THE DEVELOPMENT OF A NEW EFFICIENT AND COST-EFFECTIVE MAPPING PROCESS TO BE USED WITH GENERIC FRAMEWORKS WITH THE AIM OF CURRICULUM IMPROVEMENT

Alcion Benedict Popp

University of Sydney, Sydney, Australia

A/Prof. David C. Levy

University of Sydney, Sydney, Australia

ABSTRACT

The paper will give an overview of a new process that has been developed at University of Sydney for the mapping of curricula against any generic framework. The process is efficient, self-contained and dynamic with respect to the available data. Examples of the inputs, functions and outputs will be given to illustrate.

KEYWORDS

Curriculum mapping, generic frameworks, program improvement

INTRODUCTION

Why Map

Curricula have in many instances been developed by academics in faculty silos, without the input of other bodies of knowledge, industry or the pedagogical approach of new methods which may have been developed in the interim. Since 1996, the Institute of Engineers Australia (IEAust) in Australia and the Accreditation Board for Engineering Technology (ABET) in the United States have mandated against this trend [5], in favour of greater accountability.

The call for change towards greater satisfaction of generic skills resulting from the increased accountability has also been one of the major issues demanded by industry over the last twenty years [1].

Indeed, outcome based accountability has been described in many reports and surveys as an essential step in making degrees more transparent and inclusive of the generic skills required in modern day work environments [5].

Many authors discuss ways to enhance curriculum accountability by providing methods to more easily detect needed changes and subsequently implement them. [9] recommends the creation of ‘interactive’ curriculum maps, which can be continually accessed and updated by stakeholders for curriculum changes or development.

[8] recommends curriculum mapping for the evaluation of a program and [2] suggests that mapping can also provide information for students to enable them to 'construct' their learning to achieve the declared objectives.

Mapping is therefore recognized in literature as a vital step in the inception, development and subsequent maintenance and use of a curriculum.

Current Hurdles to Curriculum Mapping

Uptake of curriculum mapping in the past has been limited. Some of the reasons for this include the unregulated nature of curriculum development as described in the previous heading and the complexity of the mapping process, which did not have the benefit of information technologies to support its implementation [10]. In some circumstances, academics viewed curriculum mapping processes as a political stunt by government to gain greater control over faculty affairs and introduce an unfair scrutiny over their work [12].

The layout of curricula may also impede a benchmarking process. Some curricula, for example, use an embedded approach to delivering generic skills, where the generic elements are part of the technical subjects [1,4,8]; other curricula may use stand-alone subjects that teach these generic skills in parallel to core subjects, such as for example, communication and linguistic subjects [7]; others still may give the choice to students in the form of electives that are generally skewed towards more generic content, such as management subjects [11,14].

Another reason for such a limited uptake in our opinion is the wide variety of mapping techniques that have been developed, and their increased dependence on surveys as the drivers of the process. In other words, the cost of resources in developing the mapping may be a hurdle for faculty in current circumstances [13,3]. This is further coupled with the psychological hurdles to change, which produce 'doubt' and 'discomfort' in users that are unfamiliar with the frameworks and the mapping processes [6].

Different combination of the above mentioned hurdles to change have caused a rather poor uptake of a consistent mapping practice in most universities. This has been the catalyst for our work and the new approach we bring to mapping and implementation of generic frameworks towards producing real and measurable curriculum improvements. This work will be demonstrated at the Faculty of Engineering at The University of Sydney.

BACKGROUND TO THE UNIVERSITY OF SYDNEY ENGINEERING PROGRAM

Engineering education at The University of Sydney is subdivided into various programs for students to choose from including:

- Electrical & Information Engineering,
- Civil Engineering,
- Aerospace, Mechanical and Mechatronic Engineering,
- Chemical & Biomolecular Engineering, and
- Information Technologies

Each of the above mentioned programs feature various streams which affect the core subjects studied. Additionally, students can make choices in the third and fourth years by choosing various electives for their study. Most of these electives are contained within the same Faculty and are therefore closely linked to the engineering subjects being studied. Based on the discussion above, it can be said that the Faculty of Engineering at The University of Sydney implements generic items of the curriculum using a combination of the ‘embedded’ method, as well as through the use of electives.

All of these choices give students a great deal of flexibility in their education, but make the benchmarking of the various curricula harder. These challenges have been addressed in the work conducted by the authors of this paper.

BENCHMARKING PROCESS

The benchmarking that has been developed in this paper has as its main goal the improvement of the engineering curricula using existing learning outcomes as the main drivers of the process, with a reduced dependency on academics to advance the mapping.

The mapping tool presented in this paper is based on a new generic framework derived from the CDIO syllabus and from the Engineers Australia National Generic Competency Standards (NGCS) [15], for close alignment with the needs of the Australian higher education system and national accreditation requirements. This new generic framework, named the ‘Unified Code’ [16], was developed by merging the CDIO syllabus and the Engineers Australia NGCS framework. This has been done in a two step process, initially mapping the two frameworks against each other, followed by the translation of this map into a new framework using Bloom’s taxonomical domains as guiding reference.

The new tool will illustrate the ease of mapping and the reduced dependency on academic input in the initial stages. In fact, academic input can be said to be completely optional in the initial mapping phase. The results from this are anticipated to promote the uptake of the process by more faculty members as was the case at Murdoch University [12], where learning outcomes rather than interviews were used to reduce initial resistance and increase the mapping throughput.

The mapping in this case, is based on the aggregation of scores from all of the subjects constituting a stream of study. Streams are mapped independently onto the framework. Permutations in the electives or core subjects can be made freely and these are then reflected in the graphical representation. The details of the steps of the process are described in the methodology that follows.

Methodology

Data Selection & Mapping

The Electrical & Information Engineering program was selected as the driver for the benchmarking system to be developed. The program consists of five streams, as follows:

- Electrical Engineering, which has three specialist sub-streams of:
    - Computer Engineering,
    - Telecommunications Engineering,
    - Power Engineering, and
- Software Engineering, which is managed and taught jointly with the School of IT.

A third party was selected to conduct the mapping. The candidate had an engineering background with knowledge of some of the broader trans-disciplinary subjects such as project management and business. This person was assigned the task of aligning each learning outcome from each subject in a stream, to matching items in the generic framework. A score was kept of the matches between learning outcomes and items in the generic framework.

After the mapping of all the streams was complete, a post-checking survey was conducted via e-mail with each of the subject coordinators involved. Subject co-ordinators answered by their own free will, and where this did not happen, the learning outcomes were assumed to be accurate enough. The content of the learning outcomes is on average a good representation of subject content as is discussed in [13].

Moreover, the effect of any one individual subject can be considered minute on the overall stream map, when considering that most streams contain in excess of 25 subjects spanning over a four year period.

Developing the Interface

Once there was a clear understanding of the data to be mapped, an interface was developed using a programmable workbook in Excel. The workbook contains four main types of sheets with interlinked functions.

Generic Framework Sheet

This sheet contains a full copy of the generic framework down to the 3rd level of detail. The sheet also maintains a complete record of all the learning outcomes across the various subjects, which are mapped against items in the generic framework. This is illustrated in Figure 1 below.

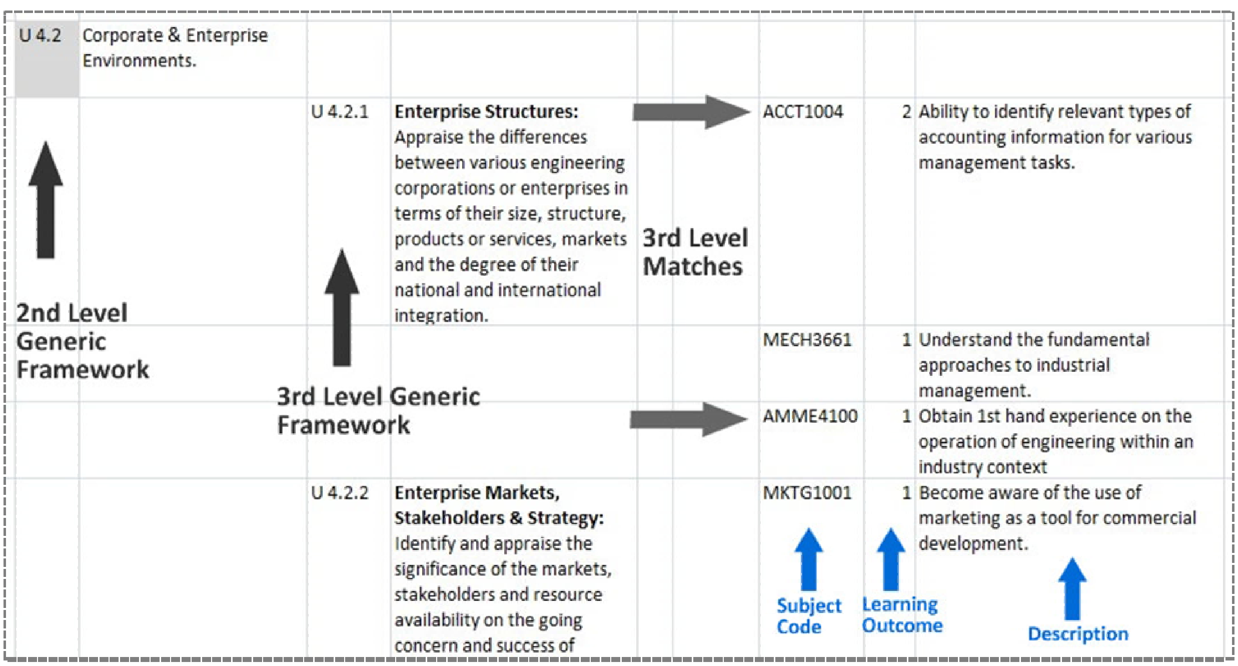
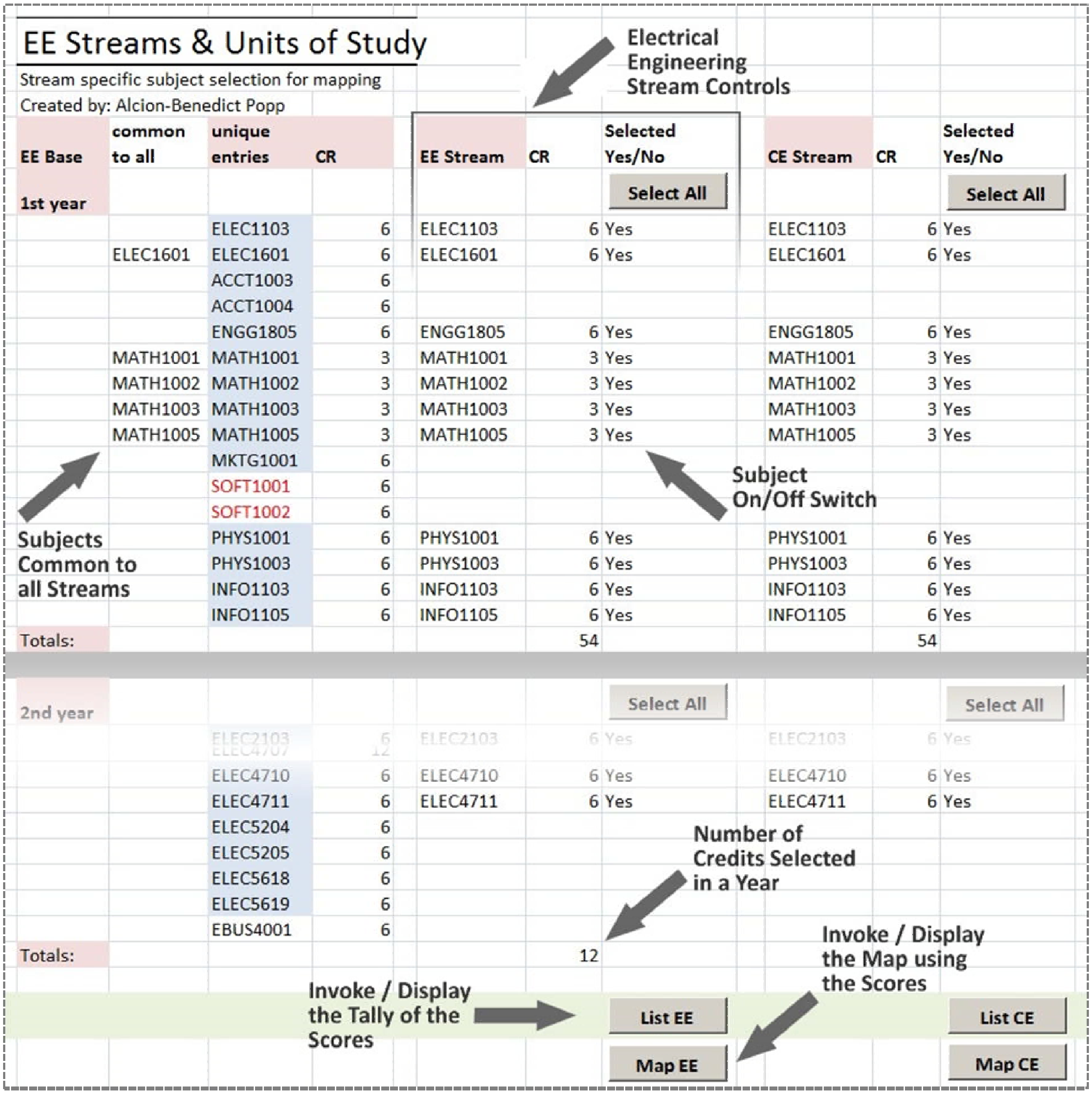


Figure 1. Generic framework sheet illustrated

Control Sheet

In this worksheet an interface was developed to allow the user to perform various operations, as is shown in Figure 2:



EE Base	common to all	unique entries	CR	EE Stream	CR	Selected Yes/No	CE Stream	CR	Selected Yes/No
1st year						Select All			Select All
		ELEC1103	6	ELEC1103	6	Yes	ELEC1103	6	Yes
	ELEC1601	ELEC1601	6	ELEC1601	6	Yes	ELEC1601	6	Yes
		ACCT1003	6						
		ACCT1004	6						
		ENGG1805	6	ENGG1805	6	Yes	ENGG1805	6	Yes
	MATH1001	MATH1001	3	MATH1001	3	Yes	MATH1001	3	Yes
	MATH1002	MATH1002	3	MATH1002	3	Yes	MATH1002	3	Yes
	MATH1003	MATH1003	3	MATH1003	3	Yes	MATH1003	3	Yes
	MATH1005	MATH1005	3	MATH1005	3	Yes	MATH1005	3	Yes
		MKTG1001	6						
		SOFT1001	6						
		SOFT1002	6						
		PHYS1001	6	PHYS1001	6	Yes	PHYS1001	6	Yes
		PHYS1003	6	PHYS1003	6	Yes	PHYS1003	6	Yes
		INFO1103	6	INFO1103	6	Yes	INFO1103	6	Yes
		INFO1105	6	INFO1105	6	Yes	INFO1105	6	Yes
Totals:					54			54	
2nd year						Select All			Select All
		ELEC2103	6	ELEC2103	6	Yes	ELEC2103	6	Yes
		ELEC4710	6	ELEC4710	6	Yes	ELEC4710	6	Yes
		ELEC4711	6	ELEC4711	6	Yes	ELEC4711	6	Yes
		ELEC5204	6						
		ELEC5205	6						
		ELEC5618	6						
		ELEC5619	6						
		EBUS4001	6						
Totals:					12				

Figure 2. Control sheet illustrated

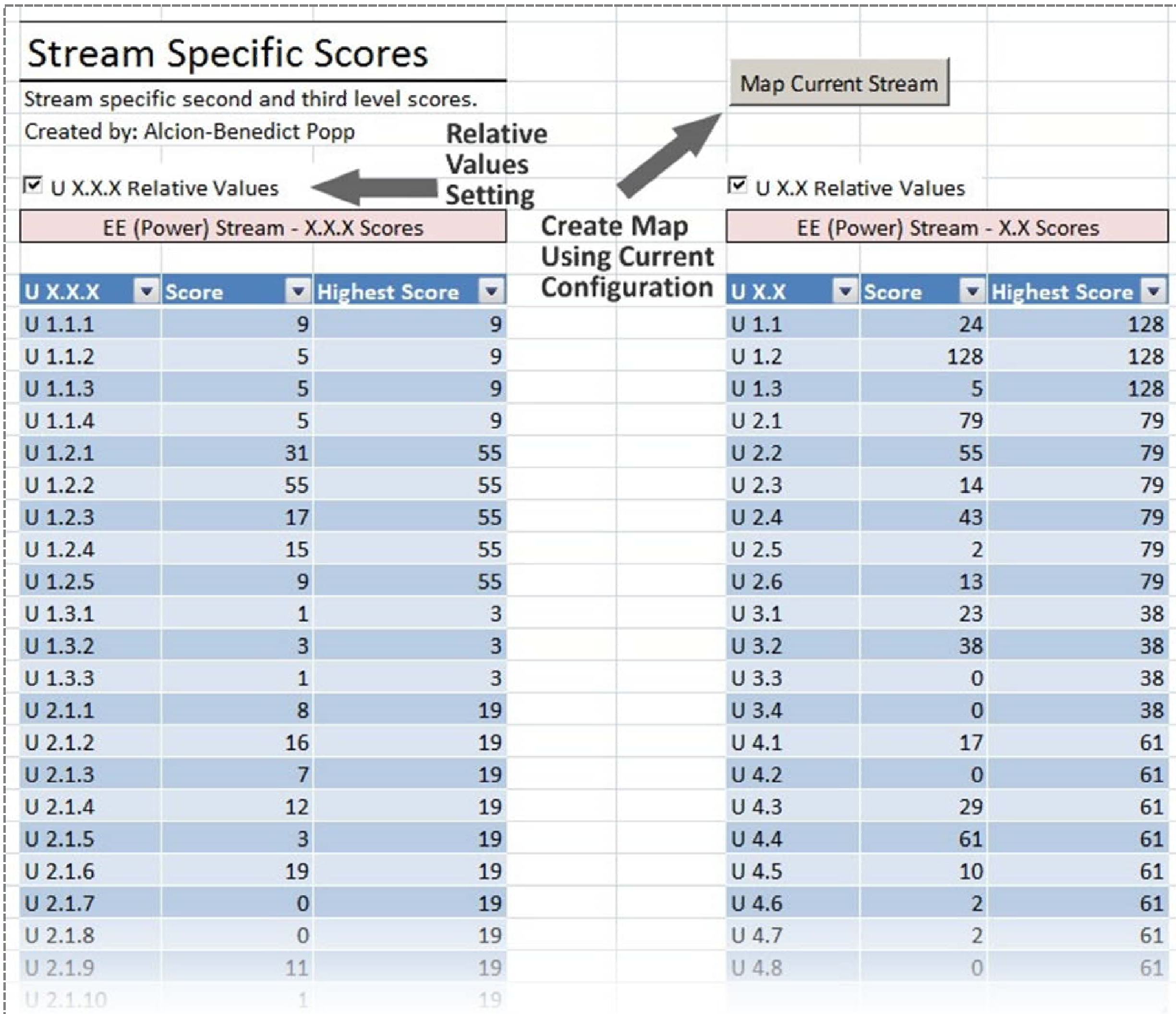
Operations include:

- View all the subjects available in the program and the credit point weight for each;
- View subjects common to all of the streams;
- View the subjects assigned to each stream;

- Add, remove, turn on or off the presence of core or elective subjects for each individual stream; and
- Start the mapping process of any particular stream, using the customized on/off configuration of each stream.

Score Card Sheet

When the user presses the ‘List’ button in Figure 2, two score-cards are automatically created for the whole program, for the 2nd and 3rd hierarchical levels of the generic framework, and the tally for each individual item in the framework is automatically computed as shown in Figure 3. Note that program designers may elect to omit coverage of some items, in which case there may be little or no coverage.



U X.X.X	Score	Highest Score
U 1.1.1	9	9
U 1.1.2	5	9
U 1.1.3	5	9
U 1.1.4	5	9
U 1.2.1	31	55
U 1.2.2	55	55
U 1.2.3	17	55
U 1.2.4	15	55
U 1.2.5	9	55
U 1.3.1	1	3
U 1.3.2	3	3
U 1.3.3	1	3
U 2.1.1	8	19
U 2.1.2	16	19
U 2.1.3	7	19
U 2.1.4	12	19
U 2.1.5	3	19
U 2.1.6	19	19
U 2.1.7	0	19
U 2.1.8	0	19
U 2.1.9	11	19
U 2.1.10	1	19

U X.X	Score	Highest Score
U 1.1	24	128
U 1.2	128	128
U 1.3	5	128
U 2.1	79	79
U 2.2	55	79
U 2.3	14	79
U 2.4	43	79
U 2.5	2	79
U 2.6	13	79
U 3.1	23	38
U 3.2	38	38
U 3.3	0	38
U 3.4	0	38
U 4.1	17	61
U 4.2	0	61
U 4.3	29	61
U 4.4	61	61
U 4.5	10	61
U 4.6	2	61
U 4.7	2	61
U 4.8	0	61

Figure 3. Score cards illustrated

For example in Figure 1, ‘U 4.2.1’ would have a score of +3 if the subjects ‘ACCT1004’, ‘MECH3661’ and ‘AMME4100’ were all included in the stream. If only some of these subjects were part of the stream, then the score would be lower. The system automatically detects which subjects are part of the stream and which are not and computes only for those subjects.

Equally, the scores from the 3rd level items are rolled up to the 2nd level item. So, using the previous example, if ‘U 4.2.1’ achieves a score of +3 and ‘U 4.2.2’ achieves a score of +2, then ‘U 4.2’ will achieve a score of +5.

The score cards also feature two tick-boxes as shown in Figure 3 to allow for two types of scoring styles. When ‘Relative Values’ are enabled, the ‘Highest Score’ column is computed from values internal to each group. For example, ‘U 1.1.1’, ‘U 1.1.2’, ‘U 1.1.3’and ‘U 1.1.4’ all belong to ‘U1.1’. If the highest score among these items is 9, then this will be used as the respective ‘Highest Score’ value for each of the four items. Each group will have its own ‘Highest Score’ value, making the intra-group items relative to each other.

If on the other hand the ‘Relative Values’ setting is turned off, then the highest score from the entire map at that hierarchical level is used instead. Hence in this case, only one value is used for all the items in the entire framework. This setting emphasizes relativity among all of the items of the framework rather than particular groups.

The same discussion applies for the 2nd hierarchical level score card.

Graphical Representation

Using the above interface, the tool has been programmed to output a graphical representation of the data. The representation which is shown in Figure 4 has been designed to clearly outline the mapping at the 2nd and 3rd levels of detail.

Results / Discussion

The resulting graphic representation as shown in Figure 4 is the final step in the mapping process. From the extensive information conveyed through this mapped representation of a particular stream against the generic framework, valuable results can be quickly deduced:

- Firstly the summarised information is presented at the top in the blue bars for users to quickly gather an overview of the current condition of the stream;
- Secondly major gaps can be quickly spotted; in particular, where ‘0’ entries exist, there is no coverage;
- Thirdly, the inter-group or intra-group coverage becomes clearly evident from the blue and green horizontal bar graph (Figure 4 exposes the inter-group representation); and
- Moving up and down through the map quickly reveals the full extent of the detail, which is represented in very clear terms, with each item assigned its own row.

Some of the major advantages of this approach include:

- The ability to iterate the mapping process with as many permutations as needed in the control sheet (Figure 2), performing ‘what if?’ analysis. For example, one may deselect all but one of the subjects (or a group of subjects) and test how that subject (or group) contributes to the mapping of the generic framework.
- The ability to analyse results in relative or global mode (selected from the score-card sheet Figure 3), giving greater insight into the coverage of items in the generic

framework. The concept of these various perspectives is also unique within the one mapping process.

- Separation of data input from the interface and mapping process ensures that the approach is scalable to the maximum capability of the software within which it runs, in this case Excel 2007.

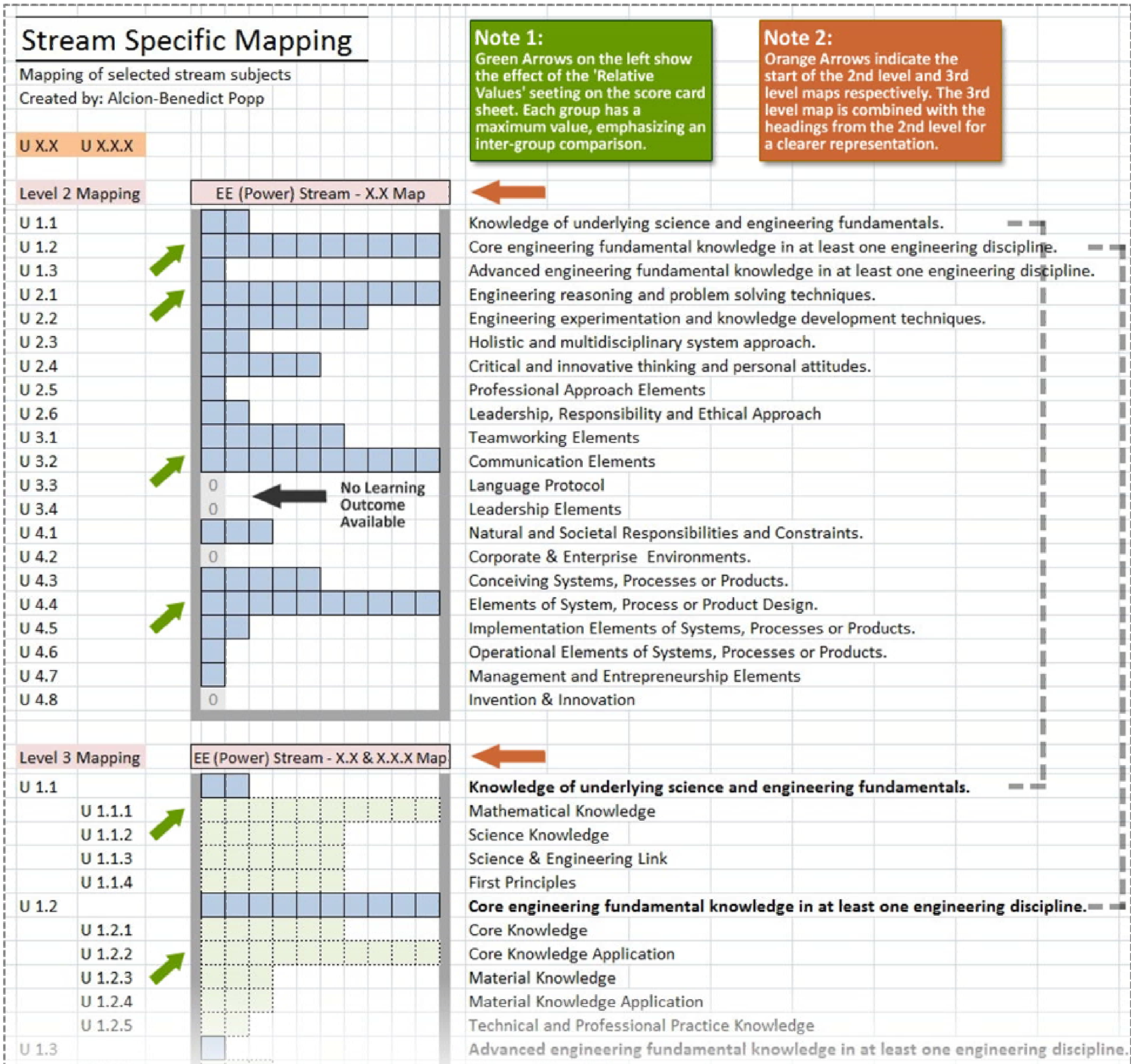


Figure 4. Graphical representation illustrated

CONCLUSIONS

Curriculum mapping has been described through literature to be very important in curriculum design and improvement, yet the implementation of a consistent faculty wide approach has been very limited for many and varied reasons. The new benchmarking approach described in this paper heeds the lessons learned from other implementations discussed in literature.

The new method features a mapping technique that takes account of the resource availability of staff and the potential limitations of interviews and surveys. Moreover, the new system operates at the global program stream level, rather than at the individual subject level, meaning that individual errors made in particular subjects or learning outcomes will have a small effect on the overall program results. The tool aids preparation for accreditation process by quickly identifying gaps and allowing program coordinators to address them.

A key application of the tool, which we are currently developing further, will be to aid students to see quickly what areas of competency are covered by their selection of programs and electives.

Lastly, fixes and corrections can always be made thanks to the clear separation of the process from the underlying data, ensuring that an iterative process can be used to arrive at the most optimal configuration of a stream with respect to any generic framework.

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Biographical Information

Alcion Benedict Popp is a PhD student at the University of Sydney in the Electrical & Information Engineering department. His background is in Project Management, Civil Engineering and Commerce (Economics). His primary focus at the moment is in the engineering education field, using new mapping techniques that leverage conformance frameworks and collaborative approaches to drive traceability and other key improvements in the curricula of engineering faculties.

David C. Levy is director of the Software Engineering program at The University of Sydney and leads the School of Electrical and Information Engineering's CDIO Initiative and is co-Chair of the ANZ CDIO regional group. His current scholarly interests are in real-time distributed systems, server performance engineering, CDIO and in team-project based learning.

Corresponding author
A/Prof David C. Levy
The University of Sydney
NSW 2006
Australia
61-2-9351-6579
dlevy@ee.usyd.edu.au