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Learning Outcome Analysis: Analysing the Design of an Academic Programme*

CARROLL Dave
(School of Computing, Dublin Institute of Technology, Dublin 8, Ireland)

Abstract: This paper describes an analysis of the match between the module learning outcomes and the programme learning outcomes of the MSc in Assistive Technology offered by the School of Computing. The contribution of each MSc module to the overall programme learning outcomes was assessed using a Module Matrix. An overall Master Matrix was used to assess the overall contribution of all 16 modules to the programme learning outcomes of the MSc programme. The analysis of the MSc programme design was taken a stage further by graphing the learning outcomes of the overall programme against the individual module learning outcomes. This provided a useful tool for analysis of the MSc programme. The approach outlined in this paper provides a visualisation tool that allows the programme designer to quickly identify the deficiencies and excesses in the relationships between programme learning outcomes and module learning outcomes.

Key words: learning outcome analysis; mapping learning outcomes; programme learning outcomes; module learning outcomes; gist analysis; graphical analysis
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1 Introduction

The MSc in Assistive Technology programme of the School of Computing was designed using the 3D alignment model of curriculum design[1]; a design model established as part of the Emersion project[2] for the development of an industry-oriented educational model for China. In this model, learning outcomes, teaching and learning methods, and assessment methods, are evaluated for alignment across modules at the same stage (horizontal alignment), between different stages of a programme (vertical alignment), and internally within modules (constructive alignment[3]). Such alignment should ensure a close relationship between learning outcomes, teaching and learning methods, and assessment methods to facilitate successful student learning.

Programme learning outcomes (PLOs), (the statements of functional and declarative knowledge the student will have on completion of a programme) define the type of graduate a programme will produce[2]. The individual module learning outcomes of a programme should contribute to the achievement of the programme learning outcomes. How well the programme design supports this is of interest to the programme designer. An analysis tool is required which allows the programme designer to quickly identify the deficiencies and excesses in the relationships between programme learning outcomes and module learning outcomes. Such a tool would be a useful quality assurance aid during the design stage of a programme.

This paper describes an analysis of the match between the module learning outcomes and the overall programme learning outcomes of the recently validated MSc in Assistive Technology programme of the School of Computing. The analysis was carried out by mapping the module learning outcomes (MLOs) of all 16 modules of the programme to the programme learning outcomes (PLOs) and graphing the results in the form of bar charts[4] to indicate how much each module contributes to the overall PLOs of the programme as a whole. This graphical analysis of PLOs versus MLOs provides an initial valuable insight into the design of the MSc in Assistive Technology programme. A listing of the titles of all the MSc in Assistive Technology modules is provided in the Appendix.

The next section describes the approach taken to analyse the contribution of each module to the overall PLOs using a matrix-based format. Section 3 discusses the limitations of this approach as it now stands and suggests how the method may be made more robust. Section 4 summarises the main achievements in this work.

*收稿日期: 2007－10－28
作者简介: CARROLL Dave (born in 1957), male, Assistant head of department, E-mail: dave.carroll@comp.dit.ie

2 Approach

2.1 Mapping the Contribution of MLOs to PLOs

Learning outcomes (LOs) are described in natural language in the module descriptors of the MSc programme document[5]. When mapping the contribution of MLOs to PLOs the analyst must interpret such natural language descriptions and decide if the functional and declarative knowledge described in an MLO will contribute to the functional and declarative knowledge described in a PLO and evaluate to what extent it contributes.

The interpretative decision appears straightforward when the natural language description of an MLO closely corresponds to the description of a PLO. In other cases the decision is less straightforward. An MLO may not appear to contribute to a PLO on first reading, due to the ambiguities of natural language. This requires a qualitative interpretation by the analyst. The analyst must decide if the description of a given MLO provides an alternative expression of the functional and declarative knowledge required to contribute to a PLO.

In the cases where ambiguities arose in the current analysis, a qualitative technique similar to gist analysis[6, p157] was used to identify alternative expressions of the functional and declarative knowledge required to contribute to a given PLO. On examining an MLO for contribution to a PLO, the analyst on reading the description of the MLO decided if its gist (or essence) was a reasonably synonymous alternative description of the functional and declarative knowledge required to contribute to a PLO. If this was so, a mapping was recorded. If there was still doubt about a contribution, the MLO was excluded as a contributor to the PLO. (The decision on the gist of the MLO was a judgement call made solely by the analyst in this current work. Such analysis could be made more robust using an independent judge for gist agreement as suggested in[6]. Judges could be selected from members of the programme team).

2.2 Module Matrix

The contribution of each module to the overall PLOs was assessed using a two-dimensional (2D) module matrix (This approach is similar to Keating et al 2007[7]). Figure 1 shows the 2D matrix for assessing the contribution of the Foundations in Assistive Technology module to achieving the PLOs. In the figure, the PLOs are listed in the column on the left hand side and the MLOs are listed across the top. The PLOs are grouped under the headings of Knowledge, Know-How and Skill, and Competence according to the National Qualifications Authority of Ireland (NQAI) guidelines[8]. This matrix layout, which is MS Excel-based, facilitates comparison of each PLO with each MLO of the Foundations in Assistive Technology Module.

Each MLO of the Foundations in Assistive Technology module was manually compared with each PLO using the module matrix. If a given MLO contributed to a PLO a '1' was inserted in the 'cell' at the intersection of the MLO and the PLO. If an MLO did not contribute to a PLO, it was left blank. Whether an MLO contributed to a PLO was decided by the analyst using a qualitative/interpretative approach as outlined above.

The complete analysis of the Foundations in Assistive Technology MLOs contribution to the overall PLOs is shown in Figure 1. The Total Contribution column in Figure 1 shows how many MLOs were deemed to have contributed to a given PLO. For example the integer '6' in the Total Contribution column for PLO (Know-How and Skill, 2), indicates that 6 of the MLOs of Foundation in Assistive Technology were deemed to have contributed to PLO (Know-How and Skill, 2). The other integers in the Total Contribution column recorded against the remaining PLOs are interpreted in the same way.

All the remaining modules of the MSc in Assistive Technology programme were analysed in the same manner as outlined above. A 2D matrix was constructed for each module and an analysis was carried out assessing the contribution of that module's MLOs to the PLOs. Each Module Matrix's Total Contribution column shows how many MLOs were deemed to have contributed to a given PLO.

2.3 Master Matrix

An overall 2D Master Matrix was constructed to assess the overall contribution of all 16 modules to the PLOs of the MSc programme. Figure 2 shows this Master Matrix. In the figure, the PLOs are listed on the left hand side and grouped under the NQAI headings of Knowledge, Know-How and Skill, and Competence[8]. Each column in the matrix represents a module and is linked to that module's Total Contribution column. This Master Matrix layout, which is MS Excel-based, facilitates assessment of the contribution of all 16 MSc Modules to achieving the overall PLOs.

	Programme LO's	ASTC1101 Total Contribution	Module LO's 1 ASTC1101 FOUNDATIONS OF ASSISTIVE TECHNOLOGY						
			A	B	C	D	E	F	G
			Describe the social and legal imperatives with regard to Assistive Technology	Appreciate the environmental constraints of people with disability	Describe the various technologies and specialised interfaces to assist people with disability	Show an awareness of various disabilities that impact the Human Computer Interface	Explain the accessibility of software	Implement software interfaces with improved accessibility	Design and develop inclusive Web sites
	Knowledge								
1	Demonstrate detailed knowledge and understanding of fundamental topics in computing for Assistive Technology and the manner in which they are combined in the overall process of inclusive design	7	1	1	1	1	1	1	1
2	Demonstrate detailed understanding of selected specialised computing topics useful in the area of Assistive Technology	4			1		1	1	1
3	Demonstrate detailed detailed knowledge and understanding of selected, leading-edge, research-based topics within computing for Assistive Technology	1			1				
4	Demonstrate detailed knowledge and understanding of research methodology and practice	0							
5	Demonstrate awareness of ethical and professional issues relevant to computing in Assistive Technology.	3	1			1	1		
	Know-How and Skill								
1	Perform problem analysis from written descriptions	1					1		
2	Derive requirements specifications from an understanding of problems	6		1	1	1	1	1	1
3	Create and/or justify designs to satisfy given requirements	4		1	1			1	1
4	Develop original ideas in a research context	0							
5	Effectively design and develop accessible systems	6		1	1	1	1	1	1
6	Define and contextualise computing research problems in the area of Assistive Technology, questions or issues	0							
7	Propose, scope, plan and manage a research project of significant size	0							
8	Perform independent and efficient time management	0							
9	Communicate effectively by oral, written and visual means	0							
10	Prepare technical reports to a professional standard	0							
11	Prepare a dissertation to acceptable academic standard	0							
12	Present and defend research findings in an academically acceptable format	0							
13	Prepare and present seminars to a professional standard	0							
	Competence								
1	Engage in and take significant responsibility for, the specification and successful resolution of Assistive Technology projects in both technical and managerial roles	7	1	1	1	1	1	1	1
2	Communicate the specification and resolution of Assistive Technology projects in both technical and managerial roles	0							
3	Confidently defend research findings	0							
4	Work effectively as an individual and as a member of a team	0							
5	Take significant responsibility for the work of individuals and groups	0							
6	Take significant responsibility for leading and initiating Assistive Technology activities	0							
7	Demonstrate an awareness of how Assistive Technology can be used in a variety of organisational types and the impact of Assistive Technology initiatives on such organisational types	7	1	1	1	1	1	1	1
8	Demonstrate an appreciation of the wider inclusive society and the challenges faced by and responsibilities of individuals and organisations in such a society.	3	1			1	1		
9	Appreciate the importance of continued academic/professional development within the field of computing for Assistive Technology	2	1		1				
10	Demonstrate an awareness of the resources available to keep up to date with new developments in Assistive Technology	0							
11	Take responsibility for their own learning	0							
12	Learn from experiences gained in different contexts	0							
13	Demonstrate an awareness of personal responsibilities within professional codes of conduct relevant to computing in Assistive Technology	1	1						
14	Demonstrate the ability to comprehend multiple perspectives	0							

Fig. 1　Module Matrix for Foundations in Assistive Technology module

The Total Contribution column in the Master Matrix in Figure 2 shows the cumulative support for the PLOs by the MLOs of the 16 modules. For example the integer '37' in the Total Contribution column for PLO (Know-How and Skill 2) indicates that this PLO was supported by 37 MLOs deriving from 16 modules of the programme. The higher the value recorded against a PLO in the Master Matrix Total Contribution column, the more support that PLO appears to have, across the 16 modules. The lower values in the Total Contribution column suggest less support. For example, the '8' recorded for PLO (Know-How and Skill 13), would suggest that this PLO does not have much support across the 16 modules. In fact this PLO (Know-How and Skill 13); Prepare and Present a seminar to a professional standard may not be expressed in the MLOs but could appear in the Assessment section of a module. It is important therefore to identify how successfully the modules have been constructively aligned[3] and in particular to ascertain if the assessment regime matches the stated learning outcomes.

As an initial critique of the design of the MSc in Assistive Technology programme these figures would suggest issues with the design of the programme. This needs further consideration but the approach would appear to be promising, at least as a tool to evaluate the overall balance of the programme. The qualitative nature of the analysis however requires that some form of calibration or benchmarking is applied to this process.

	Programme LO's	Total Contrib	Module LO's 1 ASTC1101 FOUNDATIONS OF ASSISTIVE TECHNOLOGY	2 ASTC1201 DYSLEXIA AND ASSISTIVE TECHNOLOGY	3 ASTC1301 UNIVERSAL DESIGN	4 ASTC1401 ASSISTIVE TECHNOLOGY PROFESSIONAL SKILLS I	5 ASTC1501 PROBLEM SOLVING, COMMUNICATION AND INNOVATION	6 ASTC1601 MAN AND MACHINE	7 ASTC2101 ASSISTIVE TECHNOLOGY PROFESSIONAL SKILLS II	8 ASTC2201 CASE STUDIES IN ASSISTIVE TECHNOLOGY	9 ASTC2301 RESEARCH METHODS AND PROPOSAL WRITING	10 ASTC2401 INCLUSIVE LEARNING THROUGH TECHNOLOGY	11 ASTC2501 UBIQUITOUS COMPUTING	12 ASTC2601 ACCESSIBLE WEB DESIGN	13 ASTC2701 BIOMEDICAL DEVICES	14 ASTC2801 PROJECT AND CHANGE MANAGEMENT	15 ASTC2901 ROBOTICS	16 ASTC3101 RESEARCH PROJECT AND DISSERTATION
	Knowledge																	
1	Demonstrate detailed knowledge and understanding of fundamental topics in computing for Assistive Technology and the manner in which they are combined in the overall process of inclusive design	**23**	7	2	5	0	0	2	1	2	0	2	0	2	0	0	0	0
2	Demonstrate detailed understanding of selected specialised computing topics useful in the area of Assistive Technology	**67**	4	3	10	0	1	7	1	4	4	2	4	7	5	1	9	5
3	Demonstrate detailed detailed knowledge and understanding of selected, leading-edge, research-based topics within computing for Assistive Technology	**59**	1	0	1	0	5	1	3	7	11	3	6	7	0	0	8	6
4	Demonstrate detailed knowledge and understanding of research methodology and practice	**22**	0	0	0	0	3	0	0	0	13	0	0	0	0	0	0	6
5	Demonstrate wareness of ethical and professional issues relevant to computing in Assistive Technology.	**48**	3	2	1	2	3	4	10	7	8	2	4	0	0	0	1	1
	Know-How and Skill																	
1	Perform problem analysis from written descriptions	**35**	1	0	0	0	6	1	5	1	4	2	0	0	2	7	1	5
2	Derive requirements specifications from an understanding of problems	**37**	6	1	0	0	6	3	5	1	2	1	0	0	4	6	2	0
3	Create and/or justify designs to satisfy given requirements	**91**	4	0	8	1	9	8	10	6	0	4	6	7	4	13	9	2
4	Develop original ideas in a research context	**28**	0	0	0	2	6	0	0	1	13	0	0	0	0	0	0	6
5	Effectively design and develop accessible systems	**107**	6	4	8	5	10	8	10	7	1	5	6	7	4	13	9	4
6	Define and contextualise computing research problems in the area of Assistive Technology, questions or issues	**40**	0	1	0	0	6	1	2	5	13	4	1	0	0	0	3	4
7	Propose, scope, plan and manage a research project of significant size	**35**	0	0	0	0	4	0	0	0	12	0	0	0	0	13	0	6
8	Perform independent and efficient time management	**13**	0	0	0	0	0	0	0	0	5	0	0	0	0	4	0	4
9	Communicate effectively by oral, written and visual means	**27**	0	0	0	4	2	1	2	0	9	0	0	0	0	6	0	3
10	Prepare technical reports to a professional standard	**22**	0	0	0	4	3	0	7	0	2	1	0	0	0	0	1	4
11	Prepare a dissertation to acceptable academic standard	**9**	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	6
12	Present and defend research findings in an academically acceptable format	**16**	0	0	0	0	1	0	0	0	10	0	0	0	0	0	0	5
13	Prepare and present seminars to a professional standard	**8**	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	3
	Competence																	
1	Engage in and take significant responsibility for, the specification and successful resolution of Assistive Technology projects in both technical and managerial roles	**78**	7	5	5	5	10	5	6	5	0	3	0	6	4	14	3	0
2	Communicate the specification and resolution of Assistive Technology projects in both technical and managerial roles	**52**	0	1	0	6	7	5	1	4	0	1	0	6	4	14	3	0
3	Confidently defend research findings	**17**	0	0	0	0	1	0	0	0	10	0	0	0	0	0	0	6
4	Work effectively as an individual and as a member of a team	**27**	0	0	0	6	7	1	7	0	3	0	0	0	0	3	0	0
5	Take significant responsibility for the work of individuals and groups	**14**	0	0	1	2	7	0	0	0	0	0	0	0	0	4	0	0
6	Take significant responsibility for leading and initiating Assistive Technology activities	**20**	0	0	0	5	8	3	3	0	0	0	0	0	0	1	0	0
7	Demonstrate an awareness of how Assistive Technology can be used in a variety of organisational types and the impact of Assistive Technology initiatives on such organisational types	**96**	7	5	5	3	9	7	9	7	12	4	3	5	0	10	4	6
8	Demonstrate an appreciation of the wider inclusive society and the challenges faced by and responsibilities of individuals and organisations in such a society	**73**	3	0	1	3	9	8	9	7	12	4	5	0	0	5	1	6
9	Appreciate the importance of continued academic/professional development within the field of computing for Assistive Technology	**7**	2	0	0	1	1	1	0	0	0	0	1	0	0	1	0	0
10	Demonstrate an awareness of the resources available to keep up to date with new developments in Assistive Technology	**108**	0	5	5	4	10	7	10	6	11	5	6	6	4	14	9	6
11	Take responsibility for their own learning	**16**	0	0	0	3	2	0	0	0	10	0	0	0	0	0	1	0
12	Learn from experiences gained in different contexts	**53**	0	0	0	1	8	7	9	7	10	5	2	0	0	0	0	4
13	Demonstrate an awareness of personal responsibilities within professional codes of conduct relevant to computing in Assistive Technology	**14**	1	0	0	5	1	1	0	1	1	0	4	0	0	0	0	0
14	Demonstrate the ability to comprehend multiple perspectives	**84**	0	0	0	0	11	7	9	7	12	6	3	3	4	13	3	6

Fig.2 Master Matrix for MSc in Assistive Technology

2.4 Graph of PLOs Versus MLOs Total Contribution

The analysis of the programme design may be taken a stage further by graphing the PLOs against the MLOs Total Contribution using the data from the PLO and Total Contribution columns of Figure 2. This is shown in Figure 3. This is a useful approach when analysing large sets of data[9]. The graph provides a useful visualisation tool[9] for an analysis of the programme that allows the programme designer to quickly identify the deficiencies and excesses in the relationships between programme learning outcomes and module learning outcomes.

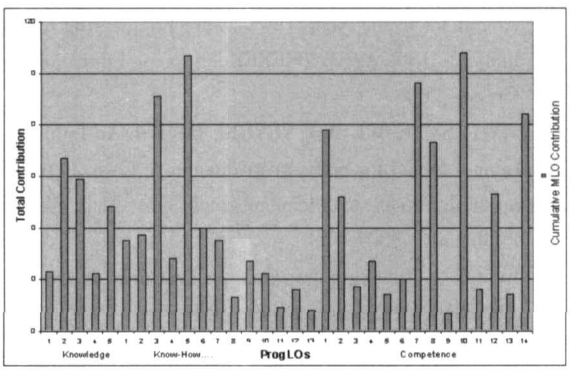

Fig.3　Cumulative contribution of MLOs to PLOs

Figure 3 represents the current MLO-PLO cumulative contribution profile for the MSc in Assistive Technology. It would appear from this profile that the programme may be unbalanced in certain areas. In some cases there may be an excess of support for some PLOs to the detriment of others. The programme design may need to be revisited to address such issues.

2.5 Graph of MLO Contributions Across Modules and Across PLOs

Some useful insight into which modules may be responsible for the imbalance in the programme design may be obtained by graphing the MLO contributions across modules and across PLOs using the data from Figure 2. This is illustrated in Figure 4 which shows the current profile of MLO contributions across modules and across PLOs for the MSc programme.

A number of gaps are apparent in the profile in Figure 4. There appears to be an excess of support for some PLOs and a deficit of support for others. In the case of excess support, the programme designer may need to revisit the design with the programme design team and rebalance the MLO-PLO contribution in certain areas. In the case of poorly supported PLOs the non-contributing modules may need to be investigated. For example, PLO (Know-How and Skill, 13) appears to be poorly supported across most modules. The graphical representation of MLO contributions across modules and across PLOs in Figure 4 allows the programme designer to quickly identify which modules are not contributing to this PLO. In this case the only modules that appear to be contributing to PLO (Know-How and Skill, 13) are Modules 4, 5, and 16.

It may be the case that some of the non-contributing modules are not properly constructively aligned[3]. The learning outcomes, teaching and learning methods, and assessment methods may be poorly aligned. The assessment regime may not match the stated learning outcomes. For example, an intended MLO relevant to a specific PLO may not be expressed in the MLOs but could appear in the Assessment section of a module without being explicitly expressed as an MLO.

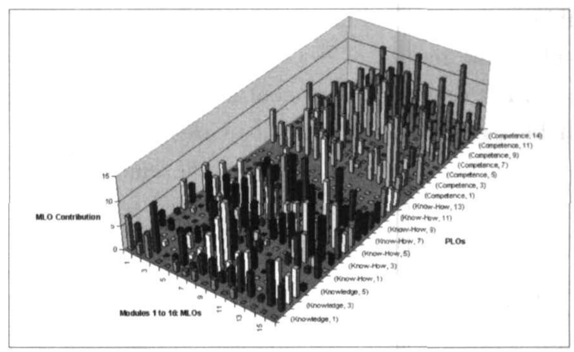

Fig.4　MLO contributions across modules and across PLOs

3 Discussion

The approach outlined in this paper would appear to be a useful tool for analysing the design of an academic programme. However, one must exercise caution when interpreting the results as the numeric data for this analysis were generated in a limited qualitative/interpretative manner.

One way of making the method more robust would be to calibrate or benchmark the scoring process by cross-checking with a number of experienced colleagues from the programme design team who would act as independent judges[6]. A group of up to five experienced colleagues[10] would be asked to independently analyse and score the MLO-PLO contributions across the 16 modules using the qualitative/interpretative technique outlined in this paper. (It may be the case that the number of independent judges should be kept open, but initially a group of up to five experienced colleagues would be used).

Each analyst would produce an individual Master Matrix. The numeric values in the Total Contribution columns would then be displayed as consensus values across the five Master Matrices to derive a single set of MLO-PLO contribution scores. If all analysts agree that a given MLO supports a specific PLO then confidence in that MLO-PLO contribution is high. In cases where judges do not agree, discussion would take place to identify the reason for the difference of opinion and resolve it before progressing. If agreement cannot be reached, the module design team would be the final arbiters in this process.

Once a consensus is reached, the programme PLOs would then be graphed against this set of MLO-PLO scores as before. The resulting graphs would illustrate a more representative set of MLO-PLO profiles.

If necessary the independent scoring process could be repeated a number of times using different groups of assessors from the programme design team with a consensus being obtained across assessor groups to reach a stable set of MLO-PLO contribution scores prior to graphing the results.

A retrospective assessment of MLO-PLO alignment can be carried out by questionnaires administered to the students on the programme at the end of each semester. These results can be compared to the staff evaluation of MLO-PLO alignment.

4 Summary

A mapping approach to the assessment of the design of an MSc Programme in Assistive Technology has been described in this paper. An analysis of the programme was carried out by mapping the MLOs of all 16 modules of the programme to the overall PLOs. A qualitative technique similar to gist analysis[6] was used to resolve any MLO-PLO mapping ambiguities.

The analysis of the MSc programme design was taken a stage further by graphing the PLOs against the individual MLOs, and also graphing the MLO contributions across modules and across PLOs. This provided potentially useful tools for analysis of the design of the MSc programme.

To improve the results of this analysis a method of making the scoring process more robust was proposed in which a team of five experienced judges would independently analyse and score the MLO-PLO contributions, with a consensus being obtained across the five judges to derive a single set of MLO-PLO contribution scores. This method will be implemented and tested in future work.

The approach to learning outcome analysis described in this paper provides a visualisation tool that allows the programme designer to quickly identify programme design issues. The approach appears to be promising, at least as a useful quality assurance tool in assessing the design of an academic programme.

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