4th Year Chemical Engineering students. For this module, the PATs system has been expanded to include another core, 3rd Year module, in Computational Methods, where PATs are implemented as computer-based sessions. This paper reports on the development and initial implementation of the Peer Tutoring module, with specific reference to Tutor-based elements and to Tutor experiences. Tutors reported improved understanding of the relevant engineering principles, increased confidence in group facilitation and a sense of satisfaction in supporting others in their learning. There is potential for implementation of the system in other Engineering curricula.

*Keywords; peer-assisted learning (PAL), peer-assisted tutorials (PAT), Chemical Engineering, transferable skills.*

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### 1. INTRODUCTION

#### *1.1 Background*

Engineering graduates are primarily valued by employers for discipline-related knowledge and for their ability to put that knowledge into practice. However, effective engineering practice depends upon an additional set of more generic, or so-called 'transferable' skills. In reviewing employer expectations of graduates (regardless of discipline), Archer and Davison, (2008) reported that employers prioritised communication and team-working skills. The relevance of such skills for engineering graduates is recognised by professional accreditation bodies, including, for example, the IChemE (2005). Crucially, these skills must be 'developed and integrated in an appropriate way', within the curriculum, within designated broad areas of study, including 'core Chemical Engineering'. This paper describes work undertaken at UCD, within the framework of a 4-year honours degree programme in

Chemical Engineering (accredited by Engineers Ireland and, at Masters level, by the IChemE) on the development and implementation of a senior-level elective module. The module, 'Peer-Assisted Tutoring in Chemical Engineering' (known hereafter as 'the Peer Tutoring Module'), is designed to facilitate students in developing relevant transferable skills, in a discipline-specific context. For a system of Peer-Assisted Tutorials (PATs), associated with two, core, 3rd Year Chemical Engineering modules, students enrolled in the Peer Tutoring Module act as Tutors to small groups of 3<sup>rd</sup> Year students (Tutees). This paper focuses on the structure and delivery of the Peer Tutoring Module and on the experiences of the students (Tutors) enrolled in it, when first offered, during the Spring semester, 2009-10.

### *1.2 UCD Pilot Study of Peer-Assisted Tutorials*

PATs may be described as a system of 'learning from others'; other such systems include peer-assisted learning (PAL) (e.g. Fleming, 2008) and supplemental instruction (SI) (e.g. Stone and Jacobs, 2006). PATs were first introduced to UCD in a 2008-09 pilot study, which is described elsewhere (Kieran and O'Neill, 2009). Briefly, PATs were implemented in the context of a core module for 3rd Year Chemical Engineering students (CHEN30020: Unit Operations). For the PATs, the 40 students (Tutees) enrolled in the Unit Operations module were allocated to groups of 5-6, with a single 4th Year student assigned as a Tutor to each group for the duration of the semester. The Tutors, who had volunteered for this work, were modestly paid. During the 12-week semester, there were 6 PATs. Examination-type questions were assigned as homework for each PAT, with 10% of the module grade allocated to Tutee attendance, participation and individual effort on completion of homework. The role of the Tutor was to facilitate the group in collectively addressing the assignments, rather than to teach the students or to simply provide the answers. Tutors were required to participate in a 2.5-hour training session, addressing the principles of PAL and PAT; the structure of the PATs; the role, responsibilities and expectations of the Tutors; techniques for supporting teams in solving problems; directed questioning (Jones, 2007); group facilitation.

The PATs exemplified several of the well-established 'seven principles for good practice in undergraduate education' (Chickering and Gamson, 1999). The responses of Tutors and Tutees reflected the benefits of the system, for both groups (Kieran and O'Neill, 2009). In developing the PATs, the focus was on the Tutees. However, Tutors reported a deepening of their understanding of the subject material (Unit Operations), coupled with improvements in their communication, time-management and group facilitation skills. Positive Tutee-feedback was significant in deciding to retain and extend the PAT system within the UCD curriculum. Positive Tutor-feedback was crucial in deciding to formalise Tutor involvement, specifically, to offer academic credit to Tutors, based on their achievement of professionally-relevant learning outcomes, within the framework of the PATs.

## **2. MODULE DEVELOPMENT**

### *2.1 Criteria for the Development of the Peer Tutoring Module*

UCD operates a modularised system, under which 4-year Engineering programme students select six, 5-credit, elective modules (from a total of 240 credits). Electives may be either 'in-programme' (*i.e.* from within the student's core discipline) or 'non-programme' (*i.e.* from any other discipline offered by the University, pending pre-requisite, time-tabling and capacity restrictions). The Peer Tutoring module was developed as an 'in-programme' elective, aimed at 4th Year Chemical Engineering students. In developing the module, emphasis was placed on designing a module aligned with the outcomes of the Chemical

Engineering degree programme. To meet Level 9 accreditation requirements of Engineers Ireland (2007) (equivalent to NQAI Level 9), for examples, programmes must enable graduates to develop ‘a knowledge and understanding of group dynamics and ability to exercise leadership’; additionally, graduates should ‘communicate effectively with the engineering community’, and ‘understand the training needs of others in appropriate engineering techniques’. Timing of the Peer Tutoring module was critical; it must be offered during a semester in which any PAT-supported 3rd Year modules are scheduled and during which 4th Year students enrol in an elective. The module workload must not exceed the 100-120 hour limit, as specified for all 5-credit, semester-long modules. Finally, in developing the module, issues arising from the 2008-09 pilot series of PATs, as identified by Tutors, Tutees and associated staff, were addressed. Tutors highlighted the importance of adequate preparation for PATs and of learning to lead Tutees towards a solution. They also suggested that Tutors might work together in pairs (as applies with PAL (Fleming, 2008)). Based on the success of the pilot scheme, PATs were also extended to another core, 3rd Year module, CHEN30160 (Computational Methods in Chemical & Bioprocess Engineering). Module descriptors for all UCD modules are available online (UCD, 2010).

### *2.2 The Peer Tutoring Module*

Based on the criteria identified above, the Peer Tutoring module was developed. Learning outcomes, learning activities and modes of assessment are summarised in Table 1. The learning outcomes (Table 1(a)) reflect the personal- and discipline-related gains accruing to Tutor involvement in the PATs. As both the Unit Operations and Computational Methods modules are compulsory for 3<sup>rd</sup> Year Chemical Engineering students, with occasional exceptions, the same students are enrolled in both modules. For PATs in both subjects, it was decided to assign the Tutees to the same group of 5-6 students. Tutors would be assigned to (self-selected) pairs; each Tutor pair would work with a different Tutee group for both subjects. In this way, each Tutee group had increased opportunities to develop as a team, while each Tutor pair was exposed to a total of 10-12 Tutees over the course of the semester. A key challenge was the development of an appropriate strategy for assessing Tutor achievement of learning outcomes (Table 1(b)) in the affective domain. The emphasis was on encouraging, supporting and rewarding full Tutor engagement with the PAT process; it was imperative that the Tutors be professional in their approach to their new teaching role and 50% of the module grade was allocated to preparation for, attendance at & participation in assigned PATs. Tutors were required to critically reflect on the success of their tutoring activities and the development of their skills over the course of the semester, presenting their findings in an end-of-semester reflective report. In preparation for this report, based on established principles of reflection on practice, each Tutor was required to develop an evidence-based portfolio of associated material, consisting of the following elements:

- 1. Online Blogs:** To encourage timely and shared reflection on the PATs, Tutors contributed to BlackBoard-based blogs for both Unit Operations and Computational Methods PATs. Each Tutor initially contributed a personal reflection on his/her experience of the PAT; Tutors were then required to read the accumulated reflections and contribute at least one reflective response.
- 2. Collective Reviews:** For each PAT, there was a short, structured, Collective Review, facilitated by the Chemical Engineering post-graduate student assigned as a Teaching Assistant to the PATs in that subject. This review was intended to discuss issues raised in the blogs.
- 3. Tutee Feedback:** At approximately mid-semester, Tutees were invited to provide feedback on their Tutors. Feedback was collected via in-class survey forms. Results

were confidential to each Tutor and to the Module Coordinators. Tutees were notified that their feedback could not affect the Tutor's grade in the Peer Tutoring module.

4. **Tutor-Partner Feedback:** During a single PAT in both subjects, each Tutor evaluated his/her partner; prior to the evaluations, each pair of Tutors identified aspects of personal performance on which they would particularly welcome feedback. The results were confidential to the Tutor pair but each Tutor was required to reflect on his/her evaluations in the end-of-semester report.

**Table 1 Summary of module information for 'Peer-Assisted Tutoring in Chemical Engineering': (a) Learning Outcomes, (b) Modes of Learning & Associated Workload, (c) Modes of Assessment.**

<b>(a) Learning Outcomes</b>		
<i>On successful completion of the Peer Tutoring module, students should be able to:</i>		
1.	Facilitate productive team work, in engineering contexts;	
2.	Effectively communicate, and encourage student communication of engineering concepts;	
3.	More fully appreciate engineering concepts, through communicating them to others;	
4.	Critically appraise personal and team performance.	
<b>(b) Modes of Learning &amp; Associated Workload</b>		
<i>Activity</i>	<i>Hours</i>	<i>Details</i>
Tutor Training & Module Review	6	2 x 2-hour tutor training workshops during Weeks 1-2 1 x 2 hour Training & Review session during Week 6
Discipline-Specific Training & Review of previous PATs	13	1-hour PAT review/preparation sessions; guided preparation for and review of PATs, scheduled approx weekly throughout semester.
PATs	8	8 x 1-hour Unit Operations PATs
	16	8 x 2-hour Computational Methods PATs
Specified Learning Activities	8	on-line reporting on each PAT (approx 0.5 hour/PAT)
Autonomous Student Learning	65	personal preparation for each PAT, plus report preparation
<b>Estimate Total Tutor Workload</b>	<b>116</b>	
<b>(c) Modes of Assessment</b>		
<i>Assessment</i>	<i>Details</i>	<i>% of module grade</i>
Continuous assessment	Preparation for, attendance at & participation in assigned PATs	50
	Short, online reporting on and appraisal of PATs	30
Assignment	1500-2000 word reflective report on Tutor experiences of PATs	20
<b>Total</b>		<b>100</b>

The module necessarily involves the application of a diverse range of pedagogical principles. Tutors were introduced to selected relevant topics during the training sessions; key works in the refereed literature were identified. Students were required to research this literature in reflecting on one or more aspects of their development as Tutors. Together, the above activities accounted for 50% of the module grade. Students were encouraged to use Hampton's (2007) guide to interpret and develop outcomes in their reflective writing (i.e. 'What have I learned from this?', 'What does this mean for my future teaching?')

#### 2.4 Module Evaluation

Evaluation processes were strategically embedded in the module. While each PAT was supervised by a Module Coordinator and/or Teaching Assistant, the blogs allowed for timely identification of issues of concern to the Tutors, or to the Tutees (e.g. optimal Tutor-Tutee

seating arrangements in the Unit Operations PATs; encouraging participation by quieter Tutees). Regular Collective Reviews allowed for group discussion of these and subject-specific problems. Feedback was formally solicited from Tutors and Tutees, via in-class surveys distributed towards the end of the semester. Questions on the Tutor Survey, relating to Tutor experiences of the Peer Tutoring module, are presented in Table 2. (Questions relating to the Unit Operations and Computational Methods PATs have been excluded; likewise, Tutee feedback is not considered here.) Data from the Tutor Surveys, administered during the penultimate week of the semester, provided a basis for an informal, Coordinator-moderated review of the module with the Tutors, at the end of the semester. This multi-faceted approach to review, although time-consuming, ensured that issues arising could be speedily addressed and difficulties resolved; equally importantly, it ensured that Tutors and Tutees had a real sense of involvement in and commitment to the PATs.

### 3. IMPLEMENTATION & EVALUATION

#### *3.1 Tutor Recruitment & Enrolment*

The Peer Tutoring module was advertised to incoming 4th Year students during Summer 2009. Enrolment was limited to students who had already taken and achieved at least a C-grade in both the Unit Operations and Computational Methods modules. Students applying for admission were invited to attend a short interview with the Module Coordinators. Ultimately, all 12 applicants (6 male, 6 female) were accepted. Students were notified of acceptance in late October. The module commenced in January 2010. (Survey responses, expressed (below) in percentages, refer to the necessarily small population of 12 Tutors.)

#### *3.2 Tutor Training*

Tutor training was based on that developed for the pilot PATs (Kieran and O'Neill, 2009). It was delivered with the support of two Teaching Assistants (one assigned to each set of PATs). There was considerable emphasis on Tutor assessment, with a view to evaluating achievement of learning outcomes; the concept of reflective writing was new to all Tutors; a 1-hour session was devoted to relevant pedagogical principles. Formal 'Preparation Sessions' were scheduled for each PAT, allowing Tutors to refamiliarise themselves with the subject material and to identify concepts with which Tutees might struggle.

#### *3.3 Tutor Experiences of the Peer Tutoring Module – Survey Results*

##### *3.3.1 Achievement of Module Learning Outcomes*

Overall, Tutor feedback on the Peer Tutoring module was extremely positive and reflected a very high degree of congruence between the expectations and perceptions of both Tutors and the Module Coordinators. All Tutors were 'very much'/'fully' aware of the module learning outcomes; all believed that they 'very much'/'fully' achieved those learning outcomes and that the methods of assessment 'very much'/'fully' supported them in this undertaking. With regard to development of specific skills, Tutors expressed most satisfaction with their improvements in the areas of 'facilitating teamwork' (100%: 'very much'), their own 'understanding of engineering concepts' (100%: 'very much'); 10 out of 12 Tutors (83.3%) believed they had 'very much' improved their skills in the areas of 'communicating engineering concepts', 'encouraging communication of engineering concepts' and 'understanding and supporting the learning process in others'. The areas in which Tutors registered the lowest levels of improvement were critical appraisal of 'personal performance' (66.7%: 'very much') and 'team performance' (50%: 'very much'). Only one-third of Tutors found the training 'very much' effective; the remainder evaluated it as 'somewhat' effective

in supporting the achievement of learning outcomes. Tutors indicated that the training sessions could be shortened ('a single session would probably have sufficed'); no topics were identified as irrelevant, no omissions were identified ('Good introduction to the module'). Tutor opinions on the effectiveness of the modes of assessment were more divided. 25% of Tutors found the blogs 'not at all' useful, while the remainder evaluated them as either 'somewhat useful' (58.3%; 'They were good at the start but as time went on they became less useful & repetitive.') or 'very much' (16.7%). However, in-class discussion revealed that, in working on the end-of-semester reflective report, the blogs provided an invaluable record of PAT experiences; Tutors agreed that the requirement to make blog entries was very effective in ensuring timely and sequential review of their efforts. Both the surveys and in-class discussion revealed some overlap between the blogs and the Collective Reviews. Although 2 Tutors found the Reviews 'very' useful ('It was great to talk through problems and realise other groups had similar problems and then discuss solutions.'). the remainder evaluated them as either 'somewhat' useful (58.3%; 'Either these or the blogs; both are not necessary as we just tended to repeat things in the review sessions.') or 'not at all' useful (25%; 'We Tutors discussed the PATs informally, so this formal method was repetitive'). The Tutors were more enthusiastic about the mechanisms for feedback from Tutees (all ranked this element as either 'very much' (58.3%) or 'somewhat' (41.7%) useful ('It gave a good insight into how the Tutees were feeling & where I needed to improve.'). With regard to the Tutor Partner Feedback, all but one of the Tutors rated this as 'somewhat'/'very much' useful.

### *3.3.2 Tutor Motivation for Enrolling in the Module*

Since the introduction of the Horizons system in UCD, which allows students to choose a limited number of elective modules, there has been concern about the bases on which students will choose these modules. However, a campus-wide study of students enrolled in non-programme electives (Hennessy et al., 2010) revealed that, although a substantial minority of students consciously seek an 'easy option', the majority are most highly motivated by an interest in the subject area. Encouragingly, the students who enrolled in the Peer Tutoring module were primarily motivated by the professional relevance of the module (91.7% 'very much'), the opportunity to improve their communication skills (83.3%) and the opportunity to improve their understanding of the subject material (66.67%).

### *3.3.3 Overall Evaluation of Tutor Experiences of the Module*

Just over half of the Tutors evaluated their experience of the module as 'very useful' (58%; 'assisting student development was very satisfying'); the remainder judged it to be 'useful'. For the Tutors, the most frequently cited 'best aspects' of the module were the satisfaction associated with supporting the Tutees in their learning, interacting with the Tutees, personal development of associated skills ('growing in confidence as a leader', developing my communication & team work skills'); increased understanding of the relevant subject material ('I got to know the subject matter in great detail'). In conclusion, 10 of the 12 Tutors (83.3%) confirmed that 'if they'd known in September what you know now', they would have enrolled for the module; the same number confirmed that they would recommend the module to the 3rd Year students. In both cases, the dissenting students answered 'maybe'; no Tutor responded negatively to either question.

### *3.4 Tutor Experiences of the Peer Tutoring Module – The Time Factor*

Time-related issues were explicitly addressed in only one question in the Tutor Survey (Table 2, Question 6). However, workload was identified by 9 Tutors as the 'worst aspect' of the module. Specifically, Tutors felt their time commitment for this module was significantly greater than for other elective modules pursued by their classmates. However, they admitted

that this module contributed to their personal, professional and academic development to a greater extent than so-called 'easy options'. They unanimously agreed that they did not devote more time to it than anticipated (Table 1(b)); in fact, they admitted spending less than 116 hours on the module. But their involvement in the module was very well-defined and they felt a greater onus to attend each scheduled element than every lecture in a 'normal' module.

**Table 2 Survey questions addressed to Tutors, relating to their experiences of the Peer Tutoring Module.** Where appropriate, 4-level Likert-scale or yes/no response options were employed. An asterisk indicates that Tutors were invited to comment on their responses.

<b>Achievement of Module Learning Outcomes</b>	
1.	To what extent were you aware of the learning outcomes for this module?
2.	To what extent do you feel you achieved the learning outcomes?
3.	Overall, to what extent do you feel the module assessment supported your learning?
4.	To what extent do you believe your skills in each of the following areas improved, as a result of your involvement in CHEN40430?
(a)	facilitating productive team work, in engineering contexts?
(b)	effectively communicating engineering concepts?
(c)	effectively encouraging student communication of engineering concepts?
(d)	your understanding of engineering concepts, through communicating them to others?
(e)	understanding and supporting the learning process in others?
(f)	critically appraising student/team performance?
(g)	critically appraising personal performance?
5.	How useful did you find the following in supporting your achievement of the learning outcomes?
(a)	'General' Tutor-Training Sessions?*
(b)	UO Prep Sessions?*
(c)	CM Prep Sessions?*
(d)	Online Blogs?*
(e)	Collective Review Sessions?*
(f)	Tutee Feedback?*
(g)	Tutor-Partner Observation?*
6.	<i>Excluding</i> the scheduled preparation sessions, on average, how many hours did you spend preparing for each (a) Unit Operations O PAT and (b) Computational Methods PAT?
<b>Tutor Motivation in Enrolling in the Module</b>	
7.	How important were each of the following factors to you in deciding to enrol in CHEN40430?
(a)	professional relevance?
(b)	improving communication skills?
(c)	improving your understanding of the topics?
(d)	mode(s) of assessment?
(e)	interest in teaching?
(f)	other? ( <i>please specify</i> )
<b>Overall Evaluation of Tutor Experiences of the Module</b>	
8.	Overall, how would you evaluate your experience as a Tutor?*
9.	With what aspects of your work as a Tutor were you most satisfied?
10.	What aspects of your work as a Tutor most require improvement?
11.	If you knew last September what you know now, would you still enrol in CHEN40430?*
12.	Would you recommend this module to 3rd Year students for next year?*
13.	What were the best aspects of CHEN40430?
14.	What were the worst aspects of CHEN40430?
15.	What changes to CHEN40430 would you recommend for next year?

#### 4. CONCLUSIONS & RECOMMENDATIONS

The Peer Tutoring module is an example of how the development of transferable skills, in a discipline-specific context, may be incorporated into an Engineering curriculum. Although specifically applied within a professionally-accredited Chemical Engineering programme,

there is obvious potential for implementation within other Engineering disciplines. The current paper reports on the initial offering of the module, involving only a relatively small number of Tutors (12). Additionally, only Tutor experiences have been considered here; a longitudinal study of the impact of the module on the Tutees involved is also required. For the immediate future, Tutor feedback will be used to modify the module. Although, dialogue with others is a key aspect of reflecting on teaching/tutoring practice (Brockbank and McGill, 2000), evidence from the current study suggested that the extent of both blogs and Collective Review sessions could be reduced, with associated reductions in Tutor workload.

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