Enhancing employability skills of Engineering students by using peer-mentoring in group projects aiming to solve real-world problems

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Aim

Present an excellent example of innovation in action where emerging technologies have been actively integrated with professional best practice into research, teaching and learning experiences.
Objectives

• Discuss the **opportunities** and **challenges** related to the **multi-disciplinary group project** which has involved the **award-winning** Huddersfield Railway Challenge 2013 team.

• Explore the **problem-based**, **experiential** and **cooperative learning activities** where the undergraduate students from Electrical and Mechanical Engineering courses have performed real research tasks alongside post-graduate students from the Institute of Railway Research.
Objectives

• Explore the problem-based, experiential and cooperative learning activities where the undergraduate students from Electrical and Mechanical Engineering courses have performed real research tasks and being mentored by post-graduate students from the Institute of Railway Research.

• Analyse the enhancement of employability skills of all students generated by this problem-based approach in solving real-world problems.
IMechE Railway Challenge 2013

Student teams assume that they work for a design consultancy producing a locomotive for a large corporation. They must design and manufacture the prototype of this locomotive and then test this against prototypes manufactured by the other teams.

Track Based challenges:
- Energy Storage Challenge
- Traction Challenge
- Ride Comfort Challenge

Presentation challenges:
- Design Challenge
- Business Case Challenge
IMechE Railway Challenge 2013

“Taking part in the Railway Challenge has taught us the fundamental aspects of Railway challenges, *practical* and *theoretical engineering* and has enabled the team to appreciate the importance of railway dynamics especially the metal-on-metal interface between the wheel and track.”

Siddiq Albusmait, Team Captain
Huddersfield Railway Challenge Team

2013 Winners of the Railway Challenge
The team

6 Mechanical Engineering students – supervised by Prof Simon Iwnicki

12 Electrical Engineering students – supervised by Dr Crinela Pislaru

3 Post-graduate students
Essential qualities of team players

<table>
<thead>
<tr>
<th>Quality</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptable</td>
<td>If you won’t change for the team, the team may change you</td>
</tr>
<tr>
<td>Collaborative</td>
<td>Working together precedes winning together</td>
</tr>
<tr>
<td>Committed</td>
<td>There are no half-hearted champions</td>
</tr>
<tr>
<td>Communicative</td>
<td>A team is many voices with a single heart</td>
</tr>
<tr>
<td>Competent</td>
<td>If you cannot, your team will not do it.</td>
</tr>
<tr>
<td>Dependable</td>
<td>Teams go to Go-To players</td>
</tr>
<tr>
<td>Disciplined</td>
<td>Where there’s a will, there’s a win</td>
</tr>
<tr>
<td>Enlarging</td>
<td>Adding value to teammates is invaluable</td>
</tr>
<tr>
<td>Enthusiastic</td>
<td>Your heart is the source of energy for the team</td>
</tr>
<tr>
<td>Intentional</td>
<td>Make every action count</td>
</tr>
<tr>
<td>Mission conscious</td>
<td>The Big Picture is coming in loud and clear</td>
</tr>
<tr>
<td>Prepared</td>
<td>Preparation can mean the difference between winning and losing</td>
</tr>
<tr>
<td>Relational</td>
<td>If you get along, others will go along</td>
</tr>
<tr>
<td>Self-improving</td>
<td>To improve the team, improve yourself</td>
</tr>
<tr>
<td>Selfless</td>
<td>There is no “I” in team</td>
</tr>
<tr>
<td>Solution-oriented</td>
<td>Make a resolution to find the solution</td>
</tr>
<tr>
<td>Tenacious</td>
<td>Never, never, never quit</td>
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</tbody>
</table>

Group project - benefits

Group projects can reinforce skills that are relevant to both group and individual work such as ability to:

• Break complex tasks into parts and steps
• **Plan and manage time**
• Refine understanding through discussion and explanation
• **Give and receive feedback** on performance
• Challenge assumptions
• **Develop stronger communication skills.**

Group project – challenges for students

- Language issues to contend with
- Cultural differences to bridge
- Disparate skills to integrate
- Limited experience to work in groups and achieve milestones related to industrial projects → students who went for one year placement in industry were better.
- Apply strategies for working with challenging personalities and cultural considerations.
- Reflect together on the quality of their team work regularly and provide feedback on how well they are doing as a team.
## Group project – challenges for students

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coordination costs</strong> –</td>
<td>coordinate schedules</td>
</tr>
<tr>
<td>supplementary time and</td>
<td>arrange meetings</td>
</tr>
<tr>
<td>energy which has to be</td>
<td>meet</td>
</tr>
<tr>
<td>spent for group work</td>
<td>correspond</td>
</tr>
<tr>
<td></td>
<td>make decisions collectively</td>
</tr>
<tr>
<td></td>
<td>integrate the contributions of group members</td>
</tr>
<tr>
<td><strong>Motivation costs</strong> -</td>
<td><em>Free riding</em> - one or more group members leave most or all of the work</td>
</tr>
<tr>
<td>adverse effect on student</td>
<td>to a few, more diligent, members.</td>
</tr>
<tr>
<td>motivation of working in</td>
<td><em>Social loafing</em> - tendency of group members to exert less effort than</td>
</tr>
<tr>
<td>groups</td>
<td>they can or should because of the reduced sense of accountability.</td>
</tr>
<tr>
<td></td>
<td><em>Conflict</em> within groups - can erode morale and cause members to</td>
</tr>
<tr>
<td></td>
<td>withdraw.</td>
</tr>
<tr>
<td><strong>Intellectual costs</strong> -</td>
<td><em>Groupthink</em> - tendency to conform to a perceived majority view.</td>
</tr>
<tr>
<td>characteristics of group</td>
<td><em>Transparency illusion</em> - tendency of members to believe their thoughts,</td>
</tr>
<tr>
<td>behaviour that can reduce</td>
<td>attitudes and reasons are more obvious to others than is actually the</td>
</tr>
<tr>
<td>creativity and productivity</td>
<td>case.</td>
</tr>
<tr>
<td></td>
<td><em>Common information effect</em> - tendency to focus on information all</td>
</tr>
<tr>
<td></td>
<td>members share and ignore unique information, however relevant.</td>
</tr>
</tbody>
</table>

Carnegie Mellon (2014) - **What are the challenges of group work and how can I address them?**

Online: [http://www.cmu.edu/teaching/designteach/design/instructionalstrategies/groupprojects/challenges.html](http://www.cmu.edu/teaching/designteach/design/instructionalstrategies/groupprojects/challenges.html) [Accessed 10 December 2015]
Values of undergraduate research and inquiry

“ - the focus is on the student as a learner;
- it explicitly brings the student into the worlds of research;
- it views the student as a potential producer of knowledge;
- it potentially values all academic and support staff;
- it may help to break down institutional firewalls between teaching and research;
- it challenges what is research.”

Undergraduate research and inquiry

Project Group aim – design, develop, manufacture a practical product which had to adhere to the IMechE competition requirements and offer competitive advantages (such as technology-enabled innovation, versatility and engineering excellence) against other teams.

Researchers have acted as mentors to undergraduate students and enabled them to be involved in the process of knowledge creation via problem-based, experiential and cooperative learning activities.

Research Mentors – “guiding students from the formulation of research questions through design and analysis stages and finally to the interpretation of the findings as well as their integration into the greater body of knowledge providing the context for the research.”

Advantages of UG research and inquiry

“The literature converges on a broad set of benefits as arising from engagement in authentic research. Notably congruent are:
- gains in confidence and in establishing collegial working relationships with faculty and peers,
- increases in students’ intellectual and practical understanding of how science research is done;
- students’ greater ability to work and think independently from faculty;
  the role of UG research both in helping students to assess the fit of research as a career and to clarify career and graduate school plans.
Across the studies, these results underscore UG research experience as offering a constellation of gains that collectively reflect students’ personal, intellectual and professional growth.”

‘Discovery' research and scholarship

Stage 1 - Process of research

Stage 2 - Process of knowledge construction

Stage 3 - Process of learning
Linking research to teaching and learning involves far more than constructing modules with the latest research results as content:

engaging students in research and research-like activities

inducting students as practitioners and partners into a RESEARCH COMMUNITY and CULTURE with their lecturers and tutors

developing students' skills to collaborate in the knowledge construction process and become aware of the nature and status of knowledge as constructed, provisional, negotiated and sanctioned.

Staff and Departmental Development Unit – Case studies of Blogging at Leeds. Available online https://elgg.leeds.ac.uk/tanrnexux/weblog [Accessed 10 January 2016]
Advantages of UG research and inquiry

“Our students, and indeed the wider society, face what appears to be a difficult and uncertain future. Immediately they may face an uncertain employment market; they look towards an indeterminate future in a world faced with uncertainties over climate change, globalisation, international conflicts and major advances in research continually reshaping our understandings of the world we live in.

Helping our students understand and cope with uncertainty, ambiguity, complexity and change is not just valuable to their development at university and after graduation, it may also be central to the future of humanity. “

Active, affective, experiential pedagogy – interaction with industry

Experiential learning enables the students to be better engineers as a result of their understanding of the real-life content of their engineering education.

Examples – students contact the producers in order to buy electrical and mechanical parts for rail vehicle.

Outcomes – increased motivation, good communication skills, habit of learning rapidly, ability to deliver results, meet customer expectations, aptitude for coping with pressures and setbacks.

Students learn through interaction with real people and have to deal with the complexity of true social relationships.

Assessing Experiential Learning in Engineering

a. Knowledge and application of fundamental concepts
b. Creativity
c. Problem solving and troubleshooting skills
d. Professional judgment and decision-making ability
e. Ability to see the connectivity of things (the big picture) – zooming in and out
f. Initiative and self-reliance
g. Ability to communicate and cooperate (teamwork)
h. Punctuality and ability to meet deadlines
i. Resilience in dealing with setbacks, crises and failures
j. Sense of responsibility
k. Leadership ability
Cooperative learning

1. **Positive interdependence** - The tasks required the students to rely on one another for the effort to be successful.

2. **Individual accountability** - Each team member was held accountable for everything in the project, and not just the part for which he or she may have had primary responsibility.

3. **Face-to-face interaction, at least part of the time** - the team met to discuss, debate, and reach consensus on solutions to problems in organised common group meetings, discipline-based meetings and ad-hoc small groups meetings.
Cooperative learning

4. **Facilitation of interpersonal skill development** - project management, time management, communication, leadership, and conflict resolution skills are necessary to work effectively on a team.

5. **Periodic self-assessment of team functioning** - at regular intervals, the team members were requested to reflect on what they are doing well as a team, what they need to work on to improve the team functioning, and what if anything they will do differently in the future.
Culture of inquiry-based learning

“Developing the Student as Scholar Model requires a fundamental shift in how we structure and imagine the whole undergraduate experience. It requires, as a minimum, the adoption of the Learning Paradigm in everything from the first introductory course through the final capstone experience. It requires a culture of inquiry-based learning infused throughout the entire liberal arts curriculum that starts with the very first day of college and is reinforced in every classroom and program.”

Conclusions

• Supervising the multi-disciplinary group project presented interesting challenges, but it was a pleasure working with the award-winning Huddersfield Railway Challenge 2013 team.

• Excellent idea of having researchers acting as mentors to undergraduate students so they become partners in the knowledge construction process.

• **Problem-based learning** – driven by challenging, open-ended questions with no one ‘right’ answer.

• **Experiential learning activities** - enabled the development skills pertinent to new engineers in a professional environment: objective decision-making, team working, autonomous learning, conflict handling, defence of initiatives.

• **Cooperative learning activities** - enabled the development or improvements of team work skills.
Conclusions

• The dichotomy between subject domain knowledge in STEM subjects and employability skills can be minimised by enabling the students to solve real-life problems so the knowledge (content), technical skills (context) and learning / employability skills (process) can be developed in an integrated manner.

• Students learned together through a combination of collaborative and co-operative activities, in a constructivist, experiential and situated manner, as they worked through team processes to produce solutions for real-world problems.

• The students took greater ownership of their education and got a taste of the workplace – working on teams, meeting deadlines, and creating and giving presentations to their colleagues and the judging panel.

• The student learning experience was focused on the development of employability graduate attributes and engaging the research community so the students become fully equipped to perform confidently and competently in their professional careers as individuals and team players.
Discussion points

• Integrate emerging technologies with professional best practice into research, teaching and learning experiences.

• Developing undergraduate students' skills to collaborate in the knowledge construction process.

• Inducting students as practitioners and partners into a RESEARCH COMMUNITY and CULTURE with their lecturers and tutors.

• Development of culture of inquiry-based learning which enhances the employability skills of all students.

• Helping our students understand and cope with uncertainty, ambiguity, complexity and change.
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