# Chapter 15

## Boundary Crossing: Negotiating Learning Outcomes in Industry-Based Student Projects

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*In order to prepare upcoming Industrial Designers so they will be able to operate successfully in increasingly complex work settings, the Industrial Design program at the University of Western Sydney is teaming up with industry to provide final year students with industry-based projects. The introduction of Industry-Based Projects into the final year research projects has disrupted many set ways in which the traditional student projects have been run in the past. Industry-Based Projects have brought to light a number of important issues associated with the assessment process and views held by academics about desired student project outcomes and assessment that were left lying dormant in the past. This paper explores the challenges academics face negotiating student outcomes and assessment while supervising Industry-Based Projects.*

### INTRODUCTION

There is a growing interest within Engineering and Industrial Design education in project based learning [1]. The reasons for incorporating this learning technique into industrial design programs include: exposing future graduates to the complexities that are associated with the new product development process [2, 3]; and introducing students to teamwork [4, 5], cross-functional communication [6] and design project coordination [7]. In order to prepare upcoming Industrial Designers so they will be capable of operating successfully in increasingly complex work settings, the Industrial Design program at the University of Western Sydney (UWS) is teaming up with industry to provide final year students with industry-based projects.

The introduction of Industry-Based Projects into the final year research projects has disrupted many set ways in which traditional student projects have been run in the past. Industry-Based Projects have brought to light a number of important issues associated with the assessment process and views held by academics about desired student project outcomes and assessment that were left lying dormant in the past. This paper explores the challenges academics face in negotiating student outcomes and assessment while supervising Industry-Based Projects.

## Background

The School of Engineering and Industrial Design at UWS offers a four-year Industrial Design program. In the final year of this program the students undertake a year long research-based project. The final year project consists of two main stages: (i) a research stage that is undertaken in the first semester; and (ii) a project completion stage that runs in the second semester culminating with the final year exhibition. The aim of this final year project to enable students to integrate and apply the knowledge, skills and experience they have obtained from their previous years of study by initiating an innovative solution to a particular design-related problem. This is done by encouraging students to explore areas, issues and activities that people in industry face in their day-to-day life [8]. For example, past research student projects have dealt with issues such as reduction of packaging waste and addressing sustainability issues [9, 10]; reduction of pedestrian injuries in collision involving four-wheel-drive vehicles [11]; baby care [12]; sport design [13, 14]; and assisting children with Down syndrome and cerebral palsy to develop their motor skills [15].

In the past, industry involvement in final year projects has been limited to in-kind sponsorship such as, for example, providing a theme for the project, supplying model-making materials and/or assisting with industry know-how. Past involvement of industry partners tended to be minimal as they had very little stake in the overall success of the project and its final outcome. In 2003, however, two of the new industry partners in the UWS final year industrial design program offered projects that went beyond a simple project sponsorship model. The industry partners provided projects that had commercial implications thereby substantially increasing their stake in the successful completion of these projects. This provided a new dynamics to the working relationships between industry partners, students, and academic supervisors. As a consequence, a new collaborative approach has been developed between the industry partners and the university that has led to unexpected opportunities and challenges. The paper titled "Working Knowledge: Industry-Based Projects in an Industrial Design/Engineering Program" provides a general overview of issues faced by academics, students and industry partners in this setting [16]. The latter paper concludes that the following issues need to be considered when establishing collaborative partnerships with industry:

- Balancing student learning and client requirements
- Providing resources for the collaborative projects, e.g. initial set-up and ongoing interactions
- Choice of industry partner
- Collaborative learning
- Equity issues
- Intellectual property

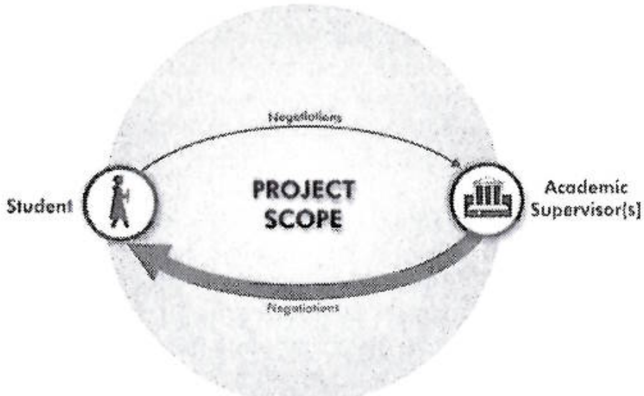


FIGURE 1
ACADEMY-BASED PROJECTS, SIMPLIFIED INTERACTION MODEL
BETWEEN A STUDENT AND AN ACADEMIC SUPERVISOR

- Developing future relationships
- Overall course structure

The current paper examines additional issues that have surfaced as a result of the introduction of Industry-Based Projects, specifically those associated with negotiating student project outcomes and assessment.

## PREVIOUS ORGANISATION OF THE COURSE

Before Industry-Based Projects were introduced, the scope/parameters and outcomes of the research projects, referred to here as Academy-Based Projects, had been generally negotiated between the student and the academic supervisor (see Figure 1). In this setting, the academic supervisors dealt only with the students and vice versa. This was viewed more or less as a routine task as it built on the existing 2nd and 3rd year design studio projects where students undertook project-based learning though, in the final year, it was the students that were responsible for establishing and developing their individual projects.

The final year program is run by a team of academic supervisors within a design studio class setting. Each of the students is assigned a primary and secondary supervisor. Each of the primary academic supervisors is responsible for monitoring the progress of about five students. During a consultation class, which runs once a week, students are also encouraged to consult with other academics, not just their primary and secondary supervisors.

The subject outline provides information on expected assessment components, their relative weighting and submission due dates. The following types of assessable component categories are included in the final year outline: project research proposal; process/visual diary; presentation posters; research thesis document and technical report; design brief and engineering drawings; and models and prototypes. These are set requirements that all students need to meet. There is ample space and opportunity, however, for negotiation between the students and their academic supervisor on the students' research topics and the specific expected assessment outcomes in regard to the above categories. This is a multi-stage process running through the semester during which a number of rounds of these negotiations take place. The first round of negotiation is about the research topic, its appropriateness and its scope. After the topic is agreed on, a second round of negotiation takes place. This is about how the research project is going to be carried out. The third round deals with working out what information is important and how it is presented. In parallel, a fourth round unfolds that focuses on the specific assessable outcomes such as their level of 'quality' and detail, scope and modes of presentation and communication.

Despite shifting some of the responsibilities to the students who, for example, have now introduced their 'own' projects, it is still the academic supervisor who largely controls the negotiations in relation to what is an acceptable project and what are acceptable deliverables. The thickness of the arrow in the Figure 1 indicates the unequal influences in the negotiation. Thus, the arrow which goes from the student to academic supervisor is much thinner than the arrow which goes from the academic supervisor towards the student, indicating the academic's relatively stronger control over the negotiation process.

## THE INDUSTRY-BASED PROJECTS

In comparison to Academy-Based Projects, the Industry-Based Projects have introduced another player on the block – the Industry Partner. The Industry-Based Projects have created an environment that was previously unfamiliar to the academic staff and students, as well as the industry partners (see Figure 2).

This does not necessarily mean that the academic staff did not have industry experience; rather, it means that the academics had not previously taken an industry partner into consideration when negotiating project outcomes with the student. It is unfamiliar for the students because previously it was only the academics who determined what was required in terms of final outcomes. And it is unfamiliar for the industry partners as they now need to collaborate with academics in terms of project outcomes and with industrial design students, a process with which many were unfamiliar. The

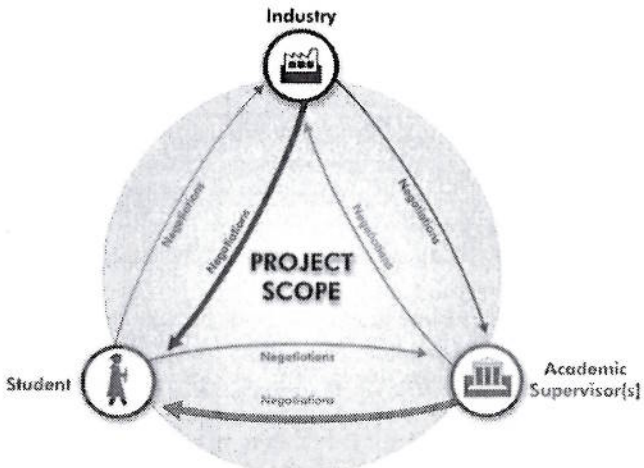


FIGURE 2
INDUSTRY-BASED PROJECTS, SIMPLIFIED INTERACTION MODEL BETWEEN A STUDENT, AN ACADEMIC SUPERVISOR AND INDUSTRY PARTNER

Industry-Based Projects are created and 'owned' by the industry partner, whereas the Academy-Based Projects were created and 'owned' by the students. This has largely affected the dynamic of how the project outcomes have been negotiated; see Figure 2. Figure 2 does not include other players such as parts and material suppliers, and University departments and offices that approve these partnerships.

The thickness of the arrow in Figure 2 indicates that there is still an uneven capacity for the student to negotiate. Thus the arrow which goes from the student to academic supervisor and the industry partner is much thinner than the arrow which goes from the academic supervisor and the industry partner towards the student, indicating the academic's and the industry partner's relative control over the negotiation process. Also, in this environment the relative overall academic control is lessened as a number of key elements of the project are now controlled by the industry partner.

Generally the Industry-Based Projects are negotiated in the following way. The prospective industry partner would contact academics within the Industrial Design program and provide a brief explanation about the nature of the project. In many instances industry partners would have very tight time frames and they would have specific outcomes in mind such as generally making their product better looking and/or less expensive. At this stage the academic would provide the industry partner with an overview of the final year program and suggest ways that the proposed project could be incorporated into the final year student program. At this stage issues in regard to intellectual property ownership and project fees would be discussed. Generally these are the most contentious issues and, therefore, take time to finalise. It is at this stage when some projects are abandoned as these issues cannot be resolved[1].

Then, the academic staff would try to enlist a suitable student or students for the project who would be briefed by the academic before going with them to visit the potential industry partner at their site. The project start and completion are generally not too difficult to negotiate as the potential industry partner is provided with relevant dates when the project needs to be finalised for it be assessed and to be part of the end-of-the-year graduate exhibition. Mostly what industry partners are interested in knowing is 'how many days per week will I have the student working on the project?' Generally industry partners provide student(s) with working space at industry work premises. This potentially facilitates students' access to the project team and its leader, as well as potentially providing students with a sense of belonging to that workplace.

After the initial discussions with the industry partner the student develops a research project proposal/plan. This document is meant to be used as a learning contract and to guide students in their projects, and to inform the industry partner on what is going to be delivered thus providing them with a project scope. So far, industry project partners have (apparently) been satisfied with initial proposals as they have all been accepted. Further consultation is undertaken with the industry partners as they are invited to attend mid-semester and end-of-semester student presentations. Also, academic supervisor(s) attempt to meet with the industry partners on their premises about twice per semester to review student project progress.

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[1] We have experienced an outcome when a prospective industry partner wanted the University and student to sign all their intellectual property rights over to the company without any compensation to student or the University. Thus, UWS decided not to pursue this project.

Industry-Based Projects are assessed using the same criteria as the Academy-Based Projects. These criteria have been developed by the academics with student learning outcomes in mind. At times, however, as will be discussed in the case studies below, using the same criteria has raised a number of issues in relation to assessment.

## EXAMPLES OF INDUSTRY-BASED PROJECTS

A number of projects have been undertaken in collaboration with industry partners including: UWS External Signage with the UWS Capital Works [17, 18], water sport accessories with Zhik [19], and various projects undertaken with different Commonwealth Scientific and Industrial Research Organisation (CSIRO)[2] divisions which involve, for example, students research and design of computer interface [15, 19], remote heath monitoring device for the elderly [20-22], and research and design work on a variety of scientific testing instruments [16, 23]. The following section describes some of these projects in more details. These case study examples highlight the complex issues in relation to the assessment of student work in these settings.

## UWS EXTERNAL SIGNAGE PROJECT

The industry partner for UWS External Signage project was UWS Capital Works and Facilities (Capital Works) [18]. Before the start of the academic year one of the industrial design academic staff members approached Capital Works to inquire whether they would be interested in sponsoring a final year industrial design student project, focusing on ways to improve the existing external directional signage system. Coincidently, at that time, the University was in the process of implementing a new corporate image. This also included an upgrade of the overall University signage system. After a number of discussions between Capital Works and the final year academic supervisors it was agreed that this would be a suitable final year project; however, because of the project size and its requirements it was recommended that two students should be engaged on this project. This initial agreement was followed by the development of a project scope in consultation between Capital Works, two final year industrial design students and their supervisors. This project scope was based on guidelines from the UWS Project Manual [24] and it included: project objectives; organisational requirements; approach, timeframe and milestones (timeline); inclusions and deliverables; exclusions; assumptions; constraints; and risks. It was envisaged that students develop detailed design solutions to a level that would enable Capital Works to commission prototypes to be installed at one of the University campuses. The plan was that students would conduct a user survey to evaluate the prototypes and if necessary modify the designs prior to going into full production. It was agreed with the students that this evaluation would form most of their research (theoretical) assessment component. Unfortunately, this evaluation did not take place as expected as the external subcontractors who were given the task of producing the signage prototypes had substantially delayed the delivery and installation until the end of the academic year. This meant that students were not able to conduct their user evaluation and testing. Even though alternative research components were explored with the students, and it was an academic requirement that some form of research be undertaken,

[2] A government funded research organization that conducts research in basic scientific areas (for more information please see http://www.ctip.csiro.au/)

one of the students saw the theoretical research component as a waste of time and lost motivation to complete it. Also, at the same time the students were in the process of completing an external signage audit for all six UWS campuses. This was additional unpaid work that was negotiated between the students and the industry partner, without consulting the academic supervisor.

In summary, this case draws attention to the added complexities that come with running Industry-Based Projects, which often involve multiple external parties such as contractors and sub-contractors. In this instance the inability of the contractors to deliver the prototypes on time meant that the academic supervisors had to renegotiate the research project assessment with the students in order for them to fulfill all the components of the assessment. However, as outlined above, this proved to be problematic.

## CSIRO-TIP's Student Projects

Five industry-based projects were established in collaboration with Commonwealth Scientific and Industrial Research Organisation, Division of Telecommunications and Industrial Physics (CSIRO-TIP) [25]. CSIRO-TIP's deputy chief initiated the partnership by contacting one of the final year industrial design academic supervisors before the start of the academic year. The CSIRO-TIP, while providing innovative scientific and technical solutions for product development, was experiencing difficulties in getting products to market. It was envisaged that the combination of science and design disciplines would benefit both parties. Meetings were arranged between the key decision makers at CSRIO-TIP and UWS staff members from the School of Engineering and Industrial Design, the Office of Business Development, and Cooperative Programs. A number of students were contacted by the academic supervisor and were asked to visit CSIRO-TIP for a brief summary of the projects on offer. During this phase students were encouraged to ask questions and start identifying that projects that interested them. Students were then asked to submit project preferences with a brief summary of why they felt the project best suited their interest and skill set. From this information the project allocations were made. Here, we focus on three of the five projects that were conducted with CSIRO-TIP.

### Portable Scientific Testing Instrument

CSIRO-TIP developed technology for non-destructive composite material testing which is used in the aeronautical industry. The initial proposition was for the student to generate a 'good-looking' housing for the CSIRO-TIP's technical package; however, the student established very early into the project that the technology, which CSIRO-TIP had developed, was sound but neglected to take into consideration human factors. The instrument's reading reliability was compromised as each of the tests depended on the user's steady hand and correct posture. Also, the instrument could not be used on anything other than a flat surface, yet most surfaces on airplanes are curved. Therefore, the student conducted user task analyses (e.g. ergonomic position of workers performing non-destructive testing, and user interface) to reduce the human error and by doing so, this student was able to propose a newly designed instrument that not only overcame the user inconsistency, but also could be used on curved surfaces. This innovation let CSIRO-TIP to apply for a provisional patent. This student worked closely with the

CSIRO-TIP project team members to ensure that the technical package was redeveloped in parallel alongside the external instrument housing. As a result of this close teamwork a test prototype was produced to ensure that the modified instrument's technical package fitted within the newly designed instrument's housing and that overall it functioned as intended. This was then followed by construction of a number of fully working prototypes, which are currently being field-tested with the end-users.

While this was a very successful design solution and the project demonstrated good collaboration between the student and the internal scientific staff of the partner organisation, problems arose at the end-of-year assessment[3]. The close and successful collaboration between the internal scientific staff and the student meant that it was difficult to disentangle their respective contributions, thus making it very difficult to ascertain which parts were completed by the student. While some academics on the panel considered that this demonstrated important learning outcomes, such as cross disciplinary teamwork and project management skills, others were concerned with issues related to equity and wanted to automatically deduct points from all projects conducted with industry partners.

## Scientific Testing Instrument

The Scientific Testing Instrument Machine is used to perform material properties testing on a nanoscale. Two students who expressed interest in undertaking this project were selected to examine the extensive number of issues that could potentially be improved. These students were briefed by the project leader on what he thought was wrong with the current design, but it was left to the students to identify whether there were other problems. The students undertook market research and a usability study and identified additional issues. They decided that one would focus on the software interface which is used to control the instrument and on the instrument's housing which functioned mainly to keep a constant environment around the specimen while the test was in progress. The project leader left students "open" space to set the design direction. The two students reacted to this in different ways. The student working on the software interface took full advantage of this and took full control of the design direction while keeping the project leader informed on progress of the software interface re-design, whereas the student working on the instrument's housing interpreted this lack of direction as the project leader's disinterest in the progress. One of the results of this was that at times this student felt lost and without direction. When the project leader provided feedback to this student, the student reacted by constantly reworking the concept design each time and as a result was unable to move from the conceptual design phase until the very end of the final year. This substantially delayed the construction of the presentation model, and was atraumatic experience for the student.

The project leader commented "the final program interface was exactly what we wanted and represents a significant step upwards from our present offering and those offered by our competitors. The new interface will be a trend-setter in scientific software." On the other hand, the project leader noted that the student working on the instrument's housing was anxious, "especially when it appeared that no one liked [the]

[3] At the end of the year a panel of four to five industrial design academics from the program assessed the projects.

earlier designs." The project leader also felt that there was not enough contact between him, academic supervisors, and the students.

This draws attention to the complexity that is introduced for students in relation to managing their collaborative projects with industry. While one student was able to take advantage of and work with multiple perspectives, the other found this far more difficult. This student, who had previously been obtaining high grades, received a lower than expected final assessment mark. This case also highlights the additional learning outcomes that are often incorporated in Industry-Based Projects, such as interaction and negotiation with 'the client', which are currently not being formally assessed.

## A Discussion of the Differences between Academy-Based Projects and Industry-Based Projects

While Academy-Based Projects and Industry-Based Projects are both examples of problem-based learning, a pedagogical practice that is increasingly being taken up by the academy [1], there are differences between these two models. As indicated above the Industry-Based Projects are created and 'owned' by industry partners whereas Academy-Based Projects are introduced and 'owned' by students. The industry project ownership and industry involvement adds further complexity to the overall negotiation process as the project scope, method and deliverables are negotiated between the three parties i.e. academic, industry, and student as opposed to just academic and student.

The students' collocation at the industry partners' premises adds another dimension to the project dynamics. The collocation could strengthen the relationship between the students and the industry partners and increase the industry partners' sense of responsibility for the students, and their assessment outcomes, to the point where the industry partners would like to be directly involved in assessing students' academic achievement. For example, it is not unusual for the industry partners to indicate their displeasure if the students they were working with get what, in their opinion, was a low mark. Thus, involvement of the industry partner could potentially challenge academic supervisor's authority over many issues associated with negotiating assessment and grading these project outcomes.

The most visible difference between Academy-Based Projects and Industry-Based Projects lies at what is to be considered project completion. Generally, Academy-Based Projects would not pass beyond the design concept stage [26] whereas, in contrast, the majority of the Industry-Based Projects move beyond this stage with one of the projects being adopted and implemented by the industry partner. To get to this point within a relatively short time frame students and the academic supervisor have, for a number of the projects, adopted a different approach to what generally would have been undertaken and assessed under Academy-Based Projects.

Another and more important factor for moving Industry-Based Projects forward is the availability of resources such as financial, materials, data and know-how. For example, industry partners must provide resources for development and construction of models and prototypes. The total cost of these prototypes is significant and can run into tens of thousands of dollars. In contrast, students who are working on Academy-Based Projects are responsible for funding and developing their design models and/or prototype(s). The outcome of this is that students working on Academy-Based Projects would have at the end of their project a conceptual model to demonstrate their design intent, whereas, many of the students working on Industry-Based Projects would have a full scale, fully working prototype. In addition students engaged in Industry-Based Projects are usually part of a product development team, which provides them with additional support and resources [16].

The above issues complicate the final student project assessment in a number of ways. For example it is difficult for the academic to identify what is the students' 'own' work or their contributions to the overall project. In the Portable Scientific Testing Instrument case study described previously, more than six internal scientific staff collaborated closely with the student thus largely contributing to the overall successful design outcome. On the other hand, for students who have undertaken Academy-Based Projects it is much more straight forward to identify what work is theirs as it mainly would be the result of their 'own' accomplishment, even though they were guided by the supervising academic.

Another implication is that to get to the fully working prototype stage more design issues have to be considered and resolved. It also means that in many instances students have to closely collaborate and in some cases manage other project team members such as electronic engineers (as was the case with the Portable Scientific Testing Instrument project) and/or computer programmers (this was the case with both the Portable Scientific Testing Instrument and the Scientific Testing instrument projects), or even manufacturing subcontractors (in the case of the UWS External Signage project). It also became apparent that Industry-Based Projects require students to exhibit skills in areas such as working in cross-functional and cross-organisational teams. This in many instances shifts the students' focus and energy from hands-on model/prototype building activity (such as in the case of Academy-Based Projects) to organising and supervising model/prototype construction development (such as in the case of Industry-Based Projects). The different focus on the activities makes it even harder for academics to negotiate and assesses the project outcomes and to reconcile issues such as: What is it that we are assessing? In what areas do we wish the student to develop and exhibit their skills?

This raised a dilemma for the academic staff in the final year design program at UWS – should we devise different assessment criteria for Industry-Based Projects? And, if so, what should those criteria be? This then led to questions and discussions and disagreements about assessment in general concerning equity issues. This began to draw attention to different values amongst the academics. For example in relation to model making, the questions being raised were:

- Should the model be built by the student?
- Should students use contemporary technology that is now available such as rapid prototyping machines?
- If they have financial capacity, should students be able to commission the building of the prototype by outside contractors?

Faced by issues associated with Industry-Based Projects, as outlined above, the Industrial Design academics reviewed the overall Industrial Design program to help them understand how the previous subjects assisted students' progression. They have introduced monthly staff meetings and have initiated an effective program titled "Reflecting on Teaching". The aim of this program is for the academic staff to develop 'Scholarship of Teaching' through regular monthly workshops and seminars. This program, now in its second year, is run in cooperation with the Educational Development Centre (EDC) and with the help of internal staff members and external participants to the course (such as staff from library, and the Student Centre), including industry representatives [27]. A very important outcome is that the program provides a forum for academic members to discuss and explore issues amongst each other in a non-confrontational environment. This review process has brought to attention, amongst other things, the vast differences in academic staff's approach to assessment in general.

For example, discussion on the various final assessment components has revealed academics' individualised approach and interpretation of the final year assessment components. In addition, academics have difficulties in articulating explicitly their expectation for each of the assessment outcomes. Further on, the review process has indicated gaps between what students were assessed on and what skill they needed to develop in order to be ready to undertake their final year projects. For instance, basic skills that are associated with research and thesis document development (skills needed for completion of the final year project) were missing from the first 3 years of the Industrial Design program. Thus, a new 3rd year second semester core subject titled Designed Enquiry has been introduced specifically focusing on developing research skills. Writing and reading skills have now been embedded within core subjects throughout the Industrial Design program.

## SUMMARY

The Industry-Based Projects at UWS have played an important part in opening-up the discussion on the assessment of learning outcomes in the fourth year design program and how these are established and negotiated. Through the Reflection on Teaching workshops it became apparent that the differences between the Academy-Based Projects and Industry-Based Projects have added further complexity to the project outcome requirements and assessment process. The recognition of the complexity of assessment has provided the Industrial Design academic staff with the opportunity to start a process of negotiation amongst themselves to examine these issues in a broader context rather than just focusing on the final year outcomes and to ask questions such as:

- What ideas, skills, and knowledge should students have on completion of the 4 year industrial design program?
- How could we as educators encourage students to 'take on' these ideas?
- What are we assessing and how we should be assessing?

Importantly, these issues draw attention to problems of assessment in general. That is, how assessments are guided by academic staff values and assumptions and how these are being challenged by the introduction of diverse teaching techniques and off-campus learning that are increasingly prevalent in academia. The shifting of student learning to sites outside the academy, and specifically, as in these case studies, to industry settings, highlights the need for more discussion on the organisation and assessment of student learning in less mainstream teaching settings.

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## REFERENCES


1. H. H. Einstein, "Engineering Change at MIT," *Civil Engineering,* Vol. 72, No. 10, 2002, pp. 62-69.

2. R. Altenkirch, W. Aung, C. B. Cruz, J. Garside, R. Hinrichs, et al., "What We Must Do Together to Increase Quality and Productivity," *Innovations 2003: World Innovations in Engineering Education and Research,* W. Aung, M. H. W. Hoffmann, N. W. Jern, R. W. King, and L. M. S. Ruiz (ed.), Arlington, VA, iNEER, 2003, Chap. 1, pp. 1-12.

3. E. Bohemia, "Designer as Integrator: Reality or Rhetoric?" The Design Journal, Vol. 5, No. 2, 2002, pp. 23-34.

4. N. M. Moskalski, "Teaching Teamwork: How Deans and Department Chairs Can Facilitate Faculty Innovation in the Classroom," *Innovations 2003: World Innovations in Engineering Education and Research,* W. Aung, M. H. W. Hoffmann, N. W. Jern, R. W. King, and L. M. S. Ruiz (ed.), Arlington, VA, iNEER, 2003, Chap. 3, pp. 17-23.

5. S. D. Snyder, "Using Project-Based Learning to Teach Plc Programming in Mechatronics," *Innovations 2003: World Innovations in Engineering Education and Research,* W. Aung, M. H. W. Hoffmann, W. J. Ng, R. W. King, and L. M. S. Ruiz (ed.), Arlington, VA, iNEER, 2003, Chap. 28, pp. 277-284.

6. E. Bohemia, "On Line Based Teaching Can Facilitate Skills Development for Today's Global Manufacturing Environment," *Innovations 2004: World Innovations in Engineering Education and Research,* W. Aung, R. Altenkirch, T. Cermak, R. W. King, and L. M. S. Ruiz (ed.), iNEER, Arlington, VA, 2004, Chap. 12, pp. 117-128.

7. F. Kanjaâ, I. M. M. J. Reymen, and K. T. Weenvliet, "Cooperative Learning at a Distance for Design Students," *Proceedings of 8th International Design Conference - Design 2004,* Dubrovnik, 2004, pp. 1087-1092.

8. Office of the Academic Registrar, "UWS Undergraduate Handbook 2005," University of Western Sydney, Penrith, NSW 1444-7770, October 2004.

9. "Exciting Ideas to Make Their Debut," *Penrith Press,* Penrith, 2004, pp. 9.

10. A. Kersten, *Water Wall a Brain Wave,* Penrith City Press, Penrith, 2004, pp. 5.

11. Industrial Design Exhibition Committee, "Widevision: Western Sydney Industrial Design Exhibition," UWS, Redfern Town Hall, Sydney, Exhibition Catalogue, 3-5 December, 2003.

12. N. Soon, "One Han-Dy Product," *Blacktown City Sun,* Blacktown, 2004, pp. 12.

13. K. Moutia, "Portending Design," *Blacktown Guardian Week-Ender,* Blacktown, 2003, pp. 7.

14. "Racking up Design Kudos," *Blacktown Sun,* Blacktown, 2003, pp. 5.

15. Industrial Design Exhibition Committee, "Widevision: UWS Industrial Design - 2004," UWS, Surry Hills, Sydney, Exhibition Catalogue, 25-27 November, 2004.

16. E. Bohemia, "Working Knowledge: Industry-Based Projects in an Industrial Design / Engineering Program," Proceedings of Changing Face of Design Education: 2nd International Engineering and Product Design Educational Conference, Delft University of Technology, 2004, pp. 475-482.

17. "Pointers for Positive Image," *Penrith Press,* Penrith, 2003, pp. 17.

18. "Watch out for New UWS Signs," *AroundUWS,* Vol. 2, No. 1, 2004, pp. 18.

19. "Wide Vision of Industrial Design," *AroundUWS,* Vol. 2, No. 1, 2005, pp. 22.

20. "Monitor Could Save Many Lives," *Parramatta Sun,* Parramatta, 2004, pp. 12.

21. "Freedom and Care for Elderly," *Northern District Times* (NSW), Parramatta, 2004, pp. 2.

22. N. McIlroy, "Healthy Hopes," *Blacktown Advocate,* Parramatta, 2004, pp. 15.

23. D. Smith, "Squid among Tools against Air Terrorism," *The Sydney Morning Herald,* Sydney, 2003.

24. P. Swan, "Project Management Methodology: Project Management Tools & Templates - UWS Methodology," Project Management Partners Pty Ltd, Sydney, NSW, Manual Issue 2, 17 February, 2003.

25. "Link with CSIRO Telecommunications and Industrial Physics," *AroundUWS,* Vol. 1, 2003, pp. 15.

26. K. T. Ulrich, and S. D. Eppinger, *Product Design and Development,* 2nd ed. McGraw-Hill Higher Education, Singapore, 2000.

27. "Collaborative Project Benefits First Year Students," *AroundUWS,* Vol. 2, No. 9, 2004, pp. 21.

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