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Supporting student experience of undergraduate research and inquiry

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9th University of Huddersfield Teaching and Learning Conference - Building our learning cultures: Putting the Teaching and Learning Strategy into practice.
23 June 2014

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.

IMechE Railway Challenge 2013

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

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

Maxwell, J.C. (2002) - **The 17 Essential Qualities Of A Team Player – Becoming The Kind Of Person Every Team Wants.** Published By Thomas Nelson Publishers.

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**.

Carnegie Mellon (2014) - **What are the benefits of group work?** Available online: http://www.cmu.edu/teaching/designteach/design/instructionalstrategies/groupprojects/benefits.html [Accessed 1 June 2014]

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

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

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 [Accessed 1 June 2014]

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****. "*

Healey M., Jenkins A. (2009) – **Developing Undergraduate Research and Inquiry**. The Higher Education Academy, pp. 9.

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*."

Ramirez J. J. (2012) - **The Intentional Mentor: Effective Mentorship of Undergraduate Science Students.** The Journal of Undergraduate Neuroscience Education (JUNE), vol1, no 11, pp A55-A63.

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**."*

Hunter, A.B., Laursen, S.L., Seymour, E., Thiry, H. and Melton, G. (2010) **Summer scientists: establishing the value of shared research for science faculty and their students**. San Francisco: Jossey-Bass (in press), chapter 2.

COMPONENTS OF RESEARCH-TEACHING NEXUS

Teaching can be *research-led* (i.e. include the products of the research process)

Teaching can be *research-orientated* (i.e the curriculum includes an understanding of the research process)

Teaching can be researched-based (i.e. the curriculum is designed around inquiry-based activities, the practice of research)

Teaching can be *research-informed* (i.e. based upon research into teaching and learning)

Good scholarship

" **Good scholarship**, in the sense of remaining aware of the latest research and thinking within a subject, **is essential for good teaching.**

This is not sufficient to achieve the aim of **excellent and inspirational teaching in a research-intensive context**."

The Future of Higher Education - 2003 White Paper

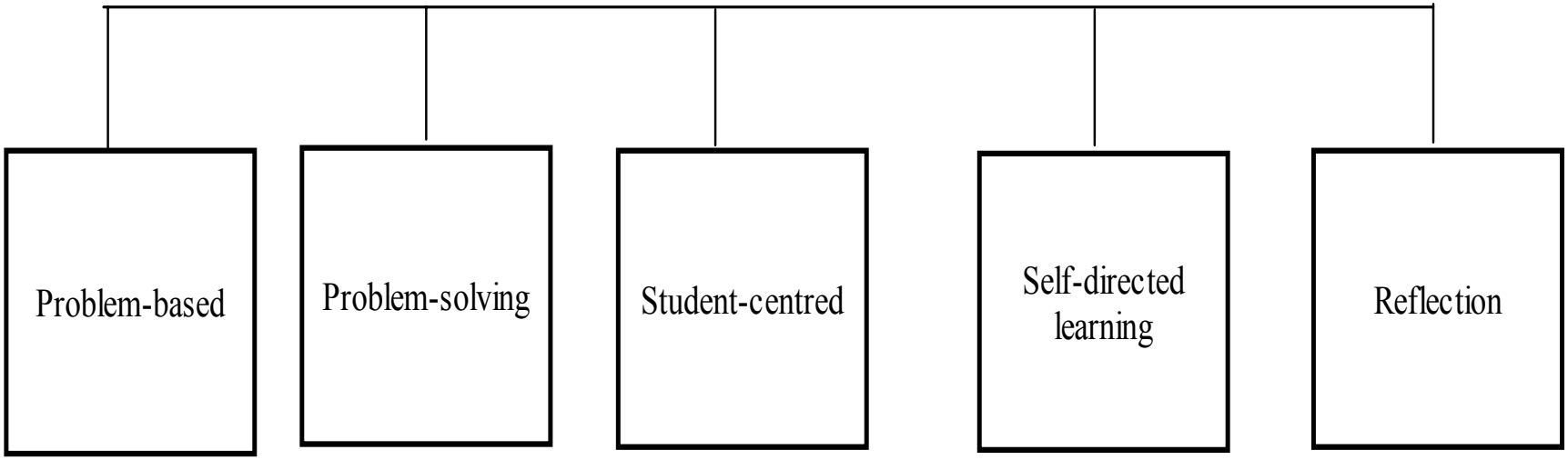
Advantages of UG research and inquiry

"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. "

Healey M., Jenkins A. (2009) – **Developing Undergraduate Research and Inquiry**. The Higher Education Academy, pp. 124.

Problem Based Learning



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.

Kolb, A. and Kolb, D. (2005) - **Learning styles and learning spaces: enhancing experiential learning in higher education.** Academy of Management Learning and Education, vol 4, no. 2, pp. 193-212.

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.

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.**

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.

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