# Enhancing Project-Based Learning Through Student and Industry Engagement in a Video-Augmented 3-D Virtual Trade Fair

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***Abstract*—Project-based learning is a widely used pedagogical strategy in engineering education shown to be effective in fostering problem-solving, design, and teamwork skills. There are distinct benefits to be gained from giving students autonomy in determining the nature and scope of the projects that they wish to undertake, but a lack of expert guidance and of a clear direction at the outset can result in confusion, frustration, and unfulfilled goals. Moreover, engineering schools face the imperative of providing students with opportunities to engage with industry during their courses, which can be difficult to accomplish due to logistical and time constraints. This paper reports on a case study in which undergraduate students of electrical, computer, mechatronics, and telecommunications engineering interacted with representatives from industry to obtain feedback at the inception phase of their design projects. Students pitched their ideas to the industry guests at a virtual "trade fair" held within a hybrid video conferencing and three-dimensional (3-D) virtual world environment, in preparation for the assessable pitches that they had to deliver on campus to a faculty audience. Survey and assessment results attest to the participants' satisfaction as well as to the effectiveness of the approach in improving student self-efficacy and performance. The paper concludes with recommendations for engineering educators looking to implement similar initiatives and a brief outline of the authors' plans for the future.**

***Index Terms*—3-D virtual world, authentic learning, engineering design, industry engagement, project-based learning, video conferencing.**

## I. Introduction

A CENTRAL goal of higher education, particularly in professional disciplines such as engineering, is to produce job-ready graduates who possess both the specialist and generic competencies that they need to operate successfully in industry and the workplace. In the pursuit of this goal, there has been an increased focus over the last two decades on the facilitation of authentic learning activities and experiences that are apposite to the challenges students will face in their future careers [1], [2]. However, prevailing approaches to "authentic" learning, including many that rely on technology-mediated tools and environments, tend to consist of contrived learning tasks culminating in outcomes predetermined by the teacher; they are by no means reflective of the richness and complexity of the real world [3]. It is arguable that in order to achieve truly authentic learning, it is necessary to draw upon outside sources and experts beyond classroom walls [4], [5]. At the same time, for learning to be personally relevant and meaningful to students, they must be empowered to carve out their own trajectories, exercising agency in determining how and in what contexts the learning will occur [5]–[7].

In engineering education, project-based learning is a favored pedagogical strategy for encouraging students to engage in open-ended, self-determined learning while developing a range of skills and abilities that are integral to the profession [8]–[10]. This paper describes an effort to incorporate authenticity and industry relevance in a project-based engineering course at an Australian university. Students participated in a virtual event that was structured in a "trade fair" format, during which they gave one-on-one and small-group presentations of their initial project concepts to industry guests to elicit feedback and constructive criticism. The event was hosted on a three-dimensional (3-D) virtual world platform with live user video, spatial audio, and slide-sharing capabilities. Through the exercise, students not only received expert insight and perspectives on their ideas from an industry audience, but also gained valuable practice in articulating those ideas ahead of the face-to-face pitches that they had to deliver to an academic panel at the university to obtain approval for their projects.

This paper is organized as follows: Section II contains a review of relevant literature, after which attention is turned to the project-based course that forms the setting of the present study. The objectives and structure of the course are detailed, followed by the design of the virtual environment and tasks. Subsequently, qualitative and quantitative feedback from surveys of the students, industry guests, and academic panelists along with assessment data from the face-to-face pitches are used to speak to the effectiveness of the activity and to the strengths and weaknesses of the overall approach. Finally, coverage is provided of practical implications, lessons learned, and future plans.

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## II. Literature Review

### A. Project-Based Learning and Student Self-Direction in Engineering Education

A variety of methods are employed by engineering schools and educators in their efforts to enable learning that is student-centered and self-directed, examples of which include problem-based learning, challenge-based learning, inquiry-based learning, team-based learning, and project-based learning [11]. A core feature of these methods is their open-endedness and emphasis on student independence and inquiry; students learn inductively through seeking answers to a question, exploring different perspectives on a topic, making and testing hypotheses, or solving a problem, which mirrors how knowledge and expertise are acquired in real-world settings. This stands in contrast to traditional approaches to engineering instruction, wherein students are first taught principles and theories before being allowed to apply them [8].

Project-based learning, in particular, has become vastly popular in engineering education, where reports of its use abound in the literature. In project-based learning, students typically work in teams to plan and carry out projects that reflect their knowledge [12]. Many engineering schools have recast one or more of their traditional, lecture-based courses in a project-based format (e.g., [10] and [13]–[16]), with some making the switch for entire course sequences or programs (e.g., [17]–[19]). Among the broad advantages cited are active involvement of learners; increased motivation and satisfaction, leading to improved academic performance; achievement of educational objectives beyond those prescribed by the curriculum; preparation of students for employment; and development of general skills and dispositions crucial for success in 21st-century society, such as entrepreneurship, critical thinking, teamwork, and digital literacy [10], [13]–[20]. More specifically, however, project-based learning is ideal for cultivating the design and design-thinking skills that lie at the heart of an engineer's role [9]. For this reason, engineering programs now commonly incorporate a mandatory project-based capstone design course calling for students to integrate what they have learned throughout the program to design and build a product of their choosing [21].

What distinguishes project-based learning from related methods like problem-based learning is the creation of a product or performance, usually over one or more semesters [8], [22]. Project-based learning is also often multidisciplinary, encompassing several subject areas [23]. Importantly, unlike problem-based learning, which tends to be structured around fictitious scenarios or case studies, project-based learning involves fully authentic, student-driven tasks undertaken in real-world contexts [22], [23]. The absence of an imposed structure and of tight stipulations regarding what is to be produced can serve not only to cater to students' diverse interests, but also to train them in setting their own goals and then self-regulating their progress toward those goals [15], [18], [22]. These benefits notwithstanding, the idea of having completely open-ended problems or projects whose scope, deliverables, and other parameters are student-determined is not without its perils and pitfalls; in fact, such minimally guided or unguided instructional approaches have been heavily criticized by prominent educational scholars [24], [25]. A lack of direction and scaffolding, particularly at the outset of a problem- or project-based learning intervention, can be highly frustrating for students, leading to demotivation and ultimately even failure [15], [26]. A major challenge in project-based engineering education, then, is assisting students in defining a clear vision and purpose for their projects at the inception stage, while still affording them autonomy in deciding what they wish to pursue [19]. Since students may interpret any teacher input as directives that they are obliged to follow, no matter if it is intended as such, an alternative may be to turn to external sources for the necessary support.

### B. Industry Engagement in Project-Based Courses

In an age when the role of textbooks and prescribed content in higher education is being questioned [27], [28] and when the teacher and academic institution are no longer seen as the sole authorities on knowledge [29], [30], universities are increasingly finding it essential to involve the wider community in their curricular, instructional, and assessment practices. Within the engineering discipline, industry experts and their organizations are frequently looked to for input on program design and evaluation, to provide external representation on advisory boards for meeting accreditation requirements, and as providers of internships and job placements for students [31]–[33].

More challenging, however, is orchestrating opportunities for these industry experts to engage directly with students to enhance and add authenticity to their learning—the need for which is ever more apparent when considered in light of data showing that, in countries such as Australia, academics responsible for teaching engineering tend to lack recent industry experience [34]. Aside from delivering the occasional invited lecture, there is much value to be gained from having industry experts interact directly with students at the course level, for example, in a coaching or mentoring capacity, or by serving as jurors and assessors of their work [33], [35]–[37]. Alumni wanting to give back to their alma mater are often especially inclined to contribute in these ways [36]. Such interactions with industry experts can help students prepare for the transition into graduate employment; develop a sense of belonging to a professional community; build relationships and networks; and supply motivation, context, and relevance for the theory that they are learning [33].

Project-based courses offer fertile grounds for student–industry engagement [38]. It is not uncommon for students' capstone design projects to be centered on developing solutions for industry partners and clients, and/or for students to undertake those projects in conjunction with industry field placements [33], [39]. However, while students are still occupied in classes full time, as tends to be the case in all but the final semesters of their degree program, making arrangements for them to spend time in industry can be problematic logistically. At the same time, professionals working in industry have limited time available to devote to interacting with students, particularly during working hours; this can be compounded by the need to travel to campus. For those who are based in other parts of the state or country, or are overseas, on-campus participation is quite simply out of the question. Fortunately, a range of rich-media synchronous collaboration technologies are now available that can be used to alleviate this problem by allowing for remote participation, making it possible for industry experts and students to engage with one another in real time regardless of their location.

### C. Rich-Media Synchronous Collaboration Tools for Student–Industry Engagement

According to Stewart, Harlow, and DeBacco [40], contemporary rich-media synchronous technologies offer universities new solutions to existing problems, such as preparing students for the 21st-century workplace and providing opportunities for expert collaboration. These technologies encompass a wide array of tools and platforms, each with its own set of features, benefits, and limitations.

*Video and web conferencing* systems enable real-time interaction between distributed users through the exchange of 2-D audio/visual information. Room-based video conferencing utilizing specialized infrastructure and equipment has a long history of use in higher education, for instance, to allow remotely located guest speakers to address a class [41]. More recently, desktop video conferencing applications like Skype have gained popularity for allowing individuals or small groups of people to communicate over the Internet through text chat, video, and voice using standard PC hardware [42]. Web conferencing platforms like Adobe Connect and Blackboard Collaborate add to these modalities other collaborative functionalities, including the ability to jointly author text and draw diagrams, broadcast the user's screen, share documents and presentation slides, and vote on issues of common interest [43], [44]—although many such features have begun to be replicated by desktop video conferencing tools, blurring the distinction between the two categories. Wang and Lee [45] used web conferencing to bring industry experts into their classes without the need for them to travel to campus. Despite the benefits arising from the sense of copresence that they can foster, a shortcoming of these systems is their scalability. Video and web conferences can become unwieldy when there are more than ten concurrently active participants [46]. Another disadvantage of video and web conferencing is that users are confined to a "caged interface" [47] incorporating a restricted toolset, which severely limits the types of interactions that are possible.

*Virtual worlds* like Second Life and OpenSim, by contrast, let users, portrayed as animated figures called avatars, navigate through a synthetic 3-D environment, interacting with other avatars and objects. The main advantages that virtual worlds have over video and web conferencing systems lie in the scalable, flexible, and extensible design of virtual worlds as well as their ability to permit free movement and embodied actions from a first-person perspective [48], [49]. However, the paucity of facial and body language cues can act as an impediment to effective communication, and may have an adverse impact on social presence [50], [51]. It has also been widely reported in the literature that virtual worlds, due to their use of avatars and with their gamelike features and fantasy elements, can have negative connotations with teachers and students, who may not see them as legitimate or "serious" educational tools [52], [53]. That being said, for users who are shy or lack confidence, using a virtual world avatar as a proxy for meeting and interacting with others can be less daunting and anxiety inducing than doing this through video [54]. Virtual worlds additionally let users collaborate on spatial tasks, which cannot be done in a video or web conferencing environment [55]. Papamichail, Alrayes, and Macaulay [56] describe how information technology students undertook project-based learning in Second Life to solve a problem for a real client, which necessitated engagement with industry representatives through inworld meetings and other virtual events.

Developed under the auspices of the Australian Smart Services Cooperative Research Centre, iSee [57] is a hybrid platform that blends video conferencing with virtual worlds in an effort to capitalize on the strengths of both technologies while abating their respective weaknesses. Each user is represented as a "video avatar" in the form of a floating window containing a live feed from his/her webcam. The use of real video, in combination with directional audio sensitive to users' relative positioning within the 3-D virtual space, is touted by the developers as affording more fluid and natural interactions than is possible with video conferencing or virtual worlds alone [58], [59]. By utilizing a priority-based algorithm [60] that dynamically adjusts the volume of data generated for transmission according to the network bandwidth available, iSee is able to accommodate large numbers of video-based participants roaming about and spontaneously congregating to hold ad hoc conversations. This algorithm preserves audio quality by sacrificing video frame rates as bandwidth becomes scarce, beginning with avatars that are the farthest away from the user within the virtual space—a strategy that for the most part results in only slight degradation, or no degradation at all, to the user's experience. It was iSee's mixture of rich-media interaction modalities, together with its purported resilience to bandwidth limitations and fluctuations, that made it an ideal choice of platform for the activity that is the subject of this paper.

## III. The ECTE350 iSee Pitch Activity

### A. Background, Context, and Motivation

ECTE350 *Engineering Design and Management 3* is a project-based learning course offered by the School of Electrical, Computer, and Telecommunications Engineering at the University of Wollongong, a public research university on the southeastern coast of New South Wales, Australia. It is a required two-semester course for third-year students pursuing bachelor's degrees in electrical, computer, mechatronics, and telecommunications engineering. The aim of the course is to provide students, working in teams, with the experience of undertaking a significant product development exercise, from target specification through to product launch [61].

The project in ECTE350 is open-ended in nature, with general themes provided for the students to choose from. Each team must come up with two project ideas aligned with their selected theme and, during Week 6 of the course, must present these in a face-to-face "pitch" to a panel of academic staff, acting as a board of directors. In pitching what they wish to develop, the team must put forward a convincing business case, demonstrating the need for their proposed product as well as its competitive advantages and positioning relative to other products on the market. The panel either accepts one of the two proposals or rejects both, requiring a resubmission, which carries a penalty to the students' marks in the course. In assessing the pitches, the panel is looking for evidence of a robust project definition, which involves confirming the objectives, scope, benefits, and risks of the project as well as developing an implementation approach and plan [62].

Once projects are approved, the teams work to design, build, and market the product over the remainder of the year. They are allotted an AUD$300 budget for materials and are able to draw upon academic staff as "costed" advisors. The team activity is also supplemented by lectures on topics such as project management concepts and tools, social and ethical considerations, usability and ergonomics, and engineering test methodology. Students are expected to apply the knowledge gained from those lectures, from other third-year courses, and from their own independent learning as they proceed through each phase of the Product Design Cycle. At the end of the year, the final products are showcased at an exposition, where members of the public vote to decide which is the best.

As highlighted earlier, while open-ended, student-determined projects can be rewarding learning experiences from which an array of pedagogical benefits can accrue, a complete dearth of guidance and support in the beginning phases can be detrimental [15], [26]. This was evident in the ECTE350 project pitches, the standard of which had historically been subpar, with many naïve and ill-thought-out ideas being presented to the academic panel, and teams giving little consideration to issues of feasibility and marketability. Each year, several teams' proposals had to be rejected outright or could only be accepted with major adjustments. To mitigate these shortfalls, a new dimension was added to the course: Students are brought together with experts from industry in a live forum where the students practice pitch their ideas and solicit feedback in advance of their official pitches. In the interest of removing the time and distance barriers that would make participation prohibitive for many of the guests, a decision was made to host the forum online, as a virtual trade fair in iSee, rather than as an on-campus event. The sections that follow report on a pilot of the activity that took place in the Autumn (March–June) semester of 2015.

### *B. Participants*

There were 12 student teams in the 2015 offering of ECTE350, all of which participated in the iSee Pitch activity. Each team was required to nominate two members to present on their behalf; attendance of the event was optional for the other, nonpresenting members. Of the 82 students enrolled in the course, a total of 41 participated in the event (24 presenters and 17 nonpresenters). Also in attendance were a small number of nonpresenting students from the University's satellite campus in Dubai, UAE, with the intention of promoting cross-cultural dialogue and exchange. The cross-cultural aspects of the activity will be the focus of a later publication.

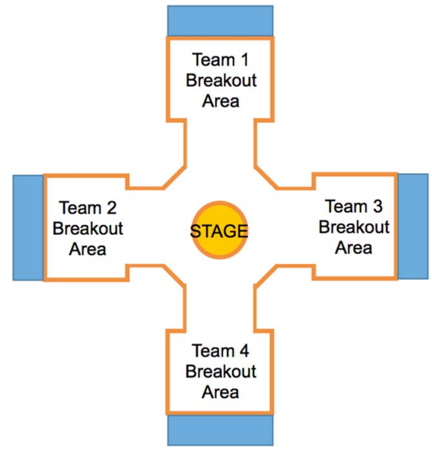


Fig. 1. Layout of one of three identical halls in the virtual environment.

Thirteen external guests were invited to be part of the activity, with ten accepting the invitation and three declining due to prior commitments, but noting a desire to participate in future iterations. Of the ten guests who accepted, the majority were alumni working in industry who themselves had undertaken the course in the past and the remainder were drawn from the authors' professional networks (including the New South Wales chapter of the IEEE Education Society). Three of the participating guests were based in the Wollongong region, four were located in Sydney (over an hour's drive from Wollongong), one was in another Australian state, and two joined the event from overseas.

### *C. Virtual Environment and Procedure*

Version 1.3 of the iSee software was used for the activity. The virtual environment consisted of three identical rooms or "halls," each made up of a central meeting area along with four smaller breakout areas for the student teams to use as stations that guests could visit (see Fig. 1). For the purposes of the pilot, a conservative decision was made to subdivide the environment into three (requiring participants to "teleport" to move between halls) as there was some uncertainty as to whether overcrowding of a single hall might pose a problem in terms of server load and network bandwidth or because of noise generated by participants talking over one another. Each breakout area was equipped with two interactive presentation boards for displaying slides and other visual aids.

In the week leading up to the iSee Pitch activity, tutorial sessions were run during the regular timetabled classes for the course to explain to students the purpose and objectives of the activity, and to provide them with an orientation to the software. In addition, immediately before the commencement of the activity, a representative from the iSee support team met with the student presenters inworld to give them advice on how to deliver an effective presentation in the environment as well as to show them how to use some of its more advanced features, such as the laser pointer tool (for pinpointing specific areas on

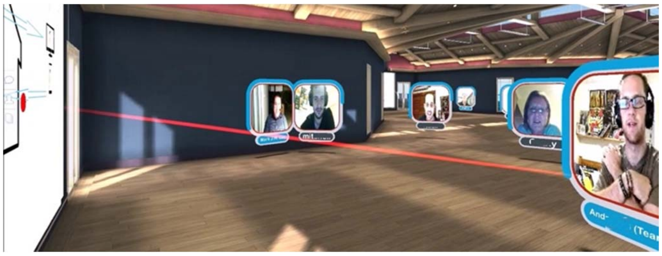

Fig. 2. Example of a student pitch in iSee.

the boards—Fig. 2 shows this tool in operation). The guests were not trained on how to use the software, but all participants (students and guests) were given information sheets outlining the basic procedures/protocols to be followed.

The virtual fair event was scheduled for a weekday evening so as to minimize clashes with the guests' work schedules. Following a welcome speech from one of the hosts, the guests and other nonpresenter attendees were invited to move freely within and between the three halls, interacting with whomever they chose, as would happen in a physical trade fair. Receiving visitors at their respective stations, the student presenters pitched their team's favorite candidate project idea (the one they believed was the most promising) to elicit reactions and feedback. Fig. 2 shows one such pitch in progress. By way of scaffolding, students were advised to include in their pitch the following: 1) an outline of the project concept, 2) its rationale, and 3) their intended business plan. Since all of the teams' pitches occurred in parallel, each team had to repeat their pitch multiple times over the course of the evening. It was hoped that, through repeated practice, they would become increasingly comfortable, adept, and polished in presenting and defending their ideas, and that their conversations with the industry guests would prompt them to think critically about their proposed designs, including how to refine them to attune with industry trends and expectations as well as market needs.

## IV. Evaluation and Assessment

Web-based surveys were administered before and after the iSee Pitch activity to gauge students' and industry guests' perceptions of the technology, virtual environment, and task as well as of the learning that arose from their participation. The iSee platform also enabled a full 3-D recording of the environment to be created, making it possible for the researchers to retrospectively "attend" the event and navigate through the virtual space as it appeared during the event. Furthermore, four researchers joined the event live to conduct participatory evaluation, capturing screen recordings from their individual points of view that reflected the activity as they saw and experienced it. The individual and environment recordings were used to perform an analysis of participant discourse and interactions. The results of that analysis, in combination with structured observation notes taken by the researchers and shared during a debriefing session, assessment data, and academic panel feedback from the students' face-to-face pitches, produced evidence of and insight into learning processes and outcomes.

TABLE I
Pre-Activity Participant Attitudes

| | Students | Industry Guests |
|---|---|---|
| *Interest in using online collaborative tools for learning* | | |
| Extremely interested | 4.8% | 30.0% |
| Interested | 50.0% | 30.0% |
| Neutral | 31.0% | 40.0% |
| Not interested | 9.5% | 0.0% |
| Extremely uninterested | 4.8% | 0.0% |
| *Opinion on whether the iSee Pitch is a good idea* | | |
| Excellent idea | 14.0% | 30.0% |
| Good idea | 51.2% | 60.0% |
| Neutral | 32.6% | 10.0% |
| Bad idea | 2.3% | 0.0% |
| Terrible idea | 0.0% | 0.0% |
| *n* (Sample) / *N* (Population) | 43 / 82 | 10 / 10 |

### A. Survey Results

Selected results from the pre- and post-activity surveys are presented here. Other aspects of the data (e.g., on cross-cultural learning and on social presence) will be reported elsewhere. As shown in Table I, responses to the pre-activity survey suggest that students $(n = 43)$ and industry guests $(n = 10)$ had similar attitudes toward the use of online collaborative tools such as video conferencing and virtual worlds, with 55% and 60% respectively indicating that they had interest in using them. Attitudes toward the iSee Pitch activity itself were more favorable in comparison, with 65% of students and 90% of industry guests responding positively in that regard.

All 18 students and all nine industry guests who responded to the post-activity survey reported participating from home. Almost 90% of students and 100% of industry respondents indicated that they wanted to participate in a similar activity again. Importantly, 80% of the industry respondents said that they would not have been able to participate in the event had it been held on campus, with distance and travel time being commonly cited reasons. Every one of the respondents found the activity to be a beneficial learning experience, and this was supported by a number of comments, such as:

> "*The experience gained by talking to the industry members was invaluable in guiding how we* [should] *proceed with the project,* [and] *also in giving us a better market understanding.*" (Student)

> "*The students has* [sic] *some very innovative ways of expanding current technologies which . . . broadened my perspectives.*" (Industry guest)

All student respondents claimed that the involvement of industry guests made a difference to the task and the way they approached it, with 80% stating that having a professional audience for their ideas motivated them to perform the task well. They highly valued the guests' expert insights and the opportunities for networking, and they believed that the exercise enhanced their readiness for their official pitches:

> "*The industry professionals . . . were invaluable in preparing us for the types of questions and thought processes that would be required during the actual pitch.*" (Student)

"*It just gave us external advice on what we could do and made us think in a different way.*" (Student)

"*Some of the people we talked to raised questions we had not fully prepared for so we had a chance to create a better response if they were asked during the physical presentation. Also some good ideas and improvements were suggested which added to our project and presentation in general.*" (Student)

Nearly 70% of student-presenter respondents reported gaining feedback that they were able to use to refine and improve their project ideas, and a similar percentage reported feeling better prepared for their official pitches. The industry guests, in turn, pointed to the opportunity to interact with students and be of assistance to them as being rewarding and enriching.

In terms of how the activity could be improved, most suggestions had to do with the features of the software and the design of the virtual environment. For example, many student and industry participants complained that noise from nearby users engaged in other conversations was distracting to them and that the flat topography of the breakout areas caused problems with other avatars inadvertently obscuring their view. Several students said that they would have liked to see more participants. (As this was a pilot, the number of guests invited was deliberately kept small.) The time needed to become familiar with, and adjust to, operating in the new environment was another recurring theme in the students' post-activity survey responses.

Finally, almost 90% of the students and industry guests indicated that they had a more positive opinion of using collaborative online tools for learning following the iSee Pitch activity. This is important because the potential of these tools for promoting student–industry engagement can only be realized if there are sufficient levels of uptake and adoption.

### B. Participatory Evaluation Results

Analysis of the recordings and of the researchers' structured observation notes established that the iSee Pitch event was a success overall, with participants moving freely about the environment and engaging in meaningful discourse. It was clear from the analysis that the repetitive nature of the activity was central to improving learning: As the researchers had intended, each time a guest or group of guests visited a team's station, the project pitch was repeated, at the end of which the team members and guest(s) chatted about the project concept in greater depth, asking questions of one another and partaking in productive dialogue about the concept's merits and areas of possible improvement. Over time, both the fluency and the content of the pitches improved, with presenters building upon and integrating feedback received from earlier discussions. The ability to see participants' facial expressions and gestures made it easy to tell when they were intrigued, excited, engrossed in thought, and so on. The student presenters' body language signaled that many of them were nervous or apprehensive initially, but they appeared to gradually gain confidence as the activity progressed.

From a technical standpoint, the iSee platform fared well. Performance was reasonable even when the number of users was at its peak. A few participants experienced skips and lags in their sound when in the vicinity of a large number of other avatars, and some complained that video within the avatars stopped when the room became crowded. These problems could have stemmed from both bandwidth and hardware capability issues, but the authors postulate that the latter was the predominant cause, given the algorithm upon which iSee relies for regulating bandwidth usage [60] and since virtual worlds are known to be highly graphics-processor intensive (which also meant that those working on laptops not connected to power outlets drained their batteries very quickly). As explained in Section II-C, the iSee algorithm prioritizes audio over video. If both audio and video quality problems are experienced when only a few users (e.g., 10–15) are present, bandwidth is most likely the main culprit; however, if no performance issues are encountered at this level, but video quality begins to decline with the entry of more users into the environment (which seems more consistent with what was reported and observed in the pilot study), then the probability that processing and memory are to blame rises dramatically. This is because beyond a certain threshold, the amount of data being transmitted by iSee does not significantly increase as is typically seen in web conferencing software ($O(n^2)$). The main bottleneck here becomes the processor's ability to render all of the additional video streams. Since the activity, the iSee developers have introduced into the user interface two "health" meters, one depicting hardware (processing and memory) resources and the other network speed/latency, to give users a better understanding of the source of problems that they may be encountering, thereby assisting them in identifying appropriate remedial steps to take.

To safeguard against performance and noise issues, the virtual environment used for the pilot was segmented into three halls, with four teams stationed in each. Guests were instructed to randomly enter one of the halls, but most started out in the first hall. As a consequence, teams in the third hall had fewer visitors, especially at the beginning of the event. Again, consistent with the survey data, the recordings showed avatars jostling for a position from which others would not be blocking their view of presenters/boards. Yet another problem observed was that it was difficult for the participants to know if someone they encountered was a Wollongong student, a Dubai student, or a guest, since the video avatars provided no indication of this, being labeled only with participant names.

### C. Assessment Results and Academic Panel Feedback

The official, face-to-face project pitches that followed the iSee Pitch activity were assessed by the academic panel as being of a substantially higher standard than in previous years. As shown in Table II, this was the first time in several years that all of the student teams had at least one proposal accepted.

When individually approached and asked to reflect on the quality of the proposals overall, the majority of the academic panelists in 2015 (none of whom, with the exception of the ECTE350 coordinator, were involved in the iSee Pitch) said that they noticed improvements over previous years in terms of the content and merit of the ideas that were proposed, but they seemed more divided as to whether there were improvements in students' delivery of their presentations. This could be because

TABLE II
ECTE350 PROPOSAL ACCEPTANCE RATES BEFORE AND AFTER INTRODUCTION OF THE ISEE PITCH ACTIVITY

| YEAR | NO. OF TEAMS | ACCEPT | CONDITIONAL ACCEPT | REJECT | % ACCEPT |
|---|---|---|---|---|---|
| 2012 | 16 | 11[b] | 1 | 4 | 68.8% |
| 2013 | 10 | 8 | 1 | 1 | 80.0% |
| 2014 | 11 | 4 | 2 | 5 | 36.4% |
| **2015[a]** | **12** | **12** | **0** | **0** | **100.0%** |

[a]The iSee Pitch activity was run for the first time in 2015.
[b]Of the 11 proposals that were accepted in 2012, five were only accepted following a resubmission containing substantially more detail than was provided in the presentation.

TABLE III
SHORTCOMINGS IN ECTE350 PROPOSALS BEFORE AND AFTER INTRODUCTION OF THE ISEE PITCH ACTIVITY

| YEAR | CATEGORY OF PROBLEM[b] | | | | |
|---|---|---|---|---|---|
| | Overly simplistic or ambitious scope | Design lacking in detail | Minor flaws in delivery of presentation | Other issues | No problems noted |
| 2012 | 6 | 5 | 0 | 0 | 6[c] |
| 2013 | 3 | 2 | 5 | 1 | 2 |
| 2014 | 6 | 4 | 5 | 1 | 1 |
| **2015[a]** | **0** | **4** | **10** | **1** | **1** |

[a]The iSee Pitch activity was run for the first time in 2015.
[b]Categories are not mutually exclusive. (Some proposals had multiple problems.)
[c]The records from 2012 contained no written feedback on some proposals. This does not imply that the academic panel did not find problems with those proposals.

the relaxed and informal nature of the iSee Pitch task was a departure from the style and tone expected in the official pitch. One panelist suggested that students would benefit from additional coaching in formal presentation skills.

As a means of triangulation and to yield a deeper understanding of the strengths and weaknesses of the pitches before and after the introduction of the iSee Pitch activity, grounded analysis of the academic panel's written feedback to student teams in each year from 2012 to 2015 was carried out using the constant comparative method [63]. This revealed that many of the project proposals that had passed in the preceding three years had barely satisfied the minimum criteria. Table III summarizes the types of problem noted by the panel on the marking sheets over the four-year period. It is clear from the analysis that, as compared with the preceding years, students exhibited a much better grasp of the scope and positioning of their projects in their official pitches. The high frequency of 2015 proposals with identified weaknesses in presentation delivery is not necessarily an indication that the delivery quality declined, but rather is likely attributable to the panelists being more critical of aspects like formality, timing, dress, and appearance of visual aids in the absence of the previously prevalent scope problems.

## V. RECOMMENDATIONS AND LESSONS LEARNED

Based on their evaluation as well as reflections and lessons learned from the experience, the authors offer the following suggestions to colleagues contemplating similar initiatives.

— *Design of the virtual environment*: There should be a default area where users find themselves when they first enter the environment; this can serve the dual purpose of both being a "sandbox" in which participants can become comfortable with the software and controls, and being a place where a formal welcome speech can be delivered. This area should contain signage providing instructions for the event and for navigating the environment. In the iSee Pitch pilot, the conservative approach of dividing the environment into multiple disconnected halls led to an imbalance in the number of visitors to each hall. If a single contiguous space is not an option, guests should be explicitly directed to different starting rooms. Additionally, in terms of the environment layout, sloped or tiered flooring is recommended because a flat design may hinder participants' ability to see in crowded areas.

— *Preparation for the event*: Adequate planning and preparation are of paramount importance. Scheduling should take into account time zone differences and each guest should be contacted personally well in advance to secure their commitment to participate. Steps should be taken to ensure that all participants have computers with sufficient graphics processing and memory capabilities, and sufficiently fast and reliable Internet access. They should be made aware that reliance on battery-powered devices is not advisable for lengthy virtual world events. The software and environment should be thoroughly tested before the event. (The iSee system requirements documentation [64] makes no stipulations about bandwidth, but from the authors' experience, 4G or higher speeds are recommended.)

— *Participant training*: The need for user orientation and training is acknowledged in the virtual worlds for education literature [53], [65]. In the iSee Pitch pilot, all students were introduced to the software in advance, which proved helpful. The student presenters appreciated having the additional training session on the evening of the event, especially in terms of pointing them to features of which they were not already aware. The guests were furnished beforehand with full instructions of what to do, but they still asked to be briefed upon arrival. A time and place should be designated for a guest orientation session prior to the start of the event.

— *Participant identifiers*: In a physical trade fair, participants wear badges or lanyards with descriptive information; it is similarly recommended that, in a virtual trade fair, participants use more detailed textual identifiers than just their names. It is also noteworthy that newer versions of iSee (1.4 and above) allow for color customization of the frame around a user's video avatar. In subsequent iterations of the iSee Pitch activity, a unique color will be assigned to each participant group (student presenters and nonpresenters from each campus, industry guests, university staff/academics, etc.) as a means of visually differentiating between them.

— *Facilitation of the event*: During the event, hosts should mingle with the invited guests and make sure that they feel welcome and appreciated. Participants should be gently reminded that if they talk over one another or are too close to other groups that are talking, voices will overlap and no one will be heard. An upcoming version of iSee will incorporate a "cone of silence" feature that will provide areas for users to hold private conversations. There will also be a radius of voice transmission to aid users in understanding how far their voice is traveling and who can be heard at a certain distance.

## VI. Conclusion and Future Plans

This paper has described how a video-augmented 3-D virtual world was used to connect students undertaking a project-based engineering design course with experts from industry in a trade-fair-style arrangement. Although the limited sample and single context of the study preclude the making of broad generalizations, the results do suggest that within the pilot scenario, by practice pitching their project ideas to the industry guests, students became more confident and honed their presentation skills in preparation for their assessable pitches. Through the activity, they also obtained objective feedback and fundamental support that helped reduce the confusion and frustration often faced in the initial, critical stages of open-ended project-based learning. Their interactions with the experts provided motivation, context, and relevance for their projects; the experts, too, reported deriving benefit and enjoyment from the exercise. Larger scale investigations spanning multiple learning and teaching settings will be needed before conclusions can be drawn that may be more widely applicable and transferable across the engineering education sector, and before evidence-based guidelines can be generated as to what does and does not work well technically, pedagogically, and logistically.

The iSee Pitch activity has been presented here not as a panacea or silver bullet to the challenge of achieving student–industry engagement, but rather as the subject of an exploratory case study of how new and emerging rich-media synchronous collaboration tools, if used appropriately and in concert with sound learning design, may help overcome some of the practical difficulties in engendering industry participation in university courses. While grandiose claims cannot be made, the findings reported in this paper provide early empirical support for the efficacy of the approach and a springboard for further research. Other engineering educators and their schools may be able to draw inspiration and guidance from this case as they work to implement their own technology-mediated ways of infusing authenticity into student projects, and into learning and teaching activities more broadly, through the involvement of external experts.

There are plans to repeat the activity in a future semester, with ECTE350 students at the Dubai campus pitching ideas to Wollongong students and industry guests. In the longer term, the authors hope to expand the initiative by including more diverse and larger numbers of guests, and by exploring the feasibility of using online collaborative tools like iSee for forming ongoing mentoring relationships between students and industry experts that extend beyond the project inception phase. A follow-up study will be conducted to investigate the impact of the iSee Pitch and these other activities on final project outcomes and grades in the course.

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