Making principled decisions about curriculum development: outcomes of a Realist evaluation across 13 universities

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INTRODUCTION

The higher education sector is under ever-increasing pressure to respond to societal and political demands for renewed curricula, whether that means a response to changes such as the Bologna Declaration, a sudden social sensitivity to pressing issues such as climate change and sustainability or governmental demands for increased participation from low SES groups [1]. While there are demands for Australian universities to recruit more diverse student groups, there is also a perception that the traditional pool of students coming straight from high school differ in important cultural and attitudinal ways from previous generations [2, 3]. In response to these pressures many Australian universities have implemented in some form the Engineers Without Borders (EWB) Challenge for first year engineering students.

Established in 2007, the EWB Challenge aims to enhance the first-year students' learning experience and initiate development of a range of graduate attributes through authentic team-based design for real and inspiring sustainable development projects. Every year, EWB nominates one of their partner organisations in a developing community and a range of projects and themes addressing needs and work in that community as the basis for the year's EWB Design Challenge. EWB develops and provides a suite of resources including on-line information about the community and the partner organisation's work. EWB also offers facilitated discussion with their partner and the community through an online forum. The EWB Challenge is designed to offer students and universities the opportunity to actively engage in real, collaborative, project work that can contribute positively to these communities.

The Challenge is unique in that it has a strong and distinctive focus on the development of graduate attributes related to social, cross cultural and ethical responsibilities in a global context. Core curriculum which is purported to be covered by EWB Challenge includes:

- Introduction to the engineering design process;
- Developing communication skills;
- Introduction to teams, teamwork and team dynamics;
- Hands-on design project, including reverse engineering;
- Ethical, professional and sustainability considerations.

The Challenge is unique in that it has a strong and distinctive focus on the development of graduate attributes related to social, cross cultural and ethical responsibilities in a global context. It has the potential to address all of the graduate attributes listed by accreditation authorities since it requires effective communication and teamwork, has a focus on the triple bottom line of social, environmental and economic sustainability and ethical practice and makes conscious for students the ongoing learning that is necessary for engineering practice in the real world and how that learning is achieved through collaboration and consultation. All institutions have implemented this innovation differently and comparison of these different implementations affords us the opportunity to assemble "a body of carefully gathered data that provides evidence of which approaches work for which students in which learning environments" [4].

In 2010 the Australian Learning and Teaching Council (ALTC) funded us to evaluate this innovation across 13 universities in Australia and New Zealand. A comprehensive evaluation strategy has been in place for 18 months and this paper reports on analysis strategy used to work on such a large body of data and gives and overview of the different contexts, the choices people make in response to that context and the resulting outcomes. This has further implications for curriculum change and renewal in engineering.

1. METHODOLOGY

Initial data was collected from all participating universities using a program logic model [5]. The program logic model of evaluation (sometimes called the Wisconsin model) "is an ongoing systematic process [which allows professionals] ... to plan, implement and evaluate their educational programs" [6]. The model serves as a conceptual framework for any investigation or evaluation. 'Program', as used by the model, can describe any activity or organisational process from a simple teamwork activity through to evaluating the educational outcomes of a course (subject) or complete curriculum. The logic model describes a sequence of actions that describe the programs goals and outcomes whilst also considering how beliefs about the program and how external factors interact and influence the program. This framework was used to map how course leaders believe the use of the EWB project should be working and what their desired outcomes were. These desired outcomes and operational matters (assessment, learning objectives etc) varied across courses and institutions. This allowed the data collection and further analysis to compare expectations against evidenced outcomes for each institution.

This large body of data has been analysed using a Realist approach [7] to isolate the aspects of Context and the Mechanisms that are triggered by these programs in order to produce the observed outcomes. Scrutiny of a variety of different implementations of the innovation in a range of contexts across the participating institutions allows us to ask "What works for whom in what circumstances and in what respects, and how?" [7]

Realist evaluation stresses the linked concepts of mechanism, context and outcome for understanding and explaining programs [8]. Mechanisms describe what it is about programs that bring about outcomes. The process of how participants act and react to resources and processes in a program is known as the mechanism. Whilst identifying critical mechanisms is a step in the evaluation it must be recognised that these mechanisms work differently in different contexts. Context should not be confused with location but rather refers to circumstances. Context describes the features of the conditions in which programs operate. Outcomes covers the consequences of programs both intended and unintended which result from the interaction of contexts and mechanisms [7]. It does not make hard and fast distinctions about the success or otherwise of a program but a good evaluation can explain a complex set of interactions and outcomes and tests these conjectures empirically [9].

Data was collected through observation of classes, interviews and focus groups with staff and students, analysis of documents such as course outlines and student work and an exit survey offered to all participating students (N = approx. 4500).

2. DATA ANALYSIS

Data from each institution, including the data from the program logic was organised for each institution according to *Fig. 1*. The table's columns were derived from existing literature on educational processes and read from left to right they represent a cascade of factors all of which affect each other and the final outcomes. Columns to the left are the highest level of context, each of which triggers a range of mechanisms, which then become contexts for further response. For instance, particular course designs form a context for teacher behaviour (mechanisms) which may vary from teacher to teacher. That behaviour then becomes a context for the next mechanism which is student behaviour which ultimately produces a range of outcomes. This organisation of the data shows the programs or courses are not isolated or constant. Many (external and unplanned) issues impact on planning and delivery and this can make them "permeable and plastic" and this may end up changing the "conditions which made them work in the first place" [8].

Institutional Context	Instructor Characteristics	Teacher behaviours	Outcomes
The institutional factors affecting the way in which the course is implemented	The experience, beliefs and attitudes of instructors before responding to this instance of the course	How teachers respond to this instance of the course, including decisions, attitudes, interactions	What happened or changed as a result of teacher and student behaviours

Institutional Context	Student Characteristics	Teacher behaviours	Outcomes

Table body (grid layout):

Institutional Context / Program Context	Instructor Characteristics / Student Characteristics / Assessment / Course Design	Teacher behaviours / Student Motivation / Student behaviours	Outcomes
Program Context The nature of the course within the program Factors affecting status, purpose and perceptions of the course within its program context	**Student Characteristics** The experiences, beliefs and attitudes of students prior to responding to the course **Assessment** The nature of assessment tasks, the nature of criteria, the weightings of criteria **Course Design** The nature, amount and sequence of organisation of the course, the topic focus of the course, the resources and learning processes it incorporates and the level and nature of prior knowledge that it assumes	**Student Motivation** The factors affecting the kinds and level of effort/ interest, etc, that students put in to the course **Student behaviours** The nature and amount of student participation in the course, including how and how much they focus on topics, processes and products	

Fig. 1 Summary of main categories affecting outcomes

The data showed contexts and mechanisms that enable/support and are disabling/inhibiting. Contexts can be 'enabling' or 'inhibiting'. Contexts that were found to have the most influence on the successful use of the EWB projects include the alignment of project context and design constraint, the alignment of assessment criteria with project goals and activities and behaviour of tutors as shown in *Table 1*. At a broad level these seem obvious. All learning should be enabled by a constructive alignment of course objectives, activities and assessment. It should be supported and championed by the academic and tutors who work as a team with shared goals and beliefs. However in large diverse classes with numbers of tutors, small misalignments which might have happened slowly overtime can have amplified changes. The interaction can lead to a very different pattern of contexts, mechanisms and outputs. For example where the nature of the project emphasises the technological aspect of the problem this context can trigger a mechanism of tutors and students focusing on 'technology' and 'a cool design' rather than something that specifically addressed the solution to a problem and its real world application. An example from the data (notes from discussions with tutor) – "*Some groups have used colour detection ..... I said "but in the real world…" and the tutors said "yeah it won't work but it was really cool the way they worked it out*".

Table 1. Prominent context clusters

Cluster	Description
Alignment of project context and design constraints	This cluster is concerned with how well the project as presented in EWB briefs is reflected in actual learning activities.
Alignment of assessment criteria	Students (and tutors) respond very strongly to assessment criteria so the descriptions of what is needed and the weightings given to various aspects of assessment are important conditions in triggering mechanisms.
Tutor behaviour	The climate the tutor develops in the class, the way they model the work of engineers and the mechanisms they exhibit, all create significant social and cultural conditions for the implementation of the EWB projects.

Contexts labelled 'enabling' are the social and cultural conditions that facilitate the operation of supporting mechanisms. 'Disabling' contexts are those that make it difficult for supportive mechanisms to be triggered.

Mechanisms are the decisions and choices people make in response to context. They can either support identified outcomes or inhibit them. At the highest level these choices were found to be influenced by concern for context (of the EWB project) or concern for sustainability (*Table 2*).

Table 2. Prominent context clusters

Cluster	Description
Concern for Context	This cluster of mechanisms relate to the perceived 'reality' of the projects either as real engineering or as real-world problems, as well as to the ways in which decision making is affected by taking the context of the EWB into account.
Concern for Sustainability	This cluster contains the mechanisms that reflect a variety of understandings of what sustainability is and how important or unimportant it is perceived to be.

Table 3 Concern for context

Concern for context - supporting		
Category description	**Category name**	**Illustrative examples from data**
Giving reality to the project by building a model/prototype	The "**making something**" mechanism	Example – open ended survey Q: What was the most positive thing about the EWB project *seeing a physical outcome from our efforts being put into action*
Students perceive that what they are doing relates to professional practice	The "**real engineering**" mechanism	Example – focus group with students (University #1) *a lot of people came in because they liked maths or physics or something in school and then you do this and you realise that yeah there's maths and physics in it but there's so much more in it than just maths and physics.*
The reality of the situation prompts concern for downstream effects	The "**responsibility**" mechanism	Example – focus group with students (University #2) *I think the responsibility is bigger than just putting in a plan and not worrying about what happens after that and it's about a long time commitment to something and making sure that there's no ill effects somewhere down the line*
The patent needs of the community prompt engagement and application	The "**doing good**" mechanism	Example – focus group with students (University #3) *I think if you focused more on the fact that you were doing it to help the community it would be easier because you'd be a lot more interested in it.*
Concern for context - inhibiting		
Details of design pursued in terms of marks awarded	The "**mark chasing**" mechanism	Example – observation of teams in tutorial (University #4) *ignore salt entirely, we'll get better marks*
Students see context as too remote from their engineering futures	The "**nothing you can take away**" mechanism	Example – focus group with students (University #5) *if you were doing aerospace engineering, that sort of stuff, it's really hard to sort of…you can relate the problem-solving aspect of it to it, but besides that, there's really nothing you can take away from it.*

The developing world context of the EWB projects is assumed by most academics[2] to automatically confer advantages in engaging students, giving them an understanding of the real-world effects of their discipline and drawing their attention to sustainability issues. While these effects are evident in some cases, in others they are countered by other mechanisms such as the drive to get good marks. The assumption that importing the EWB projects into the curriculum would address the pressures outlined at the beginning of this paper is thus opened up for more nuanced consideration.

Table 3 illustrates the themes that make up the clusters and provide brief illustrations of the data that gave rise to the themes. The whole data sets are substantially larger than these illustrative tables, with many more examples of each theme and subsidiary themes which are not pursued here.

Mechanisms are labelled as 'supporting' where they contributed to positive outcomes, and 'inhibiting' where they created problems for the effective use of the EWB projects.

3. CONCLUSIONS

Outcome-patterns show the intended and unintended consequences of implementations. The patterns show that in different contexts different mechanisms are established and enacted and the success or otherwise of implementation strategies and curriculum changes do not rely on either a single measure or a simple construct of one context and one mechanism. Nor can one curriculum innovation such as the use of EWB projects guarantee any particular outcome, whether it be improving "soft ' skills, learning about sustainability or including new student cohorts. There is no hard and fast strategy or rule which will give a specific output (intermediate target) or outcome (changed behaviour). For a complete picture of processes, impacts and outputs programs need to be evaluated across a range of measures. These evaluations need to view curriculum changes and their implementation as social practices [10] and hence the use of more robust and wide ranging strategies need to be employed. It is only through this lens that the patterns of context, mechanisms and outcomes can be seen which gives a clue as to the actual working of the intervention. We argue that curriculum design can be improved by close attention to context, mechanisms and their interaction to give different outcomes. These outcomes are empirically derived, rather than on impressions and assumptions or the latest educational fad. This provides a solid basis for monitoring further changes and implementation strategies to ensure a rigorous curriculum design to deliver required learning outcomes.

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