Reseaching the effectiveness of Activity Led Learning as a pedagogy for engagement with professional development in engineering

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Abstract
This case study reports on a research study. The study focuses on mechanical and automotive engineering (undergraduate) students’ experiences of the development of professional skills and attributes within Activity-led learning (ALL) experiences. This includes an introductory first 6-week ALL experience. The schedule of activities presented as part of the first 6 week experience demonstrate an effective template for supporting early development of professional skills, integrating, as they do, a combination of generic and subject-specific activities, as well as targeting team skills in a few key activities and providing opportunities for individual skills across many activities. Students rated various ALL experiences including the 6-week experience highly, and displayed awareness of, and ability to reflect on, the professional skills they had acquired, but had limited understanding of what constituted “a professional engineer” as a concept, typically equating it with corporate behaviour. There may be a role for a more explicit discussion of these concepts, to enable students to critically engage with notions of professionalism.

Keywords: Activity-led learning, student experience, professional skills and attitudes development, professionalism, engineering

Background
The faculty of Engineering and Computing is committed to enhancing its provision through Activity-led Learning (ALL) pedagogy (Wilson-Medhurst et al, 2008). These developments are reported in the recent ‘Engineering Graduates for Industry’ report (The Royal Academy of Engineering, 2010). One of the pioneering departments for this initiative has been the Department of Mechanical and Automotive Engineering (MAE) at Coventry University where in 2008/9 session 100 first year students took part in six-week related exercises, the evaluation of which demonstrated reduced first term drop out rates and a 26% increase in satisfaction (Green and Wilson-Medhurst, 2009). The subsequent roll out of the six week projects in all the departments and first year programmes within the faculty has been evaluated using an aligned assessment instrument developed through an action research process (Wilson-Medhurst, 2010).

The aim of this research was to take this ALL evaluation work forward, initially within MAE programmes. Specifically the focus is on the Mechanical and Automotive Engineering cohort (many now in the final year of their degree studies in 2010/11) who reported increased satisfaction rates. This is with the aim of gaining a more detailed understanding of the student experiences of ALL, particularly their experiences of ALL for professional skills development and general preparedness for industry.

1 The majority of these students were on Mechanical or Automotive Engineering programmes, with around 15% on other related programmes
Activity Led Learning (ALL) approaches including problem-based learning and project-led learning have been shown to be superior in terms of the benefits for skill development, long-term retention and student and tutor satisfaction (Strobel and van Barneveld, 2009). Evidence from Aalborg University in Denmark demonstrates that employers rate graduates from an entirely problem-based learning engineering faculty more highly in a range of ‘professional skill’ areas than those from a traditional Danish engineering university (Kolmos and Du, 2008). This study aimed to illuminate the student experiences of ALL for professional skills development to inform future curriculum development activity.

Rationale

Working definitions of the Activity-Led Learning (ALL) pedagogy are presented in Wilson-Medhurst et al. (2008) and Wilson-Medhurst and Glendinning (2009). A key feature is the activity as the starting point for engagement in learning, and the role of the tutor as facilitator. The stimulus for activity is a problem, project, opportunity, scenario, case-study, enquiry, research question (or similar) in a class-room, work-based, laboratory-based or other educational context. The learning process itself requires “a self directed […] process in which the individual learner, or team of learners, seek and apply knowledge, skilful practices, […] and resources (personal and physical) relevant to the activity [being undertaken].” (Wilson-Medhurst et al. 2008, p. 2). It is an outcomes and action focussed pedagogy which supports the formation and development of effective ‘habits of action’ (Dewey 1921) including those typically characterised as professional skills and attributes such as self-learning, communication skills, team-working, analytical and critical abilities, time-management and so on.

As indicated above, the interest in gaining a deeper understanding of the MAE students' experience of ALL for professional skills development came initially from the survey results for this cohort in their first year in 2008/9 which indicated increased satisfaction with ‘self confidence’ and ‘time-management skills’ (Green and Wilson-Medhurst, 2009). These are examples of professional skills that Activity Led Learning (ALL) curricula seek to promote (amongst others) and students were reporting early benefits that we wanted to understand better. Similarly those such as Strobel and Van Barneveld, 2008 suggest in relation to Problem Based Learning (PBL) that “since the evidence suggests that PBL works in particular contexts, especially for workplace learning with a focus on skills and long-term retention, the focus should shift from researching effectiveness of PBL versus traditional learning, and should refocus on studying the differences in effectiveness of support structures to find optimal scaffolding, coaching and modelling strategies for successful facilitation of PBL” (Strobel and Van Barneveld, 2008, p. 55). This project seeks to do just that for ALL in engineering by first taking a ‘step back’ and finding out about that student experience of ALL. Such understanding will then help curriculum designers in Engineering and other STEM subjects to identify optimal scaffolding for successful facilitation of ALL (and similar pedagogies) for professional skills development.

The Approach

As this is a research project the focus here is on describing the research framework and the methods adopted. However, in order to understand the Activity-Led Learning innovations that are the focus of this research, a brief outline of the ALL implementation details as they relate to this cohort of learners is outlined below (further information is also available from Green and Wilson-Medhurst, 2009). This section will therefore first outline the ALL implementation within the 2008/9 Mechanical and Automotive curriculum and then the research framework and methods adopted.

The student cohort

This study follows the Mechanical and Automotive Engineering 2010/11 graduating cohort. This cohort includes a significant number of the students who joined in 2008/9 and progressed to UG level 2 and beyond (but not all of them as a proportion are on industrial placement in 2010/11 session). It also includes direct entrants to year 2 undergraduate in 2009/10, as well as some students who joined in 2007/8 and are completing 2010/11 as they were on industrial placement in
2009/10 (i.e. undertook a 4 year programme). The numbers in each grouping are summarised in table 2 below.

**The Activity-Led Learning implementation for 2008/9 MAE cohort**

The action that was taken for new Students October/November 2008:

- Produce an intensive six-week introduction to the course using a rotation of six activities
- Base work on the (20 credit) core module
- Delay the start of all other teaching, (except Mathematics) to teaching week seven
- Students work in their tutorial group (15/18 in each group) and then sub-groups typically of 2 or 3
- Aim to complete and pass a module at an early stage

The table below summarises some of the key features of the 2008/9 6-week introductory ALL experience that was designed for these mechanical and automotive engineering students.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Staff</th>
<th>Accommodation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment, Design and Build</td>
<td>1 Academic, 2 Technicians</td>
<td>Modelling Workshop</td>
</tr>
<tr>
<td>Product Marketing</td>
<td>1 Academic, 2 Interns</td>
<td>Project area, Computer room</td>
</tr>
<tr>
<td>Product Image Modelling</td>
<td>1 Academic, 1 Intern</td>
<td>Computer room</td>
</tr>
<tr>
<td>Metrology</td>
<td>1 Academic, 2 Development officers</td>
<td>Metrology lab</td>
</tr>
<tr>
<td>Engine Strip</td>
<td>2 Development officers</td>
<td>Mechanical Workshop</td>
</tr>
<tr>
<td>Materials Testing</td>
<td>1 Academic, 1 Intern, 1 Technician</td>
<td>Materials lab</td>
</tr>
</tbody>
</table>

**Table 1**: The 6 activities and associated resources that formed the first 6 week experience for Mechanical and Automotive Engineering students joining in 2008/9 academic session

Key operational features of the above first 6-week ALL implementation:

- New task every Monday
- Students timetabled for 18 hours of core task (30 hours including other activities)
- Lead academic gives key note lectures and leads assessment (usually 4 hours)
- Supporting facilitator provides supervision and support (usually 14 hours)
- Students work in small groups of 2 or 3
- Students keep individual logbook
- Assessment by poster presentation / brief report / video
- Assessment, feedback and result all in final Friday session
In terms of achievement, progression rates on the module improved from 82% to 92%, while on the programme as a whole improved from 70% to 77% at the end of first year (2008/9).

Students then followed a more ‘standard’ Mechanical and Automotive engineering programme which included Activity-led learning elements at different points within the curriculum. These activity-led experiences, as identified by the students, included a one-week visit to an off-site workplace (engineering) training centre, as well as product innovation and professional development modules (in second and third years). Some students also had a one-year placement in their penultimate year.

Research framework and methods

The aim was to illuminate the student experience of the development of professional skills and attitudes within their programme of study, building on earlier findings (Green and Wilson-Medhurst, 2009) that suggest ALL implementations, in this case the 6-week experience, are helpful in supporting professional skills and attitudes development. The research framework was a phenomenological one: that is, the study aimed to understand the details of these Mechanical and Automotive students’ experiences of professional skills and attitudes development within ALL and other experiences and their subsequent perception of professional skills and professionalism.

The study focussed on the 2008/9 cohort, now (many of them) in the final year of their degree programme.

The two data gathering methods were a questionnaire with closed and open questions, and a focus group.

The table below summarises the cohort details as well as the number of respondents for each of the two data gathering exercises.

<table>
<thead>
<tr>
<th>Mechanical and Automotive Engineering, Graduating Cohort 2010/11</th>
<th>Joined 2008/9 and undertook first 6-week ALL experience</th>
<th>Joined at other times (either in 2007/8 and took optional placement year 2009/10, or direct entrant UG year 2009/10) and so did not participate in first 6-week ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>N = 71</td>
<td>N = 47</td>
<td>N = 24</td>
</tr>
<tr>
<td>Questionnaire respondents</td>
<td>N = 26</td>
<td>N = 22</td>
</tr>
<tr>
<td>Focus group participants</td>
<td>N = 2</td>
<td>N = 2 (one from each of the above categories)</td>
</tr>
</tbody>
</table>

Table 2 – 2010/11 MAE graduating cohort

The questionnaire

The questionnaire differentiated between those who had completed the six-week experience and those who had not. The questionnaire asked students who participated in the 6 week activity which of the six activities supported the development of a particular professional skill or attitude: communication skills, team-working capabilities, a professional outlook, ability to exercise responsibility, the ability to plan my own work, information retrieval and evaluation. A key objective for introducing the 6-week ALL was to give support for the early development of these 6 professional skills or attitudes. The possible responses (students can pick more than one) were:

A. Lightweight bridge design and build
B. Metrology
C. CAD modelling
D. Materials testing
E. Marketing
F. Engine strip  
G. All of them  
H. None of them

The questionnaire then asked students to identify other experiences or activities that had developed the same professional skills and attitudes: these questions were open-ended. It also asked them to describe “what does the term ‘professional engineer’ mean to you?”

Four third-year students were involved in the focus group. Two of the students had taken part in the six week introductory activities that took place at the start of the 2008/9 academic year. Another student was a direct entrant to UG level 2, while the fourth student had completed an industrial placement year and so had begun their degree a year earlier. These last two students had therefore not taken part in the first 6 week activity.

The students were asked questions on five main themes:
- What, in your opinion, is activity-led learning?  
- What is the value of activity-led learning?  
- What are professional skills and attitudes?  
- What, if any, activity-led learning supports professional skills and attitudes?  
- What non activity-led learning supports professional skills and attitudes?

**Evaluation**

The data were analysed in two key ways. Responses to open questions were thematically analysed and categorised, as was the focus group transcript. The closed questions relating to the 6-week experience were statistically analysed to allow a further perspective on the data, to triangulate with the thematic analysis. This allowed researchers to gather data on the students’ experiences of the development of professional skills and attitudes within ALL and non-ALL experiences, and then to distil their conceptions of the phenomena ‘professional skills’ and professionalism within the context of engineering. Two key sets of findings are presented here. The first relates to the questionnaire evaluation of the 6 week experience.

**Statistical analysis of questionnaire responses regarding initial six week activity:**  
**Interpretation of results**

Respondents were from two degree programmes: Automotive Engineering (n=12) and Mechanical Engineering (n=14).

**The degree of diversity and agreement in students’ perceptions of opportunities for professional skills development within the six-week activity**

This analysis of the effectiveness of individual activities supporting specific professional skills uses data that are drawn from the *perceptions* of the students regarding their effectiveness. As can be seen from figs. 1.2 to 1.4 particularly, students’ experiences regarding the learning of communication skills, teambuilding skills and the exercising of responsibility agree. This would seem plausible from the nature of the skills; when teambuilding and communication are effective, all students experience this particular activity as an effective support for that skill. When the skill is a more individual one, such as information retrieval and evaluation, or planning one’s own work, then students will have different experiences of which activity this occurs in. In the figures, the y axis represents the number of responses. On the x axis, A = Lightweight bridge design; B = Metrology; C = CAD modelling; D = Materials testing; E = Marketing; F = Engine strip; G = All of them; H = None of them.
Ability to exercise responsibility (fig. 1.4)

- Mechanical
- Automotive

Ability to plan own work (fig. 1.5)

- Mechanical
- Automotive

Information retrieval and evaluation (fig. 1.6)

- Mechanical
- Automotive
The skills that are most supported by the activities

As can be seen in figures 1.3 and 1.6, the skills that students perceived to be most effectively supported were teambuilding activities, and information retrieval and evaluation. These skills were supported by the set of activities in two different ways: Figure 1.3 shows that most students experienced effective teambuilding in the bridge-building and engine strip activities, whereas the information retrieval and evaluation skills were acquired by different students in different activities (figure 1.6).

Linking this to the previous observation, it can be seen that the activities optimised their support for professional skills development by:

- Ensuring that professional skills which must be developed through groupwork were the focus of, and supported by, two separate specific activities. Targeting groupwork-based skills in a small number of activities enables all students to develop these skills at the same time.
- Providing opportunities for the development of the professional skills that are developed through individual work across many activities. Having a provision for individual-based skills in many activities provides students’ multiple opportunities to develop these skills and the opportunity to select those most relevant to them.

The activities that provide less support for professional skills development

Of the separate activities, the metrology activity scored substantially lower on the questionnaire than the others for its development of professional skills, only performing well on information retrieval and evaluation skills (fig 1.6). The description of activities for the metrology exercise indicates why this is the case. Whereas the other activities include instructions that are more exploratory, such as “plan”, “design”, “experiment”, “test”, (e.g. the bridge-building exercise), the metrology activities are highly directive, i.e. to conduct measurements (obviously) and to define terms. This is not to say, however, that this is inappropriate to an introductory course. Indeed in the students’ recounting in the focus group of their off-site workplace training experience, metrology is an integral part of practical work in engineering.

- The acquisition of basic technical ability is a requirement of most professions, even though these may not be listed in a series of “professional skills” and still need to be supported.

Variation in professional skills supported by activities

Apart from the metrology activity, the five other activities all make a similar contribution to the professional skills of the students, but contribute to different skills. Table 3 shows that (with one or two exceptions) the types of activities fall into three groups: the marketing activity is particularly effective at promoting communication skills and a professional outlook (figs. 1.1 and 1.2); metrology supports information retrieval and evaluation (and the technical skills described); the remainder support teamworking, taking responsibility and planning own work.
Table 3: Activity that most effectively supports the 6 professional skills and attitudes that were a key focus of the 6-week ALL

Although generalising should be done cautiously, the distribution above indicates that courses benefit from having a combination of subject-specific activities (in which learners can experience working and planning the completion of tasks related to their discipline) and situated generic activity that encourages softer skills, encouraging meta-cognitive and communication activities. An effective learning opportunity does not necessarily combine these into one activity. As long as the sequence includes both, then professional skills will be developed. Indeed, alternating between the two may be most effective. The literature indicates that while learners are immersed in a task, such as bridge building or engine stripping, their opportunities for reflection are lessened (Carr, 2006) even though their team-working may be at its height.

- **Subject-specific activities may be more effective when promoting team-work and providing students with an opportunity to exercise responsibility.**
- **Appropriately situated generic “soft-skills” activities may be more effective when promoting reflective skills such as a professional outlook, and communication skills.**
- **It may be more effective to avoid combining these into one activity; reflection on and immersion in an activity are not activities that normally occur simultaneously.**

**Differences between Mechanical cohort and Automotive cohort**

For most of the professional skills analysed, the differences between the two cohorts are minimal. However, in their response to the question on ability to exercise responsibility (fig 1.4), differences do appear. The automotive students felt far more able to exercise responsibility in the engine strip activity. The mechanical engineering students felt more able to exercise responsibility in the bridge building and CAD modelling exercise. This is probably due to the activities being largely based on their own subject disciplines: a certain degree of expert knowledge on a subject is necessary for the learner to exercise responsibility.

- **The ability to exercise responsibility appears to require a degree of subject knowledge as a pre-requisite more than other professional skills.**
A minority of students were dissatisfied with their professional skills development and this point is picked up in the final conclusions section of this case study on page 11.

Conclusion

According to student perceptions, the schedule of activities presented as part of their 6 week activity demonstrates an effective template for supporting professional skills, integrating, as they do, a combination of generic and subject-specific activities, as well as team skills in a few key activities and providing opportunities for individual skills across many activities. The balance between skills required for a profession, and basic technical skills, is also effectively struck. Across the board, 25 of the 26 respondents felt that all of their professional skills had been supported at some point during the six-week activity.

Key findings and conclusions from focus group in relation to 6-week ALL

Activity-led learning was seen by the students as promoting a range of skills that would be considered to be related to professional practice by educationalists. These included:

- Supporting team-working through getting to know other people and feeling more comfortable within the university.
- Being aware of different cultures.
- Promoting enthusiasm for the subject through having fun.
- Providing an opportunity to make informed decisions about subject specialisation within the degree, and in a future career.
- Promoting a greater degree of critical self-awareness.
- Increased confidence levels (e.g. the ability to ask “silly” questions).

The students’ concept of what constitutes an “engineering professional”, professional skills and learning is a complex one, which on one hand displays that students have a good awareness of what these things are, but on the other contains many inconsistencies.

For example, these students employ the phrase “professionalism” to indicate a professional demeanour and corporate aspiration in a work-place setting. On the other hand, “professional skills” are the requisite set of attributes of an engineering professional, i.e. being professional and being a professional connote different things.

Thus, when asked if 6-week ALL promoted professionalism, the students felt that it did not, but they did feel it promoted specific skills such as communication which are seen as professional skills. Learning to be a professional is seen as, on the whole, linked solely to workplace-like environments, so developing professional skills within a classroom or lab setting requires (from the student’s perspective) recreating to some extent a workplace-like activity, for example working with a real company and/or on a “real world” problem. However, students are also aware that “professional skills” are a whole set of attributes such as team-working, communication, self-learning, and these are seen by the students as being present in a wider range of learning activities. Hence, asking of a classroom activity “does this activity promote professional skills?” may obtain the answer “no”, but asking “what are professional skills?” and then on receiving the answers, A, B, C asking “does this activity promote A, B, C?” may obtain the answer “yes”.

Educating students about professional skills therefore requires not only including professional skills in their learning, but also making them aware that they are learning professional skills. For students to feel that they are being prepared for being a professional engineer, either a workplace-like scenario needs to be created for them, or efforts need to be made to encourage them to disassociate the concept of “learning professional skills” from “engaging in workplace-like activities”.
Conclusions

The findings of the study suggest the following conclusions with regard to the learning of professional skills and attitudes by these students.

1. The six week activity as currently constructed requires little or no modification to give support for early development of professional skills

   The constituent parts of the six week activity provide a very good balance between the various professional skills. Collaborative activities are supported by the generic marketing scenario, while planning and responsibility skills are supported by relevant subject-specific activities. Information retrieval and evaluation is addressed across most of the scenarios.

2. A wide range of opportunities exist for promoting professional skills

   Students referred to specific activities within a range of modules that had provided them with opportunities to expand their experience of responsibility and planning of work. Module design could draw on this good practice to identify additional areas for developing specific professional skills.

3. Though developing effective professional skills, students’ awareness of what defines professionalism remains largely unarticulated

   Students rated various ALL experiences including the 6-week experience highly, and displayed awareness of, and ability to reflect on, the professional skills they had acquired, but had limited understanding of what constituted “a professional engineer” as a concept, typically equating it with corporate behaviour. There may be a role for a more explicit discussion of these concepts, to enable students to critically engage with notions of professionalism. This may also enable the students to identify a wider range of activities that support professionalism, in addition to those that are evidently workplace-like. This will also help students to better articulate and reflect upon their professional development.

4. A minority of students are dissatisfied with the support for professional skills

   This probably does not need to be addressed by changes in the curriculum, since the majority of students feel that this support is sufficient. However, in developing more group work and more reflective practice, some students may have become alienated, perhaps feeling that this lacks the rigour of a more traditionally constructed course. Identifying these students as well as ways to identify their concerns and reassure them may offset some of this anxiety.

Further Development

This study presents evidence of ALL practice that works in terms of supporting professional skills and attribute development according to student perceptions. The study is limited to student perceptions only, as the aim of the study was to illuminate the experience from a student’s perspective, and provide pointers for enhancement of (activity-led) curricula. Further research can now build on these findings.

Clear communication of what is meant by “professional skills” and “professionalism” and where and how these skills and attitudes can be developed will further improve the student experience of their development in these areas. Other STEM education providers may wish to reflect on the extent to which they make such distinctions and support clear in their curricula and how they might make enhancements in the light of this study’s findings.

These recommendations may also help address the concerns of students who are dissatisfied with the support for development of professional skills as they may come from a misunderstanding of what professional skills are meant to be and/or an anxiety about engaging with them.
References


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