A Cross-Discipline Technopreneurship Course: Student Perceived Benefits and Considerations

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***Abstract*—This innovative practice full paper describes the development and implementation of a cross-discipline technopreneurship course, highlighting best practice, the benefits of the course perceived by students and further considerations. The course is offered at a large prestigious UK university in a department where electronic, electrical engineering and computer science courses are taught, and is mandatory for the electrical and electronic engineering students and elective for computer engineering students, who are in their third year of study as part of combined bachelor's and master's degree programs. It emphasizes teamwork, problem identification, problem solving, and creativity. This course uniquely integrates engineering skills with entrepreneurship, using a project-based learning approach requiring students to work in teams to develop a pitch, business plan, technical feasibility study, and a working prototype. These have been shown to be the most predominant methods to assess technopreneurship courses. However, the course is set apart by the focus on real-world world problems and fostering connections between students and the local start-up ecosystem. A key strength of the course is to improve students professional skills, which has been shown to be desired by employers in industry.**

In this work, we outline the course structure, intended learning outcomes, assessment, schedule of teaching, and present findings gained from teaching the course. Therefore, it is easily replicable by other practitioners. We detail how this builds upon previous practices to further the aims of the course to increase links with the local start-up ecosystem and improve students professional skills. The results of an online questionnaire proposed by the University optionally completed by students at the end of the course in the 2022/23 and 2023/24 academic years, revealed that students do perceive the benefit of the course as a way to develop their professional skills, such as public speaking, teamwork, and writing skills. Furthermore, the students appreciated the course structure and felt well-informed about the assessment. The results also revealed that the students rated the course highly for overall quality. The work produced by the teams confirmed our hypothesis that the hardware and/or software nature of their prototype/product appears to be disconnected from the makeup of students from the two different program backgrounds enrolled on the course. For instance, a team of only electronic engineering students still had a highly important software component that was vital for their final product. However, even more interestingly, the success of each team would appear to be based upon the team dynamics, which was monitored by the academic instructor in chard of the course throughout the entirety of the course and was a part of the assessment. Teams that demonstrated good levels of teamwork, overall tended to do better in the course than teams, which did not.

***Index Terms*—computing engineering, electrical engineering, entrepreneurship, innovation, problem solving**

I. Introduction

In the contemporary landscape where the convergence of technology and entrepreneurship is not just a trend but a necessity [1], the integration of multidisciplinary approaches within higher education is paramount [2]. Furthermore, the development of engineering students' professional skills is still highly sought after by future employers [3]. Hence, this paper provides details of a technopreneurship course, that aims to improve students professional skills. This course is distinctive in its amalgamation of engineering ability and entrepreneurial skills, aiming to cultivate a proactive and inventive mindset among students. The goal of this work is to understand do students perceive the course as improving their professional skills, as well as their overall perception of the course. Furthermore, does the multidisciplinary nature of the teams influence the technical work that is produced?

Employing a project-based learning strategy, the course mandates participation from electrical and electronic engineering (EEE) students, with an elective extension to computer engineering (CE) students, urging them to collaboratively engage in the development of a business pitch, a comprehensive business plan, a technical feasibility study, and a working demonstrative prototype. This novel educational approach not only promotes the acquisition of technical skills but significantly emphasizes the enhancement of professional skills such as teamwork, problem identification, problem-solving, and creativity, which are increasingly deemed vital by industry [3].

Through an exhaustive overview of the course's structure, intended learning outcomes (ILOs), and assessment criteria, this paper explores the perceived benefits of this cross-disciplinary course as reported by the students. It further examines the role of the course in facilitating engagement with the local start-up ecosystem, thereby offering a pragmatic platform for the application of theoretical knowledge. Moreover, the study analyzes the outcomes of an online questionnaire conducted among the participants and the projects developed during the course, aiming to evaluate the impact of such an interdisciplinary approach on students' development of professional skills and its influence on the nature of their project outputs. The findings affirm the effectiveness of the course in bolstering students' readiness for the workforce and provide insights into the dynamics of cross-discipline collaboration in developing innovation.

Incorporating theoretical learning with practical application, this paper underwrties the significance of the discussed technopreneurship course as a model for future educational endeavors aimed at preparing students with a holistic skill set. To the best of our knowledge, there are very few works that specifically focus on student perception of what skills they benefit from technopreneurship courses. Furthermore, there is a lack of focus on the how cross-disciplinary team make up influences team outputs in technopreneurship courses.

II. Background

A. Related Work

In [4] the authors specifically investigated student perceptions of teaching and assessment methods regarding a cross-disciplinary engineering technopreneurship course. They showed that students found benefit in all teaching methods utilized, particularly mentor sessions and guest lectures, and that presentations was the most beneficial assessment method. However, their course is not adequately described in order to make it replicable.

The results of a survey to students studying engineering programs across multiple technopreneurship courses, found that students studying engineering programs tended to have little meaningful proir experience with entrepreneurship [5]. Though it has been reported that entrepreneurship courses can improve students attitudes towards entrepreneurship, with increased self-confidence to pursue it [6], [7]. Furthermore, the work by Edwards et al. shows that engineering students perception of entrepreneurship is not improved through extracurricular activities alone [8]. Thus, pointing out the necessity of technopreneurship courses being part of the curriculum for engineering degree programs as a method to promote innovation amongst students.

Shekhar and Huang-Saad in [9], examined technopreneurship courses from a practitioner perspective, particularly in regard to how these type of courses might be improved. One deficit noted was that students failed to see the purpose or benefit of these courses to their future careers. Though the authors noted this could be exacerbated by the lack of academic advice, another issue could be the lack of awareness around professional skills gained by taking these courses.

In [10] the authors broadly investigated engineering students perceptions of a technopreneurship course. It was found that students did perceive a benefit to their entrepreneurial mindset, and personal development. However, specific skills that are transferable to their future careers was not noted. The students also noted some criticism that the course could be elective. Therefore, it could be argued the students still do not perceive the overall benefit of such a course to their career and believe it to be less valuable compared to courses that explicitly taught domain specific knowledge. The authors did point out that those students that had little or no prior experience with experiential-based learning also had difficulty in adjusting to the different style of learning.

B. Teaching Technopreneurship

There is wide variability in terms of how technopreneurship courses are delivered [11]. Yet the use of the 3Cs framework by the Kern Entrepreneurial Engineering Network (KEEN) has shown popularity, most prominently amongst KEEN member institutions [12]. The framework is typically implemented through experiential-based learning aligned to the learning outcomes of improving curiosity, making connections, and creating value [13]. However, this is primarily based within the USA and there are other frameworks and guidance available, such as that provided by the UK's Quality Assurance Agency (QAA) [14], which also utilizes the European Commission's (EU) EntreComp framework [15]. However, all of these different frameworks, do not offer a one size fits all solution for how to implement technopreneurship courses, and hence there is resultant variability in course delivery and assessment.

The authors in [16] examined the assessment methods used within technopreneurship courses. They found that surveys were the most common form of assessment, particularly student self-report surveys, where students directly evaluate their own capabilities. However, it was noted that these surveys are prone to self-report bias, since students are not always accurate or honest when assessing themselves [17]. Peer evaluation surveys, were seen to also be prone to similar biases and other issues [18]. It was shown that project deliverables such as reports, presentations, prototypes, and business plans, were second most popular and are a effective method to evaluate student skills. Project deliverables were also shown in [11] to be a highly popular method of assessment. Technopreneurship courses typically implement an experiential-based learning approach [11], therefore making project deliverables a very appropriate form of assessment.

Since many practitioners in engineering faculties are expected to deliver technopreneurship courses this can mean a steep learning curve [19] for acadmic staff. However, the utilization of guest lectures from local experts in business-aligned topics can be beneficial for the students [20].

C. Technopreneurship Course Overview

This course is compulsory for EEE students on an Master of Engineering (MEng) pathway in the third year of their studies. Students on a CE MEng pathway in third year can optionally choose this course as well. The course uses a project-based learning approach, utilizing a combination of peer evaluation, individual continuous assessment from the course instructors, and project deliverables including a pitch, business plan and technical feasibility study as primary assessment methods. The course follows the guidelines provided by the UK's QAA for enterprise and entrepreneurship education. The students enrolled on the course are allowed to self-organize into teams consisting of either four or five members. Each team is required to deliver a pitch, business plan and technical feasibility study as part of the assessment. Though working in a team, each student will receive an individual mark as detailed in Section II-C2. The students are given previous exemplar business plans and technical feasibility studies to better understand the quality of work they should produce [21]. The course runs over two academic semesters (a full academic year). The course aims to offer the students chances to network and get involved with the local start-up ecosystem, which they can utilize immediately in their other studies and later in their careers. Another aim of the course is to improve the students' professional skills, such as presenting, teamwork, report writing, and problem solving.

1) Intended Learning Outcomes: The ILOs for this course are characterized into three different types: general, specific and skills. All of the ILOs are summarized in Table I. From the table it is clear that this course is designed to improve and assess the students' ability to work as part of a team, and assimilate business practices relevant to a start-up business. It should noted that the distribution of students from the two different degree programs varies and therefore, cross-discipline collaboration within teams is not prescriptive but typically can and will occur. The teams are expected to create a working prototype to demonstrate in the pitch assessment. This demonstration facilitates the acclimation of domain specific knowledge they have already gained throughout their studies previously and it is covered in the product development ILO. The development of students' professional skills and business acumen is predominant within the ILOs. This was decided to give the students valuable experience that will be relevant to them in graduate jobs. The idea that a person in a technical role does not need to know about business practices is outdated and it arguably becomes even more important as they progress in their careers, be it software development [22] or engineering [3].

TABLE I: Course ILOs.

General	Specific	Skills
Report writing.	Ability to pitch a concept.	Presentation delivery.
Business presentation.	Product development.	Business plan creation.
Assimilation of business practices.		Team-working.
Generation of business ideas/products.		Team-assessment.
		Creativity.

2) Assessment: The assessment takes the form of five key components: (i) pitch presentation, (ii) business plan, (iii) technical feasibility study, (iv) peer assessment, (v) individual continuous contribution. Each student must attend at least 80% of the scheduled meetings with the academic instructor in charge of the course, hereby referred to as the instructor, or they will not pass. Successful attendance is a compulsory aspect of the course and forms part of the individual continuous contribution assessment component. A breakdown of how each assessment component is weighted for each role is given in Table II. The roles available within a five member team are as follows: Chief Executive Officer (CEO), Chief Operating Officer (COO), Chief Technical Officer (CTO), Chief Marketing Officer (CMO), and Chief Finance Officer (CFO). However, within a four member team the COO role is removed.

TABLE II: Marking matrix for each role and the weighting of each assessment component.

Assessment component	Role				
	CEO	COO	CTO	CMO	CFO
Pitch presentation	25	20	15	20	25
Business plan	30	30	20	30	30
Technical feasibility study	15	20	35	10	15
Peer assessment	15	15	15	15	15
Individual continuous contribution	15	15	15	15	15
Total	100	100	100	100	100

The pitch is an oral presentation in person made to a panel with relevant experience of the processes in setting up companies, with a maximum time limit of fifteen minutes, followed by ten minutes of questions and five minutes of verbal feedback from the panel. The pitch is similar to those that start-up companies would give to potential investors. The teams are strongly advised to follow a template that is given to them. Though it is only a template and it is expected to be altered appropriately for their start-up business. This allows each team the opportunity to outline their product idea, innovation, market research, marketing, operation, and finance with the aim of appealing to the panel members to invest in their start-up venture. The panel consists of four members from the local start-up ecosystem, therefore offering realistic feedback and an impartial assessment as they would have never seen the students give the pitches before. Each panel member marks each team on the pitch content and the pitch delivery. The panel members also record at least one positive comment and one critical comment from a predetermined set of thirty-six comments, as well as write any additional feedback they have not covered by those comments. The pitches are recorded and given to the students afterwards for reflection along with the written feedback. The recordings serve an additional purpose of being used as pitch exemplars to new cohorts in subsequent years. The marks awarded by each panel member for each team are averaged before being used in the marking matrix in Table II. However, the average for each team may be moderated by the instructor if they are extremely skewed. Within each pitch there must be a demonstration of the team's prototype that has been created throughout the course.

The business plan comprises of the setup and establishment of a start-up company, addressing the innovation, marketing, operation and finance of such a venture. The technology aspect should be explained at a level suitable for senior management. Each business plan varies in emphasis depending on the product(s) and the resulting implications for marketing, sales, commercialization, etc. The main aim of the business plan is to convince the reader that the team have considered all aspects for the setup and establishment of the start-up company.

The emphasis of the business plan is that similar to the pitch: the emphasis should be on the key points and not on the detail. However, it is essential to convince the reader that this is a serious proposition. For this reason, a target page length of up to forty pages is required and teams are penalized for exceeding this limit. Appendices can be used judicially. The format of the business plan is not fully prescribed but there must be sections covering the products or service (including the problem addressed), marketing, finance (including operational costing, sales), intellectual property and competition, which it will be marked against. It is important for the teams to create the business plan to match their proposition (within reason) rather than be inhibited by a set format. Each section of the business plan must be clearly labelled with the name of the team member that was the author. This helps to better understand the contribution and distribution of work that has went into the business plan. As although this is a team based project, each student is awarded an individual final mark.

Unlike many other business propositions and courses involving company formation or commercial exploitation, a key aspect of this course is a detailed treatment of the technology aspect of the company product. This is expected due to the technical background of the students undertaking this course. Therefore, the technical feasibility study, targets the technical aspects of a business start-up, in particular, the product idea, and its technical feasibility.

The technical feasibility study will need to include a sufficient level of technical description and would need to convince a technically aware reader that it is viable. It is expected that, unlike the business plan, the format of the technical feasibility study will vary dramatically depending on the proposed product and company. For example, it may use conventional technology that would need to be only briefly described or may use innovative technology, which will need to be described in detail. It may also be a software implementation; in which case the technical description should be a description of the algorithms implemented and some of the code validation. The focus of the technical feasibility study should be obvious to any trained engineer, following from the outline of the problem and proposed solution.

A key aspect of this course is teamwork. In order for the project to be successful, it is critical that each team member works and collaborates. Individual members work will impact on each other, e.g., the CFO will require information about the marketing strategy for financial projections which is reliant on the CMO. The teams are expected to record meeting minutes using a standard template and upload them to Microsoft Teams so that the instructor can view them. If there is insufficient progress by one or more of the team members, it is important that this is either addressed internally within the team or, if necessary, be brought to the attention of the instructor who will work to resolve the issue. It is recognized that each team member will have a good insight into their fellow member's achievements. As such, each team member will be asked to grade other team members on their performance throughout the year using a peer assessment form. The peer assessment asks the students to use Likert-scale questions to assess the other members of the team on their attendance, punctuality, quality of work, quantity of work and interpersonal relationships. They are also expected to give commentary explaining the reasoning behind the marks they have given.

This course demands a high degree of teamwork, and it requires that each individual contribute within the team. The instructor will assess each team member's continuous contribution through the duration of the course. Feedback on individual performance is provided each semester during team meetings. Both the peer assessment and individual continuous contribution assessment components enable individual performance to be fully recognized in this team project, as well knowing who contributed to which sections in the business plan and technical feasibility study.

3) Lectures and Support: The instructor coordinates guest lectures and leads thirty-minute meetings with each team every week. The course is run entirely in-person. The usage of guest lectures is for two reasons. Firstly, the guest lectures allows the students a chance to network with individuals involved in the local start-up ecosystem. Secondly, the guest lecturers have greater specific working knowledge of the topic they are delivering to the students. Therefore, the guest lecturers are able to answer questions realistically. An objective this course is for the projects to be plausible in the real-world. This gives the students an experience that what they are working on has real-world impact and not just another university project, which is a common criticism [11]. What follows is a detailed weekly schedule of the course over the two academic semesters.

Week 1: The course lecture provides the students with a detailed description of the course contents and how it is assessed. The context for the course, and its relevance to promote and improve their professional skills is highlighted. Even if they do not wish to start a business currently or in the short-term future, being intrapreneurial within an organization is a key message. This also sets out the level of expectation about the quality of work, with brief information about the work that previous alumni created.

Week 2: An ideation practical is delivered, giving the students a first opportunity to be creative, and explore problems in a system process. The students use the United Nations Sustainable Development Goals [23] to work through the Double Diamond approach to design thinking [24]. This is the first time the students will have come across this methodology for problem identification and problem solving. Typically, the students will have previously had projects in their studies, which develop their problem solving ability. However, they will have had little chance to improve their problem identification skills prior to this. Hence this is a vital aspect that occurs at the start of the course. It also gives the students a process to follow during this difficult aspect of the course.

Week 3: A guest lecture is delivered from a local start-up incubator and networking organization. This is used to provide the students with real-world example success stories they can relate to. Furthermore, this is a key contact for them in the future as the organization arranges local competitions and programs for start-up ventures. After the lecture the students meet with the instructor in their teams to discuss their ideas. The expectation is that students will have numerous new ideas every week to discuss, and any that are promising should then be assigned to a team member for further investigation.

Week 4: A guest lecture is delivered on finances. This is practical lecture, which gives an example of how to use template financial spreadsheets provided to fill in key information, to project sales, costs, turnover, profit and funding required over the first five years of their proposed business. It should be noted that the template financial spreadsheets given to the students are used by local funding organizations, therefore being realistic in terms of expected detail. After the lecture the students meet with the instructor in their teams to discuss their ideas. This format of a guest lecture followed by meetings with the teams is continued during weeks 5, 6, 8, 9, and 10.

Week 5: A guest lecture is delivered on manufacturing from an engineer at a local manufacturing company (it is not required that the teams will develop are physical products, instead they can be wholly software-based). The pros and cons of local manufacturing versus manufacturing oversees is a key point within this lecture. Furthermore, the students are able to contact the engineer afterwards if they have follow on questions.

Week 6: A guest lecture is delivered on branding from a local branding company. The aim of this is to highlight the importance of branding to the students and conveying a consistent message that aligns to their company values. This is very different to anything they previously have learned but provides them with clear tools they can use to help them create a brand for their ventures.

Week 7: No new content or meetings with the teams and the instructor. However, the teams are still expected to meet individually.

Week 8: A guest lecture is delivered on intellectual property (IP) by a local patent attorney. The value of IP and the different mechanisms how the teams can protect their IP is presented. This provides them with a clearer understanding of the value of what they are doing in the course. Furthermore, it is highly relevant if they wish to continue their project on post completion of the course. After the lecture the students meet with the instructor in their teams to discuss their ideas and begin to finalize what their chosen problem and solution will be. The aim of the meetings over the next five weeks is for a suitable problem and solution to be chosen, for the teams to select roles and being their individual tasks relevant to those roles. This is typically motivated by what is expected in their pitch presentation including a prototype demonstration, business plan and technical feasibility study.

Week 9: A guest lecture is delivered on marketing and business planning from a business development manager. The concept of a business model canvas, is presented, which aids the students to focus on the important key aspects of the business they need to know once they have now (or immanently) decided their problem and solution. Furthermore, different types of business models are discussed with the students to give them a broad understanding of how this can vary. Similar to week 8, during team meetings with the instructor the students should typically have decided on their chosen problem and solution at this point and decided on roles. The CTO is immediately tasked with determining what the prototype in the pitch will be and to order in any parts required. This is to ensure the required parts arrive before the end of the semester.

Week 10: A lecture is delivered on pitching by previous alumni. This gives extra detail about the pitching template the students have been given and are expected to use for their assessed pitch presentation. It demonstrates how the pitching template is used for structure but that each teams pitch should be completely individual that relates specifically to their proposed business.

Weeks 11 & 12: In these two weeks as the semester finishes, there are no more formal lectures. The teams will meet with the instructor each week to discuss their progress.

Week 13: At the start of the new academic semester the instructor meet with the teams to ensure work starts on the project again after a break between semesters. A draft of the businesses financial spreadsheets are also due at the end of this week. These will be reviewed by the financial expert that delivered the guest lecture in week 4.

Week 14: Each team meets with the financial expert from week 4 and the course lectures to provide formative feedback on their financial spreadsheets. Key issues with their forecasting, business model and how realistic their projections are, is discussed. The students are reminded that the format of the weekly meetings will changing going forward and that they are expected to deliver their pitch every week now to the instructor to gain formative feedback.

Weeks 15, 16 & 17: The teams meet with the instructor to delivery their pitch and receive formative feedback not only on the content but also their delivery. This is used to refine their presenting and public speaking ability. However, since the instructor will have seen the pitches numerous times, this is why an external panel that has never seen the pitches before is used to assess the teams.

Week 18: No meetings with the teams and the instructor. However, the teams are still expected to meet individually.

Weeks 19, 20 & 21: The teams meet with the instructor to delivery their pitch and receive formative feedback not only on the content but also their delivery. During week 20 the teams submit drafts of the business plan and technical feasibility study, in order to gain formative feedback on them. In week 21, the teams have their pitch presentation assessment.

Week 22: All the teams are provided with the written feedback on their pitches from the panel the previous week, the written formative feedback on the business plan and technical feasibility study, and a copy of their recorded pitch assessment. The instructor hold a final lecture to reflect on the course, highlighting the skills the students have all developed and discussing the feedback given the teams. This is the last formal lecture and meeting time with the students.

Week 23: The teams submit their business plan, technical feasibility study and their peer assessments. There are no meetings with the teams unless at urgent request from a team, however most queries should already have been dealt with regarding the submissions in the previous week.

Within the weekly meetings with the student teams, the progress of each team is monitored. Furthermore, the instructor offers the students advice on what they should do to further improve their work and what to do next. The meetings act as the main mechanism to provide the student teams with formative feedback throughout the course. The students are however expected to meet with their respective teams in addition to the weekly meeting with the instructor, in order to maintain a steady pace and to stay coordinated.

III. Research Questions

In detail, we address the following research questions (RQs):

- *RQ1*: Do students appreciate the course structure and learning resources?
- *RQ2*: Are the students content with the assessment and feedback within the course?
- *RQ3*: Are the students satisfied with the course?
- *RQ4*: Do students perceive the technopreneurship course to benefit their professional skills?
- *RQ5*: Does the degree program of the individual team members influence the team's demonstrative prototype?
- *RQ6*: Does the degree program of the CTO within each team influence the team's final demonstrative prototype?

IV. Method

To address our research questions, we evaluated the responses to the online questionnaire proposed by the university at the end of the course. The questionnaire consisted of several Likert-scale questions to be rated on a five-point semantic differential scale [25] from "strongly agree" = 5 to "strongly disagree" = 1. Students could also provide written feedback via an optional question with a text response. The demonstrative prototypes created by each team were evaluated and the nature of them was classified. Based on enrollment records the degree program each student is enrolled on is known.

The online questionnaire is provided at the end of each course by the university in order to evaluate its courses. The course was run over the full academic year (i.e., both fall and spring semesters) in 2022/23 and 2023/24, with the questionnaire provided at the end of each spring semester. Over the 2022/23 and 2023/24 academic years the course had the same academic instructor. Furthermore, the instructor was from an electrical and electronic engineering background. The questions in the online questionnaire are presented in Table III, question numbers 1.1 to 1.4 relate to the course structure and learning resources, questions 2.1 to 2.4 relate to assessment and feedback, question 3.1 is concerned with overall satisfaction of the course, and finally question 4.1 is an open text based question aimed to understand what the students found beneficial about the course. Questions 1.1 to 3.1 are all mandatory, and question 4.1 is optional. The total number of students enrolled on the course was in 2022/23 was 23 and the total number of students enrolled on the course was 15 in 2023/24. The response rates of the questionnaire were 17.4%, and 86.7%, for the 2022/23 and 2023/24 academic years, respectively.

TABLE III: Online questionnaire for the technopreneurship course.

Number	Question
1.1	The course was well-prepared and well-organized.
1.2	The course learning resources (notes, web-based material, software, etc.) were accessible, clear and helpful.
1.3	The course was intellectually stimulating and challenging.
1.4	The course content met my expectations.
2.1	The criteria used in marking have been made clear in advance.
2.2	Assessment arrangements and marking have been fair.
2.3	Feedback on my work was received in line with School policy.
2.4	I have received helpful comments on my work.
3.1	Overall, I am satisfied with the quality of the course.
4.1	What did you find most valuable on the course?

V. Results

The results of the online questionnaire and the course outputs for the academic years 2022/23 and 2023/24 are provided in this Section.

A. Online Questionnaire

The results from questions 1.1 to 3.1 are presented in Table IV. The course was generally well-received, with high ratings for its preparation, organization, and intellectual stimulation (i.e., questions 1.1, 1.2, and 1.3), indicating a positive student response to the structure and learning resources provided. This is an encouraging sign that the course's design, which blends engineering and entrepreneurship, successfully engages students and meets their expectations for a challenging educational experience. The relatively lower score for Q1.4 in 2022/23 suggests that while the course was intellectually stimulating, there might have been a gap between students' expectations and the content delivered. However, an improvement in this area in 2023/24 indicates that adjustments may have been made to align the course content more closely with student expectations. Regarding the assessment and feedback processes (i.e., questions 2.1 to 2.4), students reported clarity in the marking criteria and fairness in assessment arrangements. The feedback received was in line with school policy, and helpful comments were provided on their work. These results suggest that the course's assessment methods are effective in communicating expectations and providing constructive feedback. Student satisfaction with the course (i.e, question 3.1) remained consistently high across the two academic years, further affirming the course's effectiveness in delivering a quality educational experience.

The text based answers to question 4.1 have been anecdotally categorized and the results are shown in Table V. It is clear from the responses that students perceived a benefit to their pitching/presenting/public speaking skills, as well their team work ability. Other notable benefits remarked by them included improved to their business/finance knowledge, report writing, and personal skills. Personal skills can be interpreted

TABLE IV: Online questionnaire results for questions 1.1 to 3.1 for academic years 2022/23 and 2023/24.

Number	2022/23		2023/24	
	mean	std. dev.	mean	std. dev
1.1	4.5	0.6	4.6	0.5
1.2	4.8	0.5	4.2	0.7
1.3	4.8	0.5	4.5	0.7
1.4	3.5	0.6	4.2	0.7
2.1	4.8	0.5	4.5	0.5
2.2	4.3	1	4.3	0.8
2.3	4.8	0.5	4.5	0.7
2.4	4.5	1	4.3	0.9
3.1	4.3	1	4.2	0.6

broadly in this context, but it is interesting to note that two students mentioned it.

TABLE V: Categorization of text responses from optional question 4.1 in the online questionnaire, from both 2022/23 and 2023/24 academic years, with an overall response rate of 36.84% (i.e., 14 out of 38).

Category	Number of responses
Pitching/presentation/public speaking	7
Team work	5
Business/finance knowledge	2
Report writing	2
Personal skills	2
Technical skills	1
Organization	1
Time Management	1
Leadership	1

B. Team Makeup and Outputs

The degree program of the students in each team for both academic years is provided in Table VI. It is noted that in the year 2022/23 65.22% of the students were on the EEE degree program with 34.78% on the CE degree program, and in 2023/24 73.33% of the students were on the EEE degree program with 26.67% on the CE degree program. This demonstrates that over the two years of the course running that students on the EEE degree program are predominant.

TABLE VI: Program backgrounds for each team, and demonstration focus for the team pitch assessment, which could be either electronic hardware (H), software (S), or both (B), for years 2022/23 and 2023/24

Team	2022/23				2023/24			
	size	EEE	CE	demo.	size	EEE	CE	demo.
1	5	3	2	H	5	4	1	H
2	5	4	1	S	5	5	0	H
3	4	2	2	H	5	2	3	H
4	4	1	3	H	-	-	-	-
5	5	5	0	H	-	-	-	-

Table VI also contains a classification for the students prototype demonstration they created during the course as part of the pitch assessment component. These have been classified as being either focused on electronic hardware (H), software (S), or both (B). An electronic hardware prototype typically contains embedded software, as the students make use of a Raspberry Pi [26] or an Arduino [27], since they facilitate rapid prototyping. However, the distinction is made that a software demonstration will either be a functioning web or smartphone app. Of course some demonstrations can utilize a combination of both and hence, this is included in the table. Inspection of Table VI shows that regardless of the makeup of the teams degree program most teams (i.e., 87.5%) utilize hardware with embedded software. However, it should be noted that it is not uncommon for those teams to mention a smartphone app might be a further development in the future of the business, but it is not what they demonstrate as part of their prototype in the pitch assessment. The one team that did create a smartphone app, most surprisingly contained mainly students from the EEE degree program. This is unexpected, since students on the CE degree program gain more software development experience. The CTO within that team was from the CE degree program, and therefore took it upon themselves to develop it entirely by themselves. This poses a further investigation to understand is the demonstration prototype focus more dependent on the degree program of the student with the CTO role in the team.

The results for the degree program of the CTO within in each and the demonstration prototype classification is provided within Table VII. Interestingly there overall there is an equal split amongst the CTOs' degree program between EEE and CE. Furthermore, it is also clear that the demonstrative prototype that the CTO creates is not dependent on the degree program of the CTO.

TABLE VII: Program backgrounds for the CTO in each team, and demonstration focus for the team pitch assessment, which could be either electronic hardware (H), software (S), or both (B), for years 2022/23 and 2023/24

Team	2022/23		2023/24	
	degree program	demo.	degree program	demo.
1	EEE	H	EEE	H
2	CE	S	EEE	H
3	CE	H	CE	H
4	CE	H	-	-
5	EEE	H	-	-

VI. Discussion

Several interesting significant findings were discovered. These findings confirm that the approach used in the technopreneurship course is viable and effective and can be used by other educational institutions. The research questions could be answered as follows:

RQ1: Do students appreciate the course structure and learning resources? Based on the results presented in Table IV, students indeed appreciate the course structure and learning resources. This is evidenced by the high mean scores for questions related to the course's preparation and organization, the accessibility, clarity, and helpfulness of learning resources, and the course being intellectually stimulating and challenging.

RQ2: Are the students content with the assessment and feedback within the course? The findings from Table IV suggest that students feel well-informed about how their work is evaluated and appreciate the fairness in the assessment process. Furthermore, the feedback they receive is seen as timely and constructive, aiding in their learning and development within the course.

RQ3: Are the students satisfied with the course? Yes, the students are satisfied with the course. This is evident from the responses to question 3.1 regarding overall satisfaction in Table IV. These scores demonstrate that, across the two academic years considered, students consistently rated their satisfaction with the quality of the course highly.

RQ4: Do students perceive the technopreneurship course to benefit their professional skills? Yes, students do perceive the technopreneurship course to benefit their professional skills significantly. This is supported by the anecdotal categorization of text responses from the optional question in the online questionnaire, as presented in Table V. Among the benefits highlighted by students, improvements in pitching/presentation/public speaking skills and teamwork abilities were notably mentioned.

RQ5: Does the degree program of the team members influence the team's demonstrative prototype? The degree program of the team members does not have a significant influence on the team's demonstrative prototype. This conclusion is drawn from the data in Table VI. The table indicates that, regardless of the composition of the teams in terms of their degree programs, most teams chose to create prototypes that involved electronic hardware, often with an embedded software component. This was consistent across the two academic years, with a majority of teams from both degree programs opting for hardware-based or hybrid projects.

RQ6: Does the degree program of the CTO within each team influence the team's final demonstrative prototype? The results from table VII, show that the demonstrative prototype each team produces for their pitch presentation is not dependent on the degree program of the student with the CTO role in each team. It was clearly demonstrated that a CTO on the CE degree program will still most likely produce a demonstration that requires electronic hardware and embedded software, and not a software only solutions, such as a web or smartphone app.

VII. Conclusion

This paper has presented a novel approach to integrating technopreneurship within the curriculum for EEE and CE students. The exploration into the development, implementation, and student reception of this cross-discipline course has shed light on its effectiveness in not only enhancing technical competencies but also in significantly improving professional skills deemed critical by industry employers. Feedback from students, as demonstrated through the online questionnaire and commentary responses, indicates a high level of satisfaction with both the course structure and the learning outcomes. It is clear from the findings that the course succeeded in its objectives to foster a deeper understanding of business practices within a technical context and to enhance essential professional skills, such as teamwork, presenting, and problem-solving. Additionally, the course has made significant strides in connecting students with the local start-up ecosystem, providing a practical platform for applying theoretical knowledge and nurturing potential future entrepreneurs.

Despite the diversity in the backgrounds of team members and the designated roles within teams, the final projects demonstrated a cohesive blend of hardware and software solutions, underlining the success of cross-discipline collaboration in promoting innovation. This outcome further affirms that the course's design, emphasizing multidisciplinary team projects, is instrumental in broadening students' technical and entrepreneurial horizons, irrespective of their primary field of study.

Future iterations of the course could benefit from addressing the slight gap between students' expectations and the course content, as indicated by the feedback received. The findings presented in this work show the importance of technopreneurship courses in preparing students not just for their immediate transition into the workforce but for a future where interdisciplinary skills and entrepreneurial thinking are paramount.

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