

**Comparing students' learning experiences during a major
educational curriculum reform in engineering**
Findings of a mixed-method study

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ABSTRACT

Over the past four years, the Faculty of Engineering Sciences at University College London (UCL) has been implementing a multi-disciplinary curriculum review of engineering education – the Integrated Engineering Programme (IEP) – where

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students, from the very beginning of their degree, engage with the practical application of engineering and skills needed to undertake engineering projects effectively.

The IEP was implemented at the start of the 2014/15 academic year for a new cohort of nearly 700 engineering students, and has recently graduated its first class of BEng/BSc students. Since September 2014, approximately 3,000 students have participated in this cross-faculty programme and the current 2017/18 academic year is the first year where all UCL undergraduates studying engineering are IEP students.

In order to explore the student experiences in navigating the IEP, data were collected through focus groups and an online survey, based on the National Survey of Student Engagement (NSSE), by the end of second term for five consecutive academic years.

This paper reports the findings of a mixed-method study comparing the motivations, expectations and learning experiences of IEP and non-IEP students. The results suggest that IEP students were enthusiastic about their studies, as they were more likely to discuss ideas from their reading or lectures with others outside of class. They were also more likely to agree that UCL is contributing to their ability to solve complex real-world problems. IEP students also considered that the Minors contribute to broadening their skillset education, and enables wider career options.

Conference Key Areas: Curriculum Development; Innovative Teaching and Learning Methods

Keywords: students' learning experiences; integrated curriculum; mixed-methods

INTRODUCTION

Over the past years it has been argued by industry, professional bodies and students that engineering higher education must ensure that engineering graduates are given opportunities to develop a wide range of technical knowledge and problem-solving skills to work effectively in diverse professional contexts [1]

Back in 2014, the Faculty of Engineering Sciences at UCL implemented a multi-disciplinary curriculum review of engineering education – the Integrated Engineering Programme (IEP) – where students engage with the practical application of engineering from the very beginning of their degree [2]. This curricular reform was motivated by the need to change the traditional educational approach – with very little group work and practical projects in the first two years, and with departments operating in traditional silos – in order to provide engineering graduates with the breadth of professional skills required by engineering careers.

A new cohort of nearly 700 engineering students started their studies in the IEP in September 2014. Since then, approximately 3,000 students have participated in this cross-faculty programme and the current 2017/18 academic year is the first year where all UCL undergraduates studying engineering are IEP students.

In order to explore the student experiences in navigating the IEP, data collection was planned to provide evidence-based findings and support further refinement and development initiatives. Assessing and monitoring student progress is fundamental to understand student's motivations, attitudes towards teaching and learning, and expectations about career outcomes. Researchers in engineering education have found that individual's perceptions and previous experiences, at the beginning of an engineering course, have a strong influence on student persistence [3][4]. Data was

gathered before the implementation of the IEP, to provide a baseline level for future comparisons. Collection of baseline data, before the beginning of an instructional intervention is known to be one of the most common quantitative approaches used in engineering educational research [5]. Data was also collected during the initial three years of the programme.

This paper compares the motivations, expectations and learning experiences of IEP and non-IEP students in order to explore the impact of the new engineering programme on students' experience.

1 METHODS & RESEARCH DESIGN

To assess the student's experience in the IEP, a mixed methods approach was used. Data was collected through an online survey, and focus groups by the end of second term and for five consecutive academic years starting in 2012/13. To encourage academic honesty, staff from UCL Arena Centre were commissioned to organize and run both surveys and focus groups. In line with the university's education strategy, the UCL Arena Centre works with academic and professional colleagues from across UCL to develop engaging, research-based approaches to education, and to improve the standard of learning, teaching and assessment at UCL.

1.1 Online Survey

An online survey was based on the National Survey of Student Engagement (NSSE). It comprised 29 questions about students experience during their current academic year. All engineering students were invited to participate in the survey by the end of the second term in five consecutive academic years.

The first set of questions in the survey addressed demographic data (age, sex, ethnicity, fee status, mode of study, year of study, level of study, current grades, accommodation, parents' highest level of education, students' highest level of education, and engineering department). The findings presented in this paper focus on questions addressing: students' learning experience at UCL, and how often they enrolled in certain types of academic activities, such as asking questions in class or making class presentations (very much, often, sometimes, never, or not applicable); what mental activities were emphasized by coursework, such as memorizing, synthesizing and organizing ideas (very much, quite a bit, some, very little, none, or not applicable); relationship with other students, academic staff, and administrative personnel and offices using a scale ranging from 1 (unfriendly, unsupportive, sense of alienation/ unavailable, unhelpful, unsympathetic/ unhelpful, inconsiderate/rigid) to 6 (friendly, supportive, sense of belonging/ available, helpful, sympathetic/ helpful, considerate/flexible); and how students' experience at UCL contributed to their knowledge, skills, and personal development in different areas such as acquiring a broad general education, writing clearly and effectively (very much, quite a bit, some, very little, none, or not applicable).

For reporting purposes, the level for statistical significance was set at 0.05. The chi-square statistic was used for testing relationships between categorical variables. *T*-tests were conducted to assess whether the means of two independent groups (IEP and non-IEP) were statistically different from each other.

1.2 Focus groups

Focus groups were run at the end of the second term in five consecutive academic years, focusing on three main research questions: 1) what students like about their current degrees? (subject; what do they learn and how do they learn; what job can they get from doing it); 2) what could be further developed? (what changes would students

like to see in their degrees; are they happy with the lecturers, group work, assessment?); 3) What changes have they seen in the past year and how do they view these? However, students were allowed to explore questions that emerged.

The sessions run in 2012/13 and 2013/14 were pre-IEP. In the three following academic years, focus groups sessions were run with IEP students and non-IEP students separately.

2 RESULTS

Descriptive statistics

Participants that were studying at postgraduate level (MSc, Doctorate) or were undergraduates in Y4 (MEng) were excluded from the analysis, as no comparable IEP data was available by 2016/17. A total sample of 396 students (208 IEP and 188 non-IEP) was analysed. The breakdown by student group (IEP or non-IEP) and year of study is provided in Table 1. The majority of students were between 18-21 years old, and 35% were female. Half of the participants identified as 'White' and 36% as 'Asian'. The proportion of UK students was significantly lower in the IEP group (31.3%) in comparison to the non-IEP group (47.6%) ($\chi(2) = 11.111, p = .004$), meaning that the IEP cohort was more international.

Table 1. Participants by student group and year of study

Student group	Year of study				Gender	Age	Domicile	Ethnicity		
	1	2	3	total	Female	18-21	UK	White	Asian	Black
Non-IEP	64	56	68	188	33.0%	83.4%	47.6%	50.5%	35.6%	4.3%
IEP	111	55	42	208	36.9%	81.3%	31.1%	50.5%	35.6%	3.4%

Results

IEP students were significantly more likely to have made a class presentation (86.5%) than non-IEP students (77.4%) ($\chi(4) = 7.358, p = .025$). IEP students were significantly more likely to report having used an electronic medium to discuss or complete an assignment *very often* (51.9%) than non-IEP students (39.9%) ($\chi(4) = 9.757, p = .045$). These findings align with the high proportion of active learning and teamwork that feature in the IEP.

IEP students were also significantly more likely to have discussed ideas from their readings or classes with others outside of class more *often* (41.5%) than non-IEP students (26.1%) ($\chi(4) = 11.707, p = .020$), suggesting the enthusiasm of students with their teaching and learning experience in the new programme, by having the opportunity to work in projects targeting real-world problems, and also having the chance to work with students from different disciplines. As IEP students mentioned,

[IEP] *"I mean I tell people from ... my friends from other unis about how I had this Integrated Engineering sort of module and they were really impressed with it because they'd never heard of such a thing before where loads of different disciplines had worked together for a project. And yeah they were pretty impressed by it and I think enjoyed it quite a lot"*

[IEP] *"We had two summer challenges. The second one was actually a collaboration between Mechanical Engineering and Civil Engineering. So we were a big group of about 10 students, 5 were mechanical engineers and 5 were civil. And the idea of that challenge was to essentially build or design a water dam and distribute energy to a town. So it was a nice collaboration because in mechanical engineering you're thinking about in thermodynamics, the energy flow in water dams and how energy is provided. And then civil engineers were helping as well with creating designs for the towers that were going to hold the dam and get the power cables to the town. I actually like that collaboration ... and also we ended up making friends with people in Civil Engineering"*

[IEP] *"(...) research is really actual, we work on a current topic and current problems. So even if it's biofuel, because there are kind of two different sides (...) PGTA's are currently working on virus for Zika so it's really actual research"*

[IEP] *"I think scenarios are useful because allows us to put in practice all the theories that we learned, and also they are very different. This year we had four scenarios, one was a pilot plant [and] the one before that was about producing sufficient bioethanol for the UK transport necessities, so it was very interesting because in the first we had one really lab focussed, and then the previous one was about building the overall plant and thinking of what you do, how do you recycle the water, your energy, thinking a bit about legislation, fuel. And the one before was about production of the bio ethanol but on a really close focus point. And it also allow us to go around in the labs, meet people from the departments, which was really nice, because we don't have many occasions to do so. So it kinds of gives us the opportunity to catch up on the research that's currently going on in the department"*

No major differences were found between IEP and non-IEP groups regarding coursework typology, with both groups of students equally likely to report: some memorization; *quite a bit* of analytical, synthesis and judgement skills; and *very much* applied theories to practical problems or new situations.

Students were asked to rate their relationship with other students, academic staff, and administrative personnel and offices using a scale ranging from 1 to 6. No differences were found between IEP and non-IEP students regarding the assessment of their relationship with other students (IEP M = 4.64, sd = 1.200; non-IEP M = 4.61, sd = 1.116), and academic staff (IEP M = 3.94, sd = 1.246; non-IEP M = 3.98, sd = 1.325). However, IEP students were significantly more likely to rate their relationship with administrative personnel and offices less positively than non-IEP students (IEP M = 3.88, sd = 1.282; non-IEP M = 4.33, sd = 1.312; $t(386) = 3.437$, $p = .001$). In order to further explore this result, relationship ratings where analysed by year of study. Data showed that IEP students' rating of their relationship with both academic and administrative staff decreased in year 2 (Figure 1).

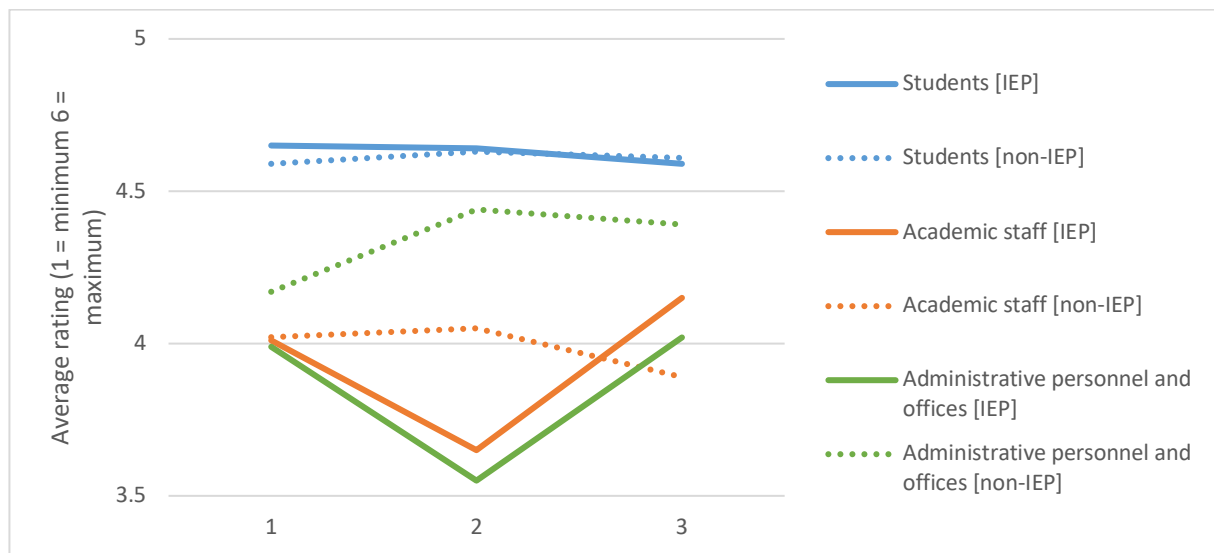


Fig. 1. Students' relationship with other students, academic staff and administrative personnel and offices by IEP status and academic year

A decrease in satisfaction was mentioned by second year IEP students during focus groups sessions, with participants saying that coursework was more intensive than expected.

[IEP] *"Second year is getting better, but probably we expect something more. Because second year when we are doing with labs we focus so much more on lab reports and how to write a lab report"*

[IEP] *"The second year is better but from a student perspective it's far more challenging. And we spend so much more time on like studies to anything else compared to last year. And I would say it's very intense"*

[IEP] *"You know in the first year you've got some time to read a bit, read outside that, but second year you just ... okay I'm done, I'm done. But by the time you say I'm done it's probably like Sunday night, which leaves you no room for preparation for the next Monday. Whereas like the first year let's say you've got the weekend I'm done probably like Saturday morning and (...) maybe I can hang out with my friends"*

This may have had an impact on IEP students' relationship with academic staff, but not necessarily with administrative staff. No particular mention to the relationship with administrative staff was found in the focus groups.

Second year students in the non-IEP focus groups shared different perceptions. Some students mentioned year 1 and year 2 as being the heavily theoretical and year 3 as being more applied,

[non-IEP] *"It's like the first and second year, they teach you the theory of it, and then the third year is when you're supposed to apply that theory, actually building the plant for example"*

Whereas other students referred to year 1 as being either more challenging or less interesting than years 2 and 3.

[non-IEP] *“Second year we didn’t have much, and then third year again it was just small courseworks, small programming courseworks, and ... yeah just lectures and stuff like that. So second and third year there wasn’t much, and then first year there was a lot, which was really good”*

[non-IEP] *“first year was very ... cos we didn’t do IEP so it was very much oh take a Maths class here, a Chemistry class here and a BioChem class here, and then we’ll have (inaudible) BioChem Eng (...) And then the second year was more sort of integrated but .. I feel like first year was more getting everything up to speed, coming from different... coming from different degrees and qualifications and things. So to make sure we’re all on the same standard (...) [First year] I found a lot of that repetitive from school. And then second year was more integrated definitely and more actual engineering and applied engineering. And that’s continuing in third year. So I was just a bit bored in first year so that’s why I was less motivated”.*

When asked to what extent their experience at UCL contributed to their knowledge, skills, and personal development, IEP students were more likely to think that UCL contributed to ‘acquiring a broad general education’ (86.7%) than non-IEP students (80.9%); and ‘solving complex real-world problems’ (87.2%) than non-IEP students (81.4%).

This was also reflected in the focus groups with IEP students, as one of the students said,

[IEP] *“Whereas the IEP is ... I would say it’s interesting (...) Because it’s ... they give you a real problem that ... which makes perfect logic sense which is daily life (...) It’s not like what you really have to just you know put some equations and get it done, you really need to think about it. And you’re doing something that you can actually do in real world where I mean ... not like coursework ... it’s not just experiment, you’re doing on like a real world scale basis, so it’s very different from what we usually learn and what we usually have. That’s why everyone likes it”.*

To give students a distinctive edge after graduation, all students study an IEP Minor option as part of their degree. Most IEP Minors are either topics from disciplines complementary to engineering (such as Biomechanics or Programming), or interdisciplinary subjects based on UCL’s research strengths (such as Finance & Accounting or Engineering and Public Policy), taught by cross-disciplinary teams. IEP Minors are selected in the first year and taught across the second and third years (three modules equalling 45 credits in total). Although not specifically asked in the survey and focus groups sessions, IEP students considered the Minors to be an important feature of the programme. Overall, they agreed that the Minors have a positive contribution to broadening their skillset education, as illustrated by the following quote from one of the IEP students,

[IEP] *“I choose Public Policy because I missed Social Sciences in the degree. Which it was nice to have (...) a topic that’s not Biochemical Engineering related. And also it can link together because (...) transdisciplinary training depending on the professional pathway you want to follow (...) I think the minors is really cool actually (...) I kind of see it as a way to do something different to my degree, and kind of broaden my skillset.*

3 FUTURE WORK

Although the IEP is in its early years, the results described in this paper seem to suggest that the programme has a positive impact in students' enthusiasm about their studies and is contributing to develop students' ability to solve complex real-world problems.

However, to better assess the impact of the programme, more data needs to be planned, collected and analysed. A pre- and post-survey study with the first cohort of students starting the IEP in 2014/15 is currently being analysed, comparing students expectations and career plans when entering UCL (Year 1 in 2014/15) and at the end of their MEng degree (Year 4 in 2017/18). A follow-up study is also being planned with alumni to explore the impact of the IEP on career choices and pathways.

It would also be interesting to further explore the expectations and perceptions of students about their relationships with administrative staff, since they support various aspects of the student journey and experience.

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