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THE RESEARCH METHODOLOGY TO INVESTIGATE THE LONG-TAIL LEARNING EFFECT ON ALUMNI FROM A LARGE TEAM PROJECT

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Abstract: Previous pedagogical research at Sheffield Hallam University by Todd et al (2006) has identified that final year students have valued final year projects to extend their degree learning experience. However, any long-term effect on their personal professional development as a graduate has not been assessed previously. This paper discusses both quantitative and qualitative research methods adopted in a comparative study of two types of individual dissertation projects; the traditional versus alternative sub-project of a larger longitudinal (over 6 years) group project led and managed by level 7 students. A student researcher has been employed to minimise bias and foster an equal's relationship between researcher and graduate. The goal is to gather insight into the alumni experiences, lessons learnt, to inform future practices and to enrich the final year project experience at Hallam.

Keywords; engineering education, long-tail learning, transformation learning, team project learning, active learning.

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1. INTRODUCTION

The Wind Tunnel Project (design, develop and build a closed recirculating wind tunnel facility) at Sheffield Hallam University has been in operation for the last 6 years and aims to replace the existing more limiting wind tunnel. In parallel, the academic lead runs a sister project to develop a rolling road (moving ground) facility to be used in the new wind tunnel. In 2017/18 the initial build phase and basic commissioning of the wind tunnel has been completed. The tunnel has demonstrated ideal uniform flow velocity and low turbulence in the working (measurement) section. The rolling road system has seen major progress on the suction system and roller framework. The wind tunnel and rolling road projects have hosted numerous (40+) MEng/BEng level 6 & 7 individual dissertation projects, led and managed by MEng (level 7) students as part of their MEng Group project. The project approach has been the adoption of Project Based Learning (PrjBL) and active learning pedagogies.

PrjBL enables students to learn through investigating and solving authentic problems (Blumenfeld, 1991). Active and PrjBL learning enables contextualisation of the learning, enhances student academic performance and students value the approach as a more effective learning method (Freeman et al, 2014; Nguyen et al, 2017; Schmidt, 2011). Chickering et al (1987) highlighted “Learning is not a spectator sport… They [students] must make what they learn part of themselves.” Medical students have shown to develop greater and deeper learning, graduate competencies and skills for successful long term professional practice through active learning and PrjBL (Prince et al, 2005; Schmidt, 2011). PrjBL engages learners in higher cognitive learning activities of critical analysis and synthesis, improving final year learning outcomes (Savery, 2015). However, students find active and PrjB learning challenging as involves group-work, and potentially working with students who socially loaf (fail to make a fair contribution) (Aggarwal, 2008). One solution is to create a pedagogy framework, one such approach has shown to provide a long tail learning effect upon journalism graduates in terms of being flexible, independent and resilient for competitive career in Journalism (Cokley and Ranke, 2010).

Todd et al’s (2006) research at Sheffield Hallam University identified that students valued the traditional style final year project as enabled them to apply their degree learning and produce a tangible output in the form of a dissertation. However, both students and academics reported it to be a chaotic experience and academics find it challenging to provide timely and appropriate supervision for each learner (ibid).

2. STUDENT ACTIVITY CASE STUDY

1.1 Rolling Road Facility: Suction Inlet Ducting Flow Characterisation

The Rolling Road Facility under development at Sheffield Hallam University will enable close to ground experimental aerodynamic testing of automotive vehicles and aircraft. The inlet to the wind tunnel boundary layer reduction system (BLRS) serves here as a suitable case study (Gleeson, 2018) to illustrate one strand of recent project work, see Figure 1. The aim was to confirm the flow rate through the system at inlet and outlet, using Bernoulli’s continuity principle (Anderson, 1984). The student measured jet exhaust total pressure from the drive fan system with the inlet ducting installed, see Figure 2a. At maximum electrical power supplied to the fan, the flow rate aft of the fan was measured to be 0.12 m^3/sec. The flow rate at the inlet 0.14 m^3/sec was measured using a static pressure tapping at the wall and a total pressure tube in the centre. This agreed reasonably well, around 15% difference, with the exhaust flow rate thus demonstrating continuity. The inlet velocity profile was derived from computational fluid dynamics (CFD) using a two-dimensional fluid domain for identical flow rate input of 0.14 m^3/sec matched to experiment, see Figure 2b.

These outputs confirmed the flow through the inlet did not have uniform velocity across the channel suggesting a pair of total and static pressure measurements may not be a detailed enough diagnostic to yield a representative flow rate value, without a calibration curve from a more detailed survey. This project yielded preliminary experimental outputs on which to build follow on investigations, towards final characterisation of the system flow through the suction inlet duct before moving to end use commissioning on the wind tunnel.

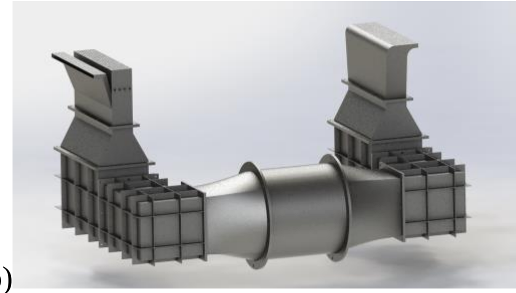
(a)  (b) 

Figure 1. Rolling Road System including (a) conveyor belt rollers, belt suction, liquid cooling and (b) wind tunnel boundary layer reduction sub-systems (Griffiths, 2015).

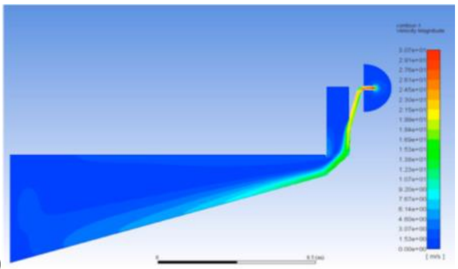
(a)  (b) 

Figure 2 (a) Suction system inlet ducting connected to diffuser duct, converting to interface with fan. (b) Velocity contour plots from 2D CFD simulation (Gleeson, 2018).

3. RESEARCH HYPOTHESIS

This study will explore whether the Wind Tunnel Project, that has employed active and PrjBL pedagogies, has had an impact on the students' personal development of both technical and employability skills. It will also investigate the *long-tail learning effect* on graduates' professional employment performance in comparison to the more traditional third year engineering dissertation projects. The project research hypotheses;

- What long tail effect does the Wind Tunnel Project has/have upon students who contributed to the Wind Tunnel project?
- What is the impact on students' *learning* on students who contribute to the longitudinal project through individual projects?
- What is the impact on students' *experience* on students who contribute to the longitudinal project through individual projects?
- What is the impact on students' *graduate skills* on students who contribute to the longitudinal project through individual projects?
- What is the impact on students' *engineering (technical) skills* on students who contribute to the longitudinal project through individual projects?
- How do these student learning, experience and skills development differ to students engaged in more traditional level 6 projects?

4. METHODOLOGY

The study will use quantitative and qualitative research methods. The quantitative method of survey instrument is based upon Prince et al (2005) to explore students' perceptions of their skills confidence and development, using scales to explore the students' concept of learning (Entwistle et al. 2013). However, the survey is to enable students to self-assess and reflect on skills associated with good engineering learning development practice, for example spatial awareness (Lucas et al. 2014).

The initial survey was developed by the academic leads. Pilot interviews with current students have been employed to inform and improve the survey design to ensure the responses are more of a true reflection of the effect PrjBL has had on the project alumni. The final survey is concise and consists of Likert and Short answer questions, developed using best survey design practice (Prince et al, 2005) and has been revised, to be deployed (via email with weblink) and analysed by the employed student researcher. All responses will be collated anonymously, adhering to good ethical research practice. However, the respondents could, if they so choose to, volunteer for the follow up qualitative research study.

Survey data builds on students' personal project reflections documented in their dissertation. The survey is to be deployed to former students who have volunteered to keep in touch (via email and social media) with the wind tunnel academic lead, Dr. J. Potts, and traditional project academic lead, Dr. A. Nortcliffe. Short answers will be codified in relation to the research question, "What long tail learning effect has the third year project had upon them?" The survey responses of the two groups of former students are to be compared for common and contrasting themes with respect to the impact on their learning and experience, in line with the Prince et al (2005) research approach. This will enable the research to compare the student learning experience of being involved in;

- A long term project with a real tangible output i.e. wind tunnel.
- Individual final year projects with more limited tangible outputs; prototype, proof of concept or theoretical simulations.

5. RESEARCH RESULTS

5.1 Pilot interviews

An informal interview was carried out with BEng/MEng level 6 and MEng level 7 students, 6 in total, currently working in various roles in design, build, test and management of the Wind Tunnel Project during academic year 2017/18. The informal interviews focused on questions related to their; role on the project, reason to join, how they heard about it, key learnings and skills developed, challenges overcame, memorable learning, improvements. The interviews took 10-15 minutes and allowed students to reflect on their own experience with the freedom to volunteer information, noting remarkable, specific and unique learning experiences that have contributed to their future career aspirations.

Results from these interviews showed that the most important qualities learnt; time management, teamwork and problem solving. Students appreciated the opportunity to implement technical, analytical and experimental testing skills. Notable PrjBL experiences enabled them to overcome specific obstacles, grow personally, professionally and manage stress and navigate University procurement processes. Participants found PrjBL rewarding as entailed designing, building and obtaining tangible results particularly correlating simulation data with real experimental data. Though the build was not assessed, it kept them motivated to perform at a high standard to inform and impact upon the next set of projects and collaborations in producing a functioning wind tunnel. This reflects the students' emphasis on the importance of self-management, responsibility and teamwork. All students interviewed fully recommended the Wind Tunnel Project as a learning experience, particularly as it involves formal group meetings and discussions creating a sense of belonging. This PrjBL uniqueness differentiates them from their peers' skills development, funding and institutional support.

Additions to the research survey questionnaire as a result of the pilot interviews, include;

- Practical and project management skills question, linked to a skills choice option list.
- Open questions;
    - What was remarkable (challenges, opportunities) of the project experience?
    - Would you recommend this project, if yes for what reasons?
    - If you could go back in time, what you would change, and for what reason?
    - From the mentioned competencies, is there any that might have had a significant impact in your workplace? If yes, please give an example.
    - Are there any other skills that were developed during the project and you have subsequently used at work or in further study? Please give an example.

These questions are intended to gather a wider picture of the participants reflections of the PrjBL and competencies developed during the project and currently applied in the workplace.

5.2 Student Reflections

Each student in partial fulfilment of the project assessment are required to reflect upon their learning and personal development gained during the project. Some common themes observed over the last six years are;

Theme 1 - Opportunities for Leadership

- Student 1A "I was not expecting to undertake any leadership tasks apart from managing my own area of the project, I was pleasantly surprised at how natural leadership felt. I feel as though this project has given me the tools and the confidence to put myself forward for a management or leadership role."
- Student 1B "It has been interesting seeing it from a management side and can take this into industry. It has been a priceless learning experience and given me the tools to lead and manage people."

Theme 2 - Team Working

- Student 2A “This new structure of concurrent team working… worked for us as the style allowed for greater autonomy between each area of design, meaning that the whole team was allowed to work together toward a common goal.”
- Student 2B “During this project my team-working ability has also improved significantly since I have been exposed to the conditions of working in a cooperative engineering environment.”

Theme 3 - Communication

- Student 3A “Future groups need to ensure that they maintain strong communication between team members, ensuring that everyone is kept up to date with the progress of all other members. This is especially important for the systems projects as their interdisciplinary nature requires cooperation from the entire group.”
- Student 3B “I feel the project ran smoothly as problems were solved as quickly as they were identified. The key reason for this is the clear communication within the wind tunnel team, without this level of communication between the team the construction of the wind tunnel would not have been possible.”

6. DISCUSSION

6.1 Pilot Interviews

Suggestions obtained from the pilot interviews focused on how to improve the overall project management of the Wind Tunnel Project with a clear rationale as to why;

- Maintain the validation and testing stages, these continuous improvement cycles are where students can feel the realness of the project to their professional future.
- Students prefer a holistic experience involving all phases: Design-Build-Test-Validate
- Implement training sessions to improve key organisation and time management skills
- Improve communication channels between team members, there is a need to embed professional communication and methods, for example MS Office 365 tools.
- Attract a wider variety of students from a different array of engineering and science bachelors who can contribute to other aspects of the wind tunnel.

6.2 Academic Lead Reflections and Observations

One of the major learnings to come from PrjBL from the Academic Lead perspective is realising the ambitiousness of scoping a project to be designed, built and then tested within an academic year. The more successful projects have entailed taking the previous year’s design, then appraise and improve it towards final end use. For example, during the most recent cycle, the build phase of the wind tunnel build was only possible because the ducting sections were procured at the end of the previous year and ready to be assembled. Also, the BLRS was comprehensively investigated, see section 2, as the ducting pre-existed. Previously projects that have been highly interdependent on multiple student peers’ input have been challenging with the potential to result in an occasional show stopping project.

The best example of this was the vibrational testing of the rolling road support frame, which is central to all the sub-system projects that were delegated to the various team members. However, the required design input was not possible until too late in the academic year for the frame to be fabricated and tested. Instead the student investigated an alternative vibrational input source altogether and learnt a valuable project management lesson. Similar occurrences should be strategically designed out of individual projects sitting within a larger team project at the proposal stage, identifying potential showstoppers early. Implementing a framework where students test and progress the previous year's design, propose a new or improved design then fabricate or procure towards the end, in other words *test design build*. The *test design build* approach decouples the individual project outcomes from any peer interdependence and empowers the student with every chance to succeed right from the start.

7. CONCLUSIONS AND FUTURE WORK

From an academic perspective a large and long term project consisting of multiple sub-projects needs to identify a method that enables individuals to successfully complete their aims and objectives, without hindrance and interdependence on others sub-projects. However, as the parent project is so large it needs to be broken into individual sub-projects and therefore requires careful management by the student leadership team, to minimise the already chaotic experience of traditional projects (Todd et al, 2006). A large project is an opportunity for students to learn and experience; project engineering, cross-fertilisation between subject areas, exposure to procurement, fabrication and testing activities. The PrjBL approach has enabled students to synthesise, apply and critically analyse their own and previous student's project work, fulfilling key final year learning outcomes (Savery, 2015).

From the student perspective, being involved in a large and long term project has the additional benefit of being an active participant in their learning (not a bystander) (Chickering et al, 1987) and contributing to authentic tangible outputs, which students value (Todd et al, 2006), although not always immediate but rather long term. The students appreciate the opportunity to develop and apply their technical and employability skills; communication, project management and commercial awareness through procurement and time management. Well designed PrjBL provides students with opportunities to apply and develop both their engineering technical and transferable employability skills (Savery, 2015). However, the students highlight that each year there is the need for training development at the start of the year in project management, organisation and communication. With the advent of MS Office 365 tools there is an opportunity use these to assist them in managing the project and aiding communication.

The questionnaire survey is to be deployed and the survey data collated, codified and analysed by the employed research student. Two types of individual project student responses (traditional vs large project) are to be compared for common and contrasting themes. Any commonality with dissertation personal reflections will be highlighted.

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