# Integrating industrial expertise into the delivery of an MEng aerospace engineering module

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## Abstract

This project sought to develop an engineering module which would bring in experts from industry to educate future engineering specialists in aircraft product development in order to address the industry standards and codes of practice. The industry staff lectured on key aspects of aircraft design integration and collaborated with the academics involved in teaching this module. The proposed development was mapped against the current accredited MSc/MEng curriculum. The industry partners participated in the aircraft design project development and its technical quality assessment during the academic year.

The student learning experience and employability was enhanced through the application of the theory in a practical module assessed according to industry requirements.

**Keywords:** higher education, employability, assessment, aerospace engineering, aircraft design

## Background

The practice of embedding employability into a curriculum has been a continuous concern for the higher education (HE) sector (Yorke and Knight, 2004; Cade, 2008; CBI, 2008; Ehiyazryan and Barraclough, 2009; Lowden et al., 2011; The Royal Academy of Engineering, 2010; CBI, 2011; The Royal Academy of Engineering, 2012). The 2006 HEFCE report *Engaging Employers in Higher Education* stressed the need for the HE sector to improve collaboration with employers in order to enhance employability skills.

In this case study, the practical experience of delivery and assessment of a specialist module in the aerospace engineering MSc/MEng curriculum at Brunel University is presented. In the core module *Aerospace Vehicle Analysis and Design*, key aspects of fixed wing aircraft design are taught and the students are asked to work on a project on aircraft conceptual design. This project sought to bring in experts from industry to provide the opportunity to educate future engineering specialists who can appropriately weigh technical, practical, business and management considerations in aircraft product development, whilst meeting the industry rigours and standards.

The programme offers a working understanding of specialised information coming from industry expertise. This module leads to an enhanced design overview of technical decision-making and vehicle morphology analysis (taking stock of business case and risk), as well as systems integration, by presenting the industrial decision-making approach, integrated with business case and risk analysis, regulatory and operational considerations, marketing requirements and objectives. Highly complex cross-functional aerospace system architectures are governed by the edicts of technical, practical and business management. The specialised information is supported by advanced computational tools currently used in project delivery by academics (i.e. *Advanced Aircraft Analysis,* highly used in academia and industry), along with dedicated advanced CAD programs (i.e. *SHARX, AEROPack* and *Concepts Unlimited)*.

## Rationale

The rationale for this project was to close the gap between academia and industry in terms of hands-on experience and prepare students for the complex technical environment of industry. A core module was used as a vehicle for collaboration with industry in terms of delivery and assessment, with the objective to encourage “deep” learning, making it relevant to industry and producing a strong and competent work force. The aircraft design project given by the industrial partners required the students to engage with a complex situation, be active in their learning and structure their knowledge and learning processes, enhancing the student experience and promoting quality learning. The interaction between industry specialists and academics provided an opportunity to introduce experience–led teaching into the aerospace engineering programme and prepare this degree to be fit for the future.

## The approach

In order to prepare students for the requirements of the industrial environment, the fixed wing aircraft design brief was prepared by the industry partners, the Future Projects Group of Airbus UK. Support from the industrial partners during the academic year was given through specialised lectures complementing the initial syllabus. The main phase of the project was achieved through a session of preliminary design review (PDR) by means of poster presentations carried out by the students a fortnight before final project submission (see Figure 1).

At the PDR, each individual was given the opportunity, by means of a few joint staff panels, to present their preferred conceptual design option and the rationale for the choice to an invited audience of industrial and academic specialists. Each individual was expected to present details of a “Loop Zero” baseline design, which comes closest to meeting the specifications from the project issued by Airbus. At the presentation, the students were encouraged to convey an understanding of the nature of the specifications and the market (including competitor aircraft analysis). Finally, an account of the logic and rationale employed for down-selection from the pool of candidate aircraft morphologies was expected.

The PDR presentation was a “walkabout review”, where each student was visited by a number of parties of reviewers made up of industry representatives and academic staff (five or six per group). Each party (panel) stayed with each student for approximately 20 minutes. All students were advised to be prepared to respond to questions and have suitable supporting material (not necessarily all on “public” display).

The students received feedback based on their technical acumen, critical review and understanding of their own research work, including critical steps in project management, communication and presentation skills.

Based on the feedback from the joint staff panel, a *Final Engineering Definition Report* was compiled and submitted by each student, covering studies carried out in the initial phase and additional iterations in order to meet full design specification. This process has been approached so that comprehensive feedback is received by students from key stakeholders with respect to the mindset and skills needed within the current industry climate to ensure research and technology success.

After the PDR, a thorough discussion amongst industry members and academics took place in order to identify milestones achieved on the assessment day and throughout the project, student performance and what went well and wrong with the entire process. All panel members took part in the discussion and highlighted their own points on the status, including how to improve the process in the future. The meeting was minuted.

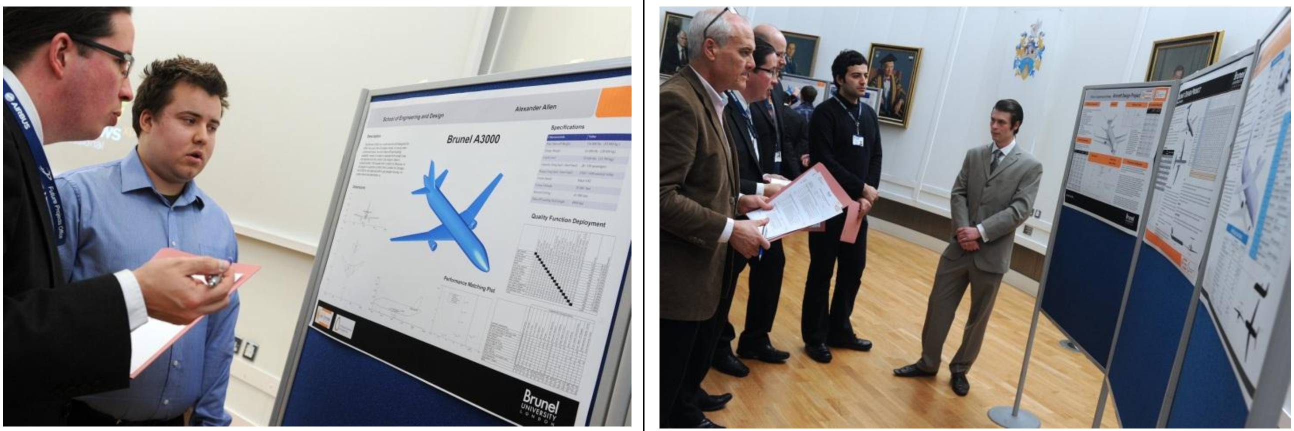


**Figure 1. Preliminary design review: the assessment session**

## Assessment

Two questionnaires were prepared for the industrial partners taking part in this project and for the students enrolled in this module, respectively.

A. The industry panel was asked to answer the following questions:

1) What is (are) the value proposition(s) in such collaboration proposal (i.e. academia-industry) and what outcomes do you expect this (these) to have? What are your motivations for collaboration?
2) What difficulties do you envisage in developing collaboration with academia for the development of curriculum and student project assessment tailored to industry needs?
3) What skill set should students have developed during such collaboration? Would it suffice for employability?
4) Is this hybrid assessment formative and appropriate for students' development?
5) Realistically, what can be done to improve the links with the university for curriculum development and student project assessment tailored to industry needs?
6) To enhance student employability, what are the best ways of the ensuring student's profile (e.g., technical acumen, soft skills, numeracy, etc.) is tailored to industry needs?
7) What do you think are the main issues in the gap between industry and academia and how to address them?
8) What could be improved or changed to develop a sustainable collaboration with industry?
9) What haven't we asked in order to address and understand the main hurdles regarding student employability?

B. The following evaluation survey was used for analysis of the learning process and the impact on the student learning experience. This approach should detail any "lessons learned", both from technical and project coordination perspectives, along with skills attained. The survey can also be used as a sounding board for any strong objections to the critical assumptions adopted during the course of the project:

1) The teaching staff of this course motivated me to do my best work
2) The staff put a lot of time into commenting on my work
3) My lecturers' explanations were clear and simplified the understanding of the subject for me
4) This activity helped me to discover what was expected of me as a learner
5) The staff gave me the support I needed to learn in this module
6) The teaching staff worked hard to make their subjects interesting
7) The staff focused more on encouraging me to find information than on giving me the facts
8) I found this activity challenging
9) I can see a range of ways in which I can contribute to a group task
10) The group was effective in developing shared goals
11) It was often hard to discover what was expected of me in this course
12) I usually had a clear idea of where I was going and what was expected of me in this course
13) This activity helped me to develop my team working skills
14) It was always easy to know the standard of work expected
15) I learned how to plan my learning
16) The staff seemed more interested in testing what I had memorised than what I had understood
17) To do well in this course all you really needed was a good memory
18) I felt I could get through the activity simply by memorising things
19) During the module I was given opportunities to establish my own research questions
20) As a result of this activity, I am now more confident about my ability to establish my own research questions
21) The assessment methods employed in this course required an in-depth understanding of the course content
22) There was a lot of pressure on me to do well in this course
23) There was a lot to learn
24) I felt I had to work hard to complete this activity
25) As a result of my course, I feel confident in tackling unfamiliar problems
26) The course developed my problem-solving skills
27) The course improved my skills in written communication
28) I feel I am now better at making oral presentations
29) I learned about how to present my findings to an audience
30) I feel I am better at evaluating different sources of information
31) I am more confident in my ability to evaluate the information I have found
32) I am more confident in my abilities to solve problems
33) During the module I was given opportunities to establish my own research questions
34) The staff put a lot of time into commenting on my work
35) The teaching staff of this course motivated me to do my best work
36) The teaching staff worked hard to make their subjects interesting
37) I enjoyed working in this way

38) The staff focused more on encouraging me to find information than on giving me the facts
39) I found this activity challenging.

## Evaluation

The programme delivery was subject to a number of milestones which were enforced in order to track progress and evaluate the success of the project against the objectives.

The employers' evaluations and suggestions will be taken into account for further continuation and development of good practice and future active involvement of the aerospace industry. The relevant recommendations and conclusions will be used for all of the courses and the development of new initiatives for further curriculum innovation within the School of Engineering and Design.

The impact on students' learning by means of innovative practice has been assessed through the industry/academics overlooking the design project outcomes, student feedback and student satisfaction surveys.

To assess the quality of the teaching process in a metric format based on the students' perceptions and needs, the approach developed by Mousavi *et al.* (2001) for analysis of quality in product design was used. In this approach, quality can be interpreted as the degree of user satisfaction with product attributes. The approach, linked with the Prospect Theory developed by Mowen (1993,) uses a quality measurement to reflect the relationship between the user's requirements and the adopted design. This can determine a scale and become an aid for decision-making in evaluation of the customer's preferences and product improvement.

The psychological value of customer satisfaction is based on the difference in actual distance between the required value and the design solution value. A representation of this variation is presented in Figure 2. A rescaled version of the curve in Figure 2b, to be used in a standard questionnaire for a discrete scale from least to most appropriate, was determined and used for student satisfaction analysis.

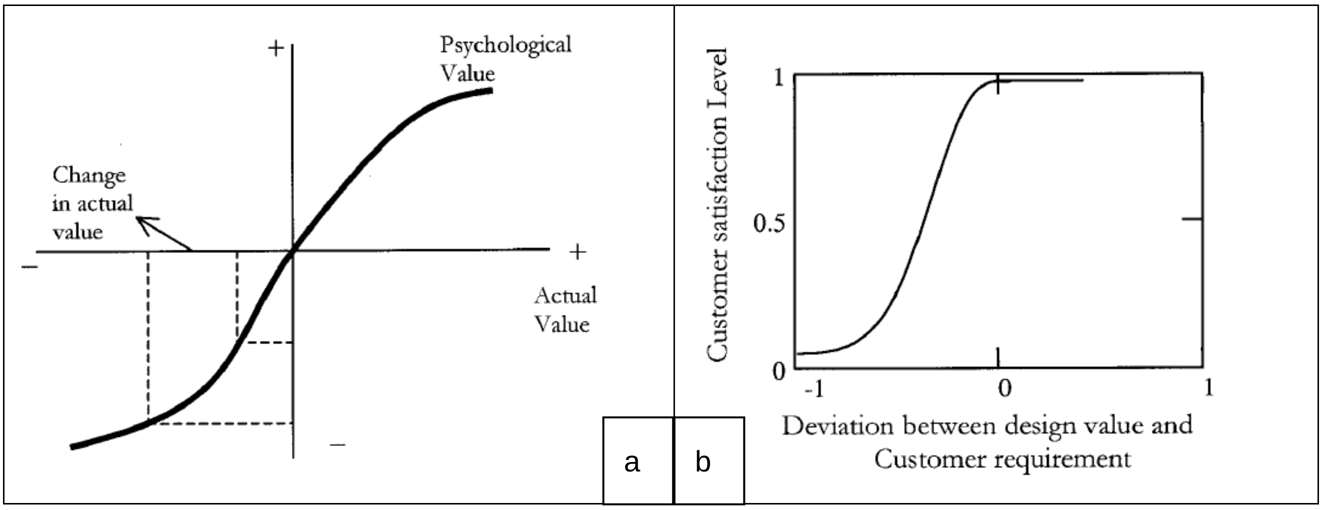


**Figure 2. a) Psychological value versus value of the actual attribute (consumer behaviour); b) User satisfaction level based on the actual deviation between design solution and customer requirement**

## Discussion, summary

- The answers given by the industry partners of the project show that industry considers that a link and a continuous dialogue with academia are essential for a shared vision and to shape the future. It has been observed that recruitment of appropriately capable engineers is becoming increasingly difficult and that any collaboration with universities should result in a better quality of graduates matching more readily the expectations of their potential employers.
- Education should seek to find the compromise between academic need for breath of understanding and industry need for specialised knowledge; academia should not seek to answer to a perceived industry demand but to develop the ability to think and solve problems, to avoid indoctrinate with current methods and processes.
- The industry could help to provide direction for the development and delivery of course material in order to enable students to be more exposed to industry needs.
- When recruiting, industry would like to see someone who has a general understanding of the design aspects, can learn quickly, has good problem-solving skills in a complex environment, can think critically and laterally and articulate results. The ability to listen and communicate thoughts and ideas to others and to make and defend technical decisions can only help their chances of employment. Internships, one-year or summer industrial placements, group design projects or final year projects based on industry input, can enhance the chances of future employment by developing the skills needed by industry.
- It is difficult to establish a constant stream of information and communication between industry and university, and a tailored project such as this one seems to be an excellent endeavour.
- The assessment carried out together with industry is highly valuable, as it gives the students a taste of the real world, challenges their thought processes and gives them extra motivation, helping them to question their own work and provide a context for it. It improves the level of soft skills, making students better technically equipped for interviews.
- Industry wants to see a return on its investment, with the need for a business case for continued investment and growth, and this kind of exercise proves to be as useful for students and industry alike, giving the students a better understanding of what is expected from them in similar situations and helping them after they finish their studies.

This perspective from the industry partners was correlated with the results obtained from the students during the design exercise and with their views regarding the outcomes and effects on their development. A questionnaire was developed, based on previously published research by Ramsden (1993) and Moore and Poikela (2010), analysing the problem-based learning efficiency. The questions highlight good teaching practices, clarity of teaching objectives and engagement, as well as assessment and workloads in relation to the development of the proposed skills for an engineering module.

The questionnaire presented above was organised into six sections: good teaching practice, clear goals formulated during the project, the assessment difficulty, workload perception, skills enhanced during the project and the efficiency of student engagement. The results are presented in Figure 3 (see Table 1 for correlation between the *x* axes of the histograms and the questionnaire). The values represent the average obtained from the student responses calculated using the metric (see Figure 2, based on Mousavi *et al.* (2010)) for each question.

The analysis of the teaching practice reveals that the activity was perceived as challenging, requiring effort to understand and integrate the knowledge for the design process. The academic and industrial partners were working hard to motivate the students, make the subject interesting and comment on their work, encouraging them to take ownership of the project. The aircraft design project required the application of knowledge from aerodynamics, flight mechanics, aircraft performance, etc., and filtering all of this knowledge in a creative manner at the industry level of requirement was not an easy task for students or for the academic delivering the teaching.

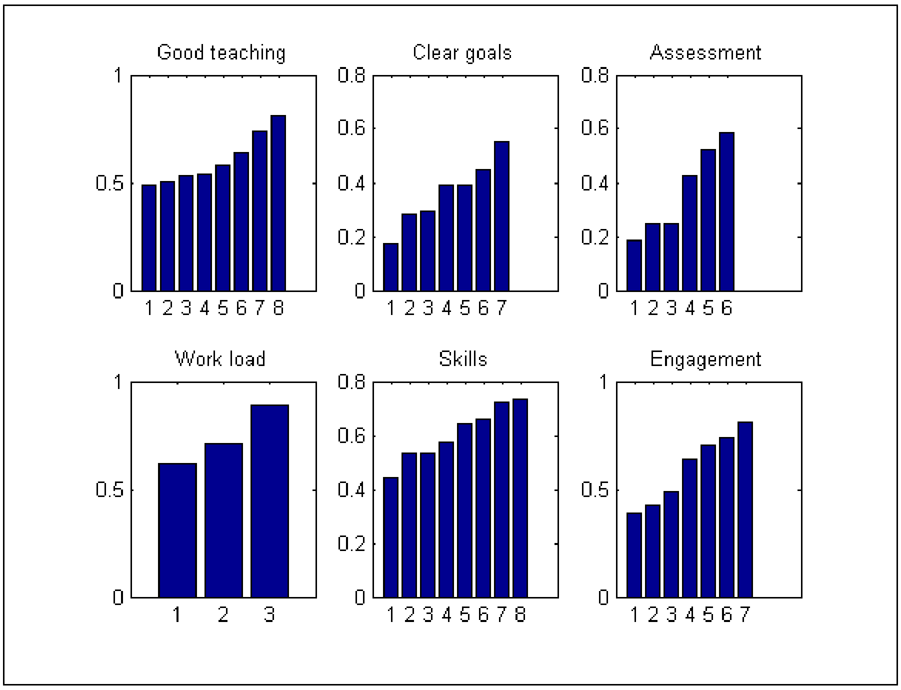


**Figure 3. Questionnaire evaluation (see Table 1 for question correspondence)**

**Table 1. Questionnaire criteria grouping**

| Criteria | Questions set |
|---|---|
| Good teaching | 1 to 8 |
| Clear goals | 9 to 15 |
| Assessment | 16 to 21 |
| Workload | 22 to 24 |
| Skills | 25 to 33 |
| Engagement | 34 to 39 |

The fact that the design exercise was an individual task is reflected in the lower scores for the questions specific to group work, although discussion with peers during the project was helpful. The project complexity, which in its progression represents a non-linear process, is acknowledged, with final goals seeming distant in different phases for the students. But these difficulties led to something special: the students learned how to plan their work better in the context of very clear requirements in terms of results and work standard.

The assessment section reveals that the design exercise required an in-depth knowledge (i.e. not just memorising things) and during the design exercise the students had the opportunity to develop their own ideas and redirect the project requirements towards their own solution.

It is recognised that the workload was high, with the students having a lot to learn and feeling the pressure to finalise the project at a high standard. But the reward was obtained through the skills developed during the project. At the end, the students felt confident that they could prepare a complex technical report, present their ideas in front of an audience and defend their work, find and analyse complex information and demonstrate an improved ability to solve difficult problems. Finally, the students enjoyed working in this way, as evidenced in the engagement section of the questionnaire.

These results are confirmed by the trends presented in Figure 4, showing the correlation between good teaching practices and student engagement and skills development respectively.

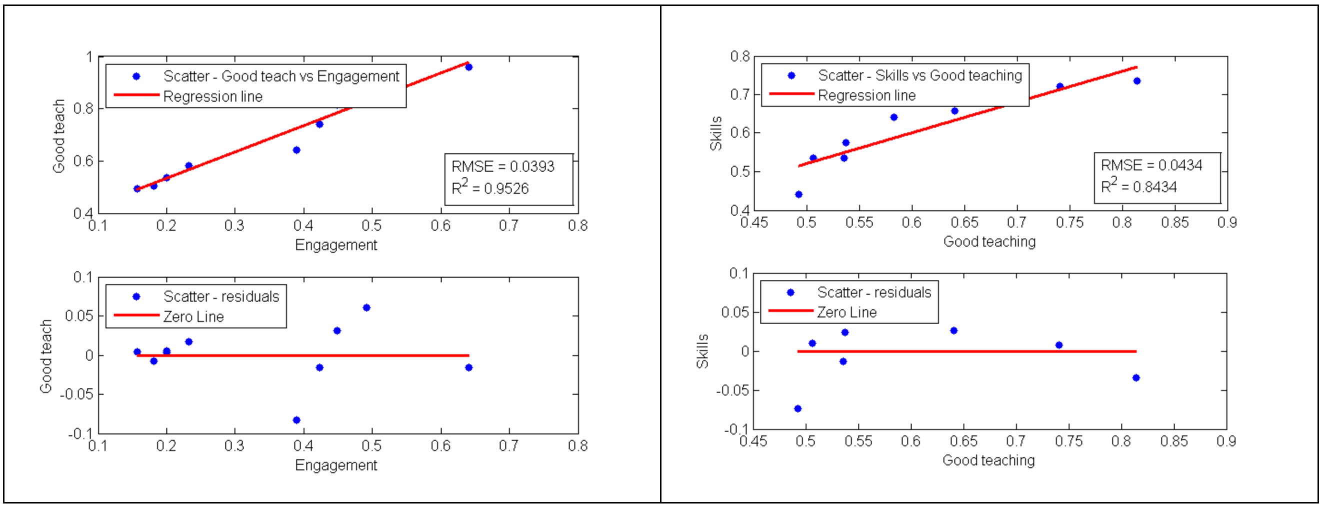


**Figure 4. Relationship between good teaching practice and student engagement and skills development respectively**

## Further development

The increase in student employability represents a strategic programme for the School of Engineering and the success of this project means that this will continue as an exercise to enhance the student experience, learning from its triumphs and challenges alongside our industrial partners.

This project sets a new strand in teaching innovation and is a model for bridging the skills gap between academia and industry. By developing similar teaching innovation projects, a stronger partnership can be achieved with key industry players so that companies' standards can be implemented into the curriculum to develop students who are suitable for current market industry needs.

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