Building a Taxonomy of Learning Outcomes from Module Descriptions for the Computer Science Degree

Final Report

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Learning Outcomes are an important and necessary part of setting course material within educational programs. The report explains the analysis methods chosen and the actual analysis process of the Computer Science Degree Learning Outcomes, the results of the project and the future direction of the project. The overall aim of the project was to provide recommendations for both the course syllabus and module descriptions.

Table of Contents

Table of Figures

1. Introduction

The School of Computer Science & Informatics recently underwent a redesign of all its degree schemes, changing the content of what was being taught and how this was going to be taught to the students to better reflect their needs, keep up-to-date with the latest developments within the industry and to more appropriately follow the outcome-centred learning. As a result of this redesign 3 years ago, many new and improved modules have been introduced. However, while a lot of feedback has been gathered from running these modules, this is only on an individual basis i.e. each specific module; it does not relate to how all the modules in a year interact or how they build upon each other year on year. Certain issues such as were the overlap between modules lies and whether students are properly building upon their knowledge base year on year need to be better understood and clarified to ensure that learning is occurring in the way the school intended.

One of the key ways that lectures communicate the main aims and objectives of a module to their students is through Learning Outcomes. Learning Outcomes are statements describing what a student should know, understand and be able to do at the end of a module (Moon 2002, p. 42). The focus of this project has been to examine both the overall programme Learning Outcomes and also the Learning Outcomes for each of the modules on the Computer Science degree scheme. A Taxonomy was then produced which made Bloom’s Taxonomy more specific to the Computer Science degree programme by classifying the objects of learning outcomes along with the six categories and verbs associated with Bloom’s taxonomy. Along with this, research was carried out into students’ perceptions of the actual learning outcomes as they are delivered in teaching practice and how they match the pre-defined Learning Outcomes. Overall, the analysis was used to provide recommendations for improvements to both course syllabus (i.e. how the content is distributed across modules) and the learning outcomes themselves for a module in order to better reflect the desired outcomes of the taught content.

1. Extended Background

Back in the 1950’s when Bloom et al. originally met to begin the process of developing Bloom’s Taxonomy the intent was to build the taxonomy of educational objectives that would allow for classification of the goals within the educational system (Bloom et al. 1956, p. 1). The purpose was to help teachers, administrators, professional specialists, and research workers by producing a framework which they could work around (Bloom et al. 1956, p. 1).The taxonomy when originally proposed was developed in three major parts – Cognitive Domain, Affective Domain and Psychomotor Domain.

The Cognitive Domain relates to the objectives that “deal with the recall and recognition of knowledge and the development of intellectual abilities and skills” (Bloom et al. 1956, p. 7).

The Affective Domain relates to the objectives which “describe changes in interest, attitude, value and the development of appreciations and adequate adjustments” (Bloom et al. 1956, p. 7).

The Psychomotor Domain is the “manipulative or motor-skill area” (Bloom et al. 1956, p. 7).

The Cognitive Domain is the most developed of all the three domains as it was found that teachers and educational institutes could clearly describe the objectives; therefore allowing for more accurate and detailed analysis for the building of the taxonomy (Bloom et al. 1956, p. 7).

In the case of the other two domains, it was harder to produce a taxonomy for these areas. Eventually a taxonomy was developed for the Affective Domain but educational institutes had very little content surrounding the Psychomotor Domain and a taxonomy was never developed by Bloom (Bloom et al. 1956, p. 7).

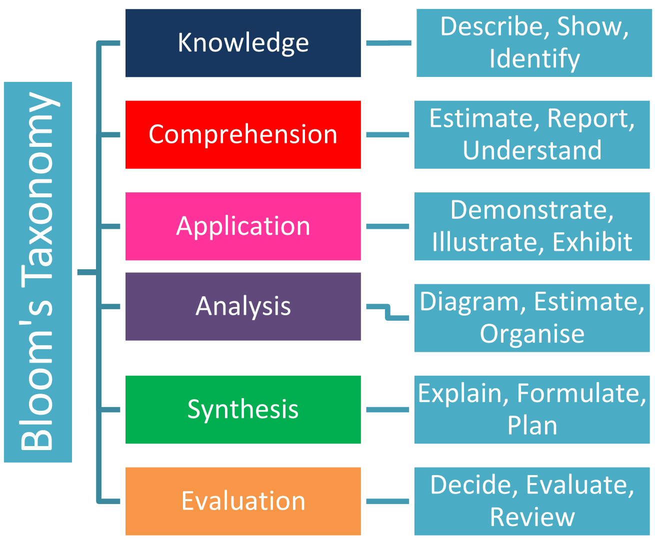
The main focus of the project therefore it to analyse the objectives against the Cognitive Domain Taxonomy as further research and development has been carried out in this area making it preferable to analyse the learning outcomes against. Further work on the project could extend it to analysing the learning outcomes against the Affective Domain and more modern proposals for the Psychomotor Domain (Refer to Section 7 for more information).

The Cognitive Domain Taxonomy was developed and divided into six levels of understanding in a hierarchical sequence. The six levels were developed to firstly reflect the distinction teachers make among students behaviours; that is the intended behaviour the student should demonstrate i.e. the way they act, think or feel as a result of taking the course (Bloom et al. 1956, p. 12). Secondly, so that the taxonomy would be logical and consistent and that each term would be defined and used in a consistent way throughout (Bloom et al. 1956, p.14). Lastly, that it acts as a purely descriptive scheme allowing for every type of learning outcome to be represented in a relatively neutral fashion.

It was also noted that the intended objective of learning outcomes is to facilitate the changes expected of the student's behaviour from a simpler type to another more complex one (Bloom et al. 1956, p.16). This change occurs from building on the simpler behaviours; therefore one behaviour that is classified in one way at the start may later on be developed and integrated with another behaviour to form a more complex type which is classified differently (Bloom et al. 1956, p. 16). For example:

> *"the acquisition of facts (knowledge) marks only the beginning of understanding. The facts must be understood (comprehension) before they can be applied to new situations (application). Knowledge must be organized and patterns recognised (analysis) before it can be used to create new ideas (synthesis). Finally, to discriminate among competing models or evidence, the learner needs to be able to assess (evaluation) the relative merits and validity of information or ideas."* (Wirth, K. and Perkins, D. 2008, p. 6).

In this way a student must build upon each level of understanding to successfully achieve each of the new more complex behaviour types. The taxonomy was developed and organized therefore to reflect this by classifying from the simple to complex classes of behaviour (Blooms et al. 1956, p. 16). The taxonomy was organized as follows:



By organizing the taxonomy in such a way it allows courses to arrange their learning outcomes so that they acknowledge the need to develop and build upon understanding, thus learning outcomes can be set that reflect the desired level of learning the students are to reach. This project will use these levels to analyse each modules learning outcomes against and determine whether they appropriately reflect the expected understanding, that years build upon previous understanding levels reached and that they also reflect students experience of the module.

2. Overview of Analysis Methods

The project was spilt up into two distinct research and analysis areas which complemented each other. Firstly there was the analysis of the learning outcomes themselves as stated by school set module descriptions. Analysis in this area comprised firstly of storing, breaking down and querying the learning outcomes in an SQLite Database and from this producing taxonomies which clearly showed the learning patterns that were taking place. An overall taxonomy was also produced at the end of this which revised Bloom's Taxonomy so it was more specific to the Computer Science degree programme.

The second area was research into students' perceptions about the learning that was taking place and how this related to the specified learning outcomes. This was conducted through focus groups and surveys as described in the Interim report and then analysed through the use of NVivo.

Sections 4 and 5 detail the steps and analysis process for both of these areas and then Section 6 draws together all of the conclusions to present a list of recommendations for the improvement of the learning outcomes. The report concludes then with a look at the future of the project and others areas that could be researched in to.

3. Learning Outcomes Analysis

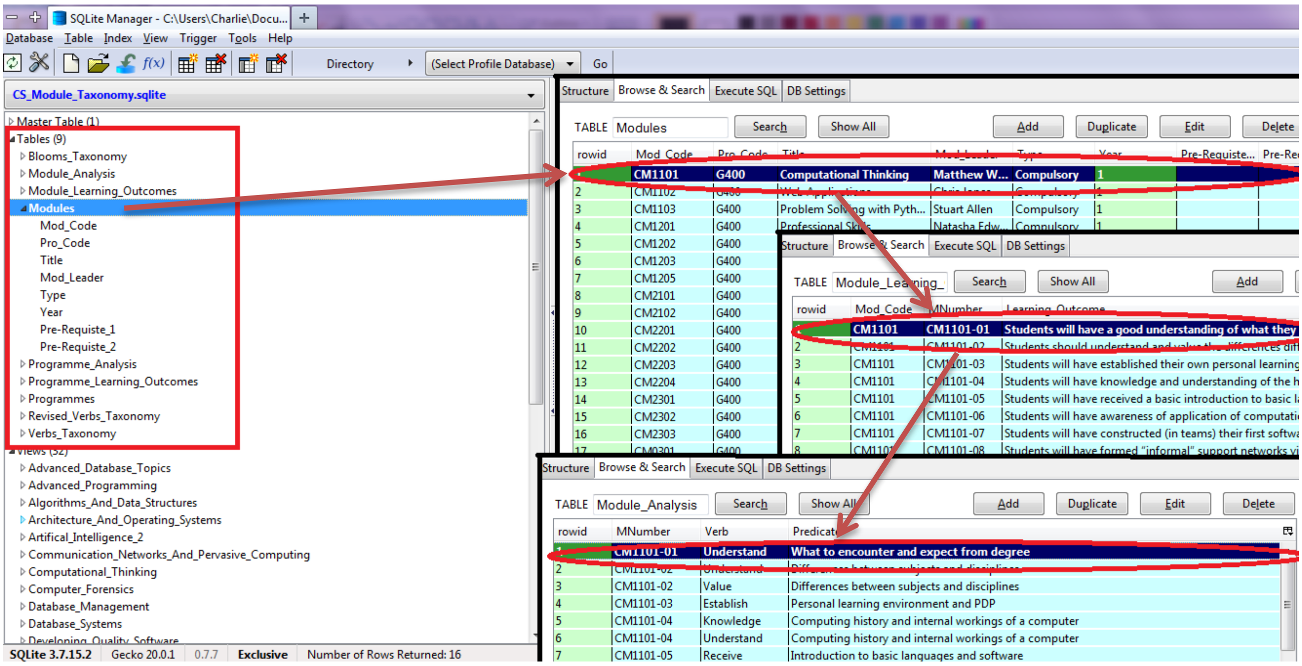
The section details the steps taken throughout the analysis process and the conclusions which were made at each stage.

3.1. SQLite Database Development

As discussed in the Interim Report the chosen database to store and analyse the learning outcomes was SQLite Manager. The use of the database allowed for information to broken down, stored separately and then analysed through the construction of queries and views. SQLite manager also provided a Graphical User Interface (GUI) that was easy and efficient to use (Figure 2).

Multiple tables were created to store details about the degree programme and its associated overarching learning outcomes, individual module details for the Computer Science degree programme, and then their associated learning outcomes. Further tables were also created to store the broken down learning outcomes which were used for analysis. Referencing between these tables occurred with the use of primary and foreign keys. Mod_Code (refers to Module Code) appeared in both the Modules and Module_Learning_Outcomes tables and was used to relate each individual module to its associated learning outcomes. MNumber (refers to a unique number associated with each individual learning outcome) appeared in both the Module_Learning_Outcomes and Module_Analysis table and was used to relate each learning outcome with its broken down form (i.e its predicate/verb and object). The same was done for each of the programme learning outcomes using Pro_Code and PNumber instead.

Figure 2: Overview of SQLite Database



Bloom's Taxonomy was then stored in the database across two tables; the six categories, their stage and a definition were stored in the Blooms_Taxonomy Table and then the verbs and their associated category were stored in the Verbs_Taxonomy table. These two tables were linked together using the Learning_Cat attribute (refers to the six Learning Categories defined by Bloom). It is worth noting at this point that the verbs stored in the database are not an exhaustive list but ones that most commonly appear in different educational institute's lists of Blooms Taxonomy.

The remainder of this section will detail the exact queries and uses of the database in the breaking down of learning outcomes, their storage and the eventual construction of the taxonomy. A copy of the final database can be found in the Archive Files under CS_Module_Taxonomy_DB.

3.2. Breakdown of Learning Outcomes

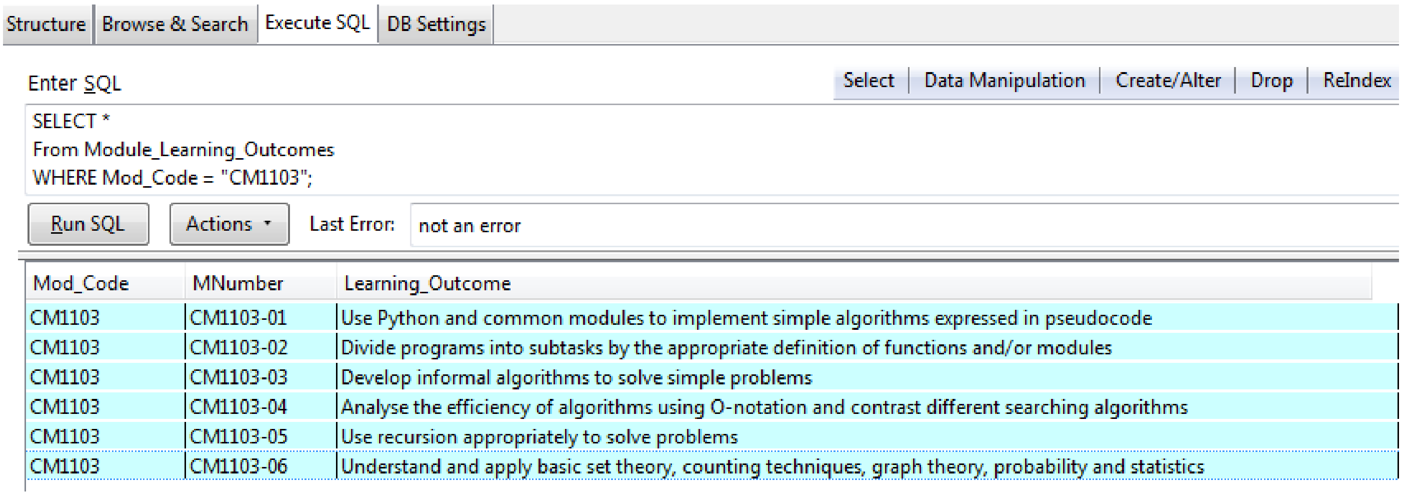
The interim report introduced the concept of producing a taxonomy that was specific to the computer science degree programme. This was to be done firstly through the deconstruction of the learning outcomes into their predicate and objects. The predicate relates to the verb that is describing the intended learning behaviour and the object relates to the actual material that is taught. For example: "Implement fundamental data structures and algorithms." In this context "Implement" is the verb specified within Blooms Taxonomy and "data structures, algorithms" are the objects describing the content of the module.

Once all the learning outcomes for the modules on the Computer Science degree programme had been imported into the database there were exactly 202. This was a large amount of data to handle and breakdown; the following query was therefore used to help reduce the amount of data that was being viewed at any one time allowing for easier handling.

```
SELECT *
From Module_Learning_Outcomes
WHERE Mod_Code = "CM1103";
```

This simple SQL query returns all the attributes for the records whose Mod_Code attribute is set as (in this instance) "CM1103" from the Module_Learning_Outcomes table (Figure 3). The value highlighted in red is changed for each module that needs to be displayed. In this way the 202 records can be reduced down to only the specific few associated with the module currently needed. While this is not a complex query it allowed for data to be handled in smaller chunks and was a faster and easier approach to breaking down the learning outcomes.

Figure 3: SQL Query - Displaying Only Specific Module LO's



Mod_Code	MNumber	Learning_Outcome
CM1103	CM1103-01	Use Python and common modules to implement simple algorithms expressed in pseudocode
CM1103	CM1103-02	Divide programs into subtasks by the appropriate definition of functions and/or modules
CM1103	CM1103-03	Develop informal algorithms to solve simple problems
CM1103	CM1103-04	Analyse the efficiency of algorithms using O-notation and contrast different searching algorithms
CM1103	CM1103-05	Use recursion appropriately to solve problems
CM1103	CM1103-06	Understand and apply basic set theory, counting techniques, graph theory, probability and statistics

3.3. Mapping Learning Outcomes to Blooms Taxonomy

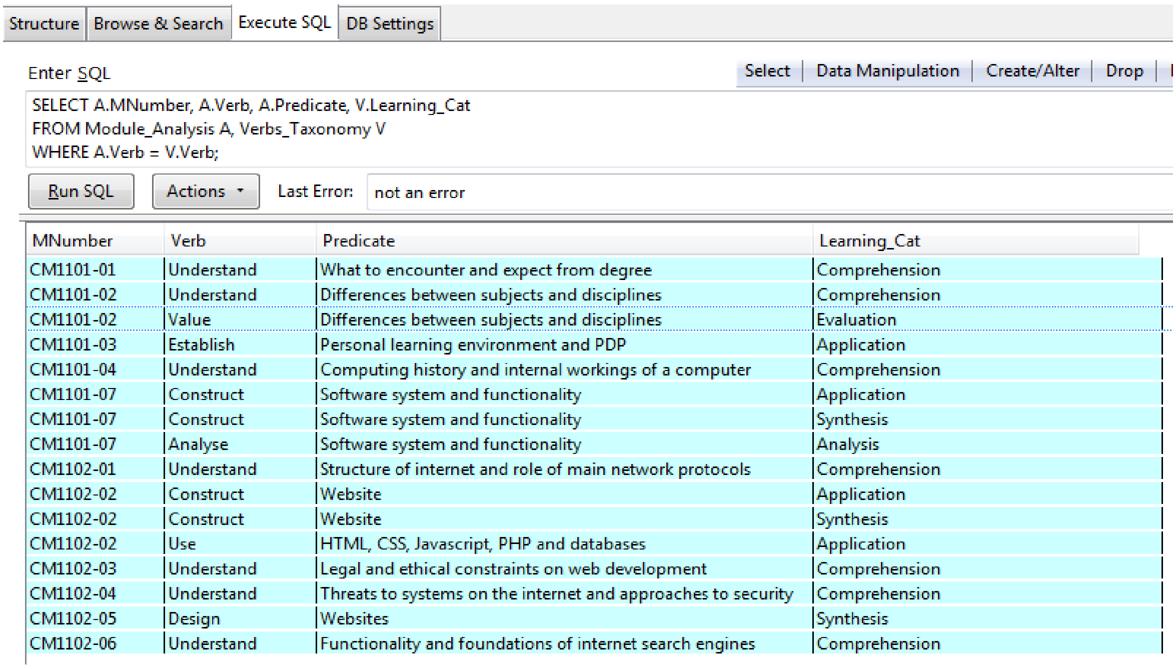
Once all the learning outcomes had been broken down into their predicate/verb and object these could then be mapped to the Bloom's Taxonomy category that each one was associated with. By relating them to the Bloom's Taxonomy category, steps could be made towards the construction of an overall taxonomy and analysis of the learning taking place on the Computer Science Degree programme.

The following query was used to show which Blooms category each learning outcome belonged to; again this was broken down into more manageable chunks by displaying learning outcomes a module at a time.

```
SELECT A.MNumber, A.Verb, A.Predicate, V.Learning_Cat
FROM Module_Analysis A, Verbs_Taxonomy V
WHERE A.Verb = V.Verb
AND A.MNumber LIKE 'CM1203%';
```

This query returns the MNumber (Module Number – this refers to a unique number for each learning outcome. The start of the number relates to the module code that the learning outcome belongs to), Verb (this is the predicate of the learning outcome) and the Predicate (this column refers actually to the object of the learning outcome it was wrongly named at the construction of the database) attributes from the Module_Analysis table and the Learning_Cat (this refers to one of Bloom's Categories) from the Verbs_Taxonomy table; for the records where the verb associated with a learning outcome in the Module_Analysis table matches one of the verbs stored in the Verbs_Taxonomy table, which contains verbs associated and classified by Blooms Taxonomy. It then also only returns records where their MNumber follows the pattern (in this instance) "CM1203%", the % means that any character can follow i.e. learning outcomes that are associated with the CM1203 module (Figure 4). Again it should be noted that the value highlighted in red is changed for each module that needs to be displayed.

Figure 4: SQL Query - Mapping Learning Outcomes to Blooms Category

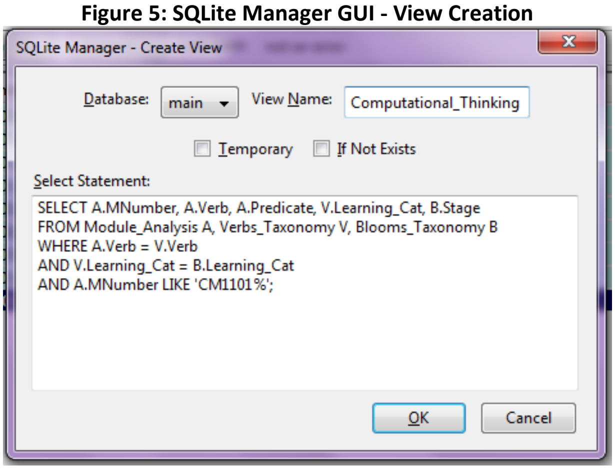


MNumber	Verb	Predicate	Learning_Cat
CM1101-01	Understand	What to encounter and expect from degree	Comprehension
CM1101-02	Understand	Differences between subjects and disciplines	Comprehension
CM1101-02	Value	Differences between subjects and disciplines	Evaluation
CM1101-03	Establish	Personal learning environment and PDP	Application
CM1101-04	Understand	Computing history and internal workings of a computer	Comprehension
CM1101-07	Construct	Software system and functionality	Application
CM1101-07	Construct	Software system and functionality	Synthesis
CM1101-07	Analyse	Software system and functionality	Analysis
CM1102-01	Understand	Structure of internet and role of main network protocols	Comprehension
CM1102-02	Construct	Website	Application
CM1102-02	Construct	Website	Synthesis
CM1102-02	Use	HTML, CSS, Javascript, PHP and databases	Application
CM1102-03	Understand	Legal and ethical constraints on web development	Comprehension
CM1102-04	Understand	Threats to systems on the internet and approaches to security	Comprehension
CM1102-05	Design	Websites	Synthesis
CM1102-06	Understand	Functionality and foundations of internet search engines	Comprehension

Through this it was clearly shown which category each learning outcome belonged to and therefore the intended learning stage. However, it also highlighted the fact that not all learning outcomes were associated with a category from Bloom's Taxonomy. For each of these instances the specific verb was double checked against further resources to ensure that it could not be classified in Bloom's Taxonomy (the verbs listed in the database are not an exhaustive list but the most common ones therefore there was possibility a verb could have been overlooked). If it was discovered that it was not part of Bloom's Taxonomy it was documented in a table of learning outcomes not associated with Bloom's Taxonomy (Refer to Section 4.6 for more information).

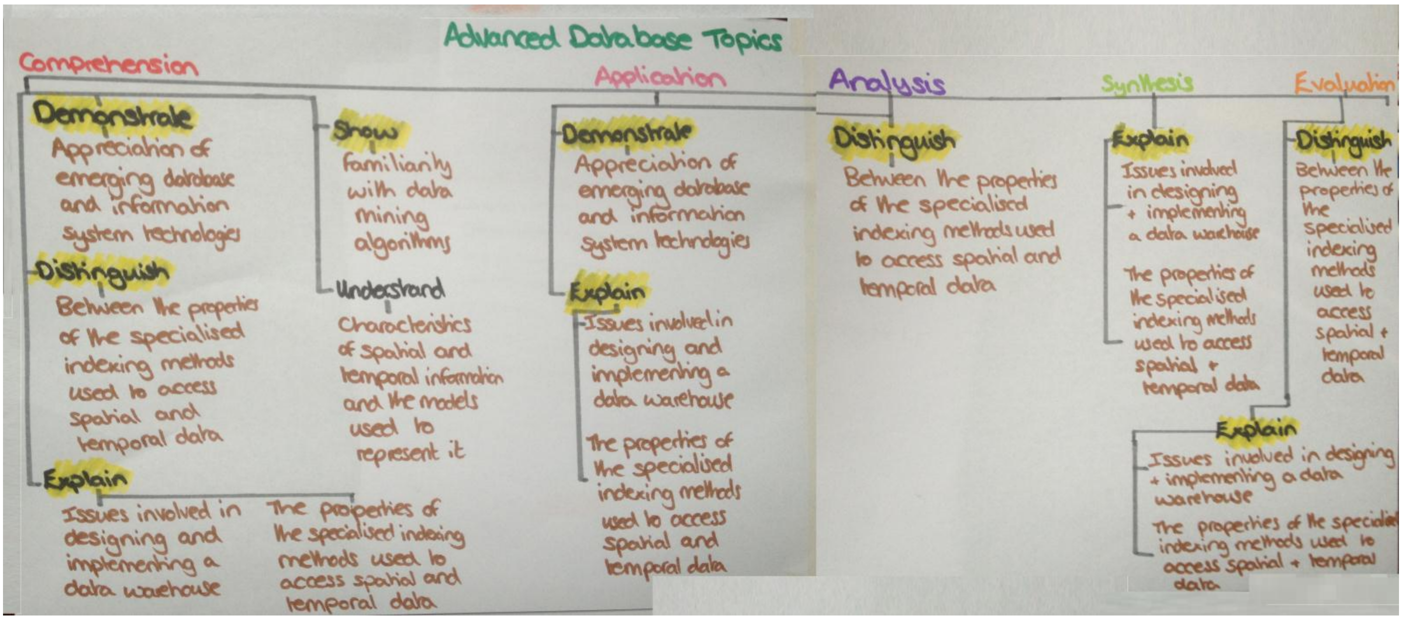
In order to avoid constantly having to rewrite the above query every time a different modules data needed to be displayed, views were created to temporarily form a new table for every module. SQLite Manager handles the creation of Views through its GUI which provides a form to enter the simple SQL query as stated above which is then manipulated to create the query that will produce the view (Figure 5). Figure a and b in Appendix 1 show the resulting view table and the completed list of views created.

Figure 5: SQLite Manager GUI - View Creation



Once the views were created initial taxonomies were produced on paper for each module where the learning outcomes were taken in their broken down form and categorised under each of Bloom's Categories depending on which one the verb/predicate belonged to (Figure 6). The view helped with this as a single module could be displayed at a time. Appendix 2 contains images of all the original module taxonomies created.

Figure 6: Sample Module Taxonomy - Version 1



The problem that was obvious once these had been drawn was that a lot of the verbs are placed into several of the categories (as shown in Figure 6 by the yellow highlighting for verbs that appear under more than one category). This occurred because several different tables of Bloom's verbs were used to originally populate the database. Research has shown that many different institutes vary with their categorisation of verbs into the levels which is often due to it being unclear as to what level of understanding it refers to (Almerico, G.M. and Baker, R.K. 2004, p. 5). It has also been shown that some lists can contain a verb that appears in several different categories because it refers to the same thinking abilities but at different levels (Almerico, G.M. and Baker, R.K. 2004, p. 5).

However, in order to simplify the classification and aid in the analysis process each verb was classified into only one of the six Bloom's categories. Almerico and Baker's (2004) study had produced just such a taxonomy; with the help of three experts within the educational field they classified the verbs into only one of the categories. The resulting taxonomy can be seen in Appendix 3.

3.4. <u>Revising Blooms Taxonomy</u>

Since the development of the taxonomies was reliant on being able to match each verb/predicate to a single Bloom's category, the taxonomy as stored in the database needed to change. A new table was created called Revised_Verbs_Taxonomy that consisted of the Taxonomy as identified in Section 4.3 (Appendix 3).

The verbs - as identified in Almerica and Baker's (2004), were imported from a text file when this new table was created (see Figure a and b Appendix 4). However, this was not an exhaustive list and there were still lots of verbs that had been stored in the original Verbs_Taxonomy table that didn't appear in this new list. The following query was therefore used to find these verbs so that they could be included into the new taxonomy.

```
SELECT DISTINCT V.Verb, V.Learning_Cat
FROM Verbs_Taxonomy V, Revised_Verbs_Taxonomy R
WHERE V.Verb <> R.Verb;
```

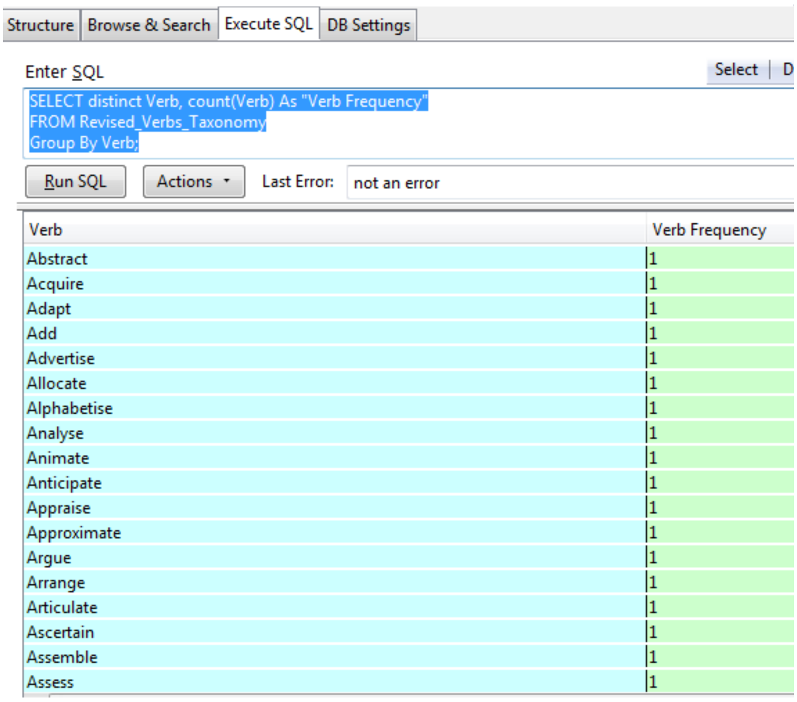
This query returned the attributes Verb and Learning_Cat (refers to Bloom's categories) from the Verbs_Taxonomy table (older version used to store verbs and their associated category). The distinct was used to specify that each verb was only to be displayed once. The further restriction was that only the verbs that were not already stored in the Revised_Verbs_Taxonomy table (newer version of the verbs table that stores each verb only once) would be returned (see Figure c Appendix 4). From this, these verbs could be categorised in the new Revised_Verbs_Taxonomy and under only one Bloom's category. If any conflicts were found these were resolved by referring to multiple tables and taxonomies as defined by educational institutes to determine which one it was best suited to.

Once the new table had been populated the following query was run to check that each verb only occurred once in that table.

```
SELECT distinct Verb, count(Verb) As "Verb Frequency"
FROM Revised_Verbs_Taxonomy
Group By Verb;
```

This query returned a list of each verb along with its frequency (the number of times it appeared in the table). Distinct was again used to specify that each verb was only displayed once and the count to add up the number of times each verb was recorded which was then displayed under the title "Verb Frequency" (see Figure 7).

Figure 7: SQL Query - Checking Verb Frequency



Once all of the verbs had been re-categorised so they only appeared once in one of the six Bloom's categories the views that had been created, were modified to reflect this and allow new more defined taxonomies to be created (see Figures c and d in Appendix 1). This was achieved by simply referencing the Revised_Verbs_Taxonomy table instead of the Verbs_taxonomy table.

3.5. <u>Creation of Taxonomies</u>

At this point, new taxonomies could be created from each of the modules (See Appendices 5, 6 and 7). Each of these broke the learning outcomes down into firstly the different objects and then linked these to the verb/predicate that was classifying it; this could then be linked to the Bloom's

Category it referenced. These taxonomies helped to easily highlight the different levels of learning that were occurring on the module and so see if there were any gaps. It also helped to clearly show where learning outcomes failed to properly classify the learning intent. In finding these, suggestions for improvement can be made. The main advantage of these smaller taxonomies was that they proved to be much more effective at understanding what was occurring within the module. A larger one would prove to be too cluttered and relationships would have been difficult to find.

As well as looking at each individual module and the learning that was taking place, it was also important to look at what learning was taking place within each year and across all three years. Again diagrammatic representations were produced that highlight all the Bloom's levels that were covered by each module in a year (See Appendix 8); each year could then be analysed to see what the general pattern of learning was and see how this changed over the three years.

Specific analysis was also carried out on the building upon of knowledge for modules that stated pre-requisites. This was to ensure that the learning outcomes and expected learning behaviours appropriately built upon each other from year to year and also that there was not any unnecessary overlap.

Taxonomies were also produced for the programme learning outcomes; these were split up into four areas of learning that the school has specified for the degree – Knowledge and Understanding, Intellectual Skills, Discipline Specific Skills including Practical Skills and Transferable Skills (Appendix 9). Each of these were analysed separately and as a group to determine if all learning stages were covered and expected in these overarching learning outcomes.

3.6. Discussion of Findings

3.6.1. Modules

Each individual modules taxonomy was analysed to find learning outcomes that were not properly constructed and so could not be classified under Bloom's Taxonomy, where verbs/predicates had been used that did not belong to Bloom's Taxonomy, what learning stages were being covered within the module and whether these were appropriate and also if learning outcomes were separate and distinct enough from each other (i.e. there were not two learning outcomes that meant the same thing). All the taxonomies referred to within this section can be found in Appendices 5, 6 and 7, they have been spilt up according to year group.

Computational Thinking

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 8: Computational Thinking - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Computational Thinking	CM1101-05	Students will have *received* a basic introduction to basic languages and software (e.g., Python and Excel)	Receive	Verb is associated with the Affective Domain Taxonomy
Computational Thinking	CM1101-06	Students will have *awareness* of application of computation processes to real-world problems	Aware	Verb is associated with the Affective Domain Taxonomy
Computational Thinking	CM1101-04	Students will have *knowledge* and understanding of the history of computing and the internal workings of a computer	Knowledge	Educational resources classify it as a non-measurable verb

The following learning stages are covered:

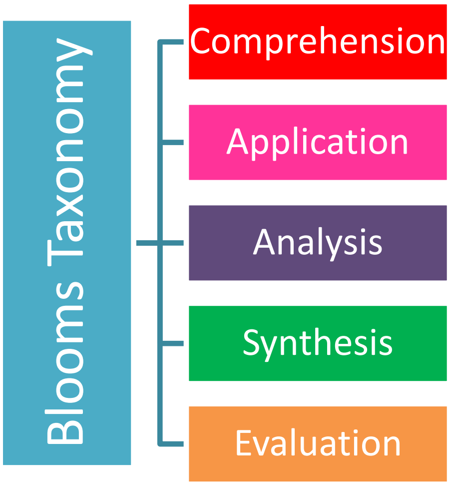


Figure 9: Computational Thinking - Bloom's Learning Stages Covered

- The module builds from comprehension right the way through to evaluation this is in line with its purpose of being an introductory module run for the first 4 weeks that introduces students to what will generally be happening over the next year and beyond.
- The initial knowledge stage has not been covered which you would expect to see for a year one module. However, as the module covers many general areas and is simply an introductory course maybe the expectation is that students already have an initial knowledge base about the course.
- No repetition of any learning outcome aims

<u>Web Applications</u>

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 10: Web Applications - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Web Applications	CM1102-07	*<u>Appreciate</u>* the main types of e-commerce and business models in modern marketing	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

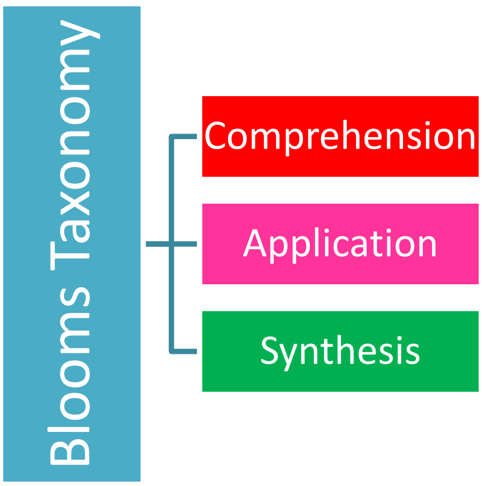


Figure 11: Web Applications - Bloom's Learning Stages Covered

- The module builds from comprehension to application and then jumps to synthesis. The two major points stand out from this are that there is no knowledge stage covered which you would expect for a first year module introducing the subject area. Also that the analysis stage is skipped over; the learning outcomes mention using web technologies in the construction of a website and the construction of websites, but skips the step were application of the web technologies is fully understood, broken down and generalisations are made about them. This may be because the learning stage is implied within the learning outcomes or that it is generally not needed, however a review is needed to determine this.
- No repetition of any learning outcome aims

Problem Solving with Python

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

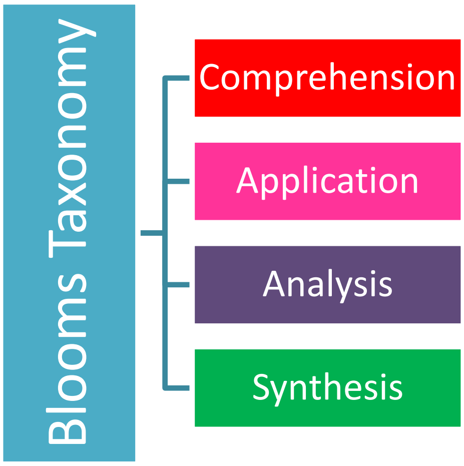


Figure 12: Problem Solving with Python – Bloom's Learning Stages Covered

- The module builds from comprehension to synthesis but misses out the knowledge and evaluation stages. It is expected that as a first module that not all stages would be covered as it is introducing concepts and ideas for the first time. However, the fact that the knowledge stage is not covered is unexpected, as you would presume a first year module that requires no previous knowledge to cover this first stage. A review of the learning outcomes is needed to ensure that this is intentional or that the learning outcomes need to be updated to reflect this gap.
- No repetition of any learning outcome aims

Professional Skills

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 13: Professional Skills - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Professional Skills	CM1201-06	*Present* themselves to employers and organisations in a professional manner	Present	Verb is associated with the Affective Domain Taxonomy
Professional Skills	CM1201-01	To *learn* how to communicate effectively and appropriately	Learn	Educational resources classify it as a non-measurable verb

The following learning stages are covered:

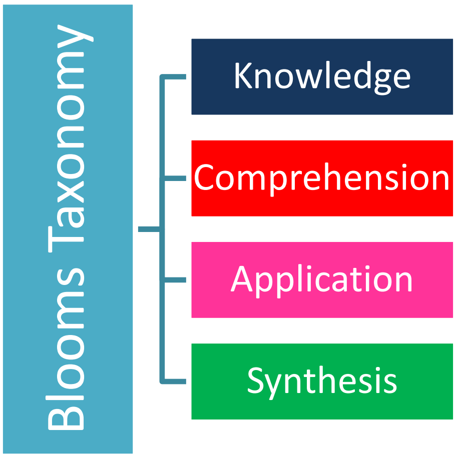


Figure 14: Professional Skills - Bloom's Learning Stages Covered

- The module builds from knowledge to application, skips analysis and then covers synthesis. The initial building from knowledge to application is to be expected for a first year module. The missing out of the analysis stage could again be because it is implied within learning outcomes but a review is needed to determine whether it is.
- Several of the learning outcomes focus in on the communication and presentation skills and the use of a variety of tools; they do all cover different areas and aspects of these however a review may be needed to determine whether they are all needed.

Developing Quality Software

- No repetition of any learning outcome aims

Figure 15: Developing Quality Software - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Developing Quality Software	CM1202-03	Gain an *appreciation* of how the main stages in the software development lifecycle contribute to the development of a high-quality software system by performing key technical tasks from each stage of the project	Appreciate	Verb is associated with the Affective Domain Taxonomy
Developing Quality Software	CM1202-10	*Reflect* on your experience of working in a team and your individual contributions to the project	Reflect	Educational resources classify it as a non-measurable verb

The following learning stages are covered:

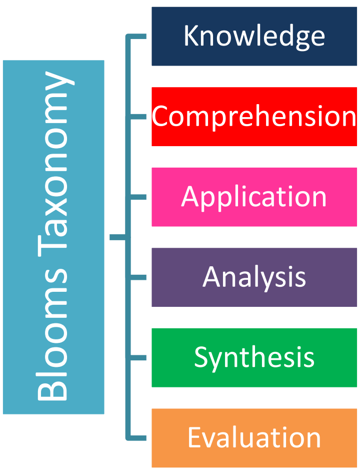


Figure 16: Developing Quality Software - Bloom's Learning Stages Covered

- The module covers all six learning stages which is to be expected as the module centres around the development of a software system within teams; therefore the whole cycle would need to move through each of the stages of learning for successful completion.
- No repetition of any learning outcome aims

Fundamentals of Computing with Java

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 17: Fundamentals of Computing with Java - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Fundamentals of Computing with Java	CM1203-02	*Appreciate* how mathematical techniques contribute to the study of computing	Appreciate	Verb is associated with the Affective Domain Taxonomy
Fundamentals of Computing with Java	CM1203-06	*Appreciate* the relationship between Computing and Information Systems.	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

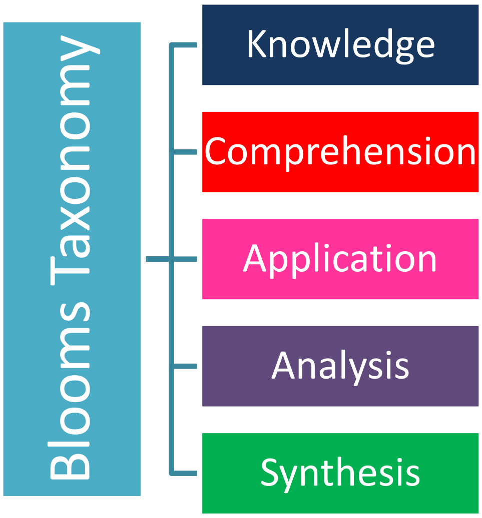


Figure 18: Fundamentals of Computing with Java – Bloom's Learning Stages Covered

- The module builds from knowledge right the way through to synthesis and misses out the final stage, evaluation. This is to be expected not only because it is a first year module but also due the fact that it is the second programming language that is introduced to students. The first semester covers problem solving with python and then in the second semester this one is studied. Therefore students can build upon previous skills they have learnt to help them with this one. However as it is a new language it is important that the earlier stages of knowledge and comprehension are present also otherwise students could struggle.
- Two of the learning outcomes focus on a similar area but cover different learning centred around the same area.

Architecture and Operating Systems

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 19: Architecture and Operating Systems - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Architecture and Operating Systems	CM1205-01	*Display* a good understanding of the main components of a computer system and their functionality	Display	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

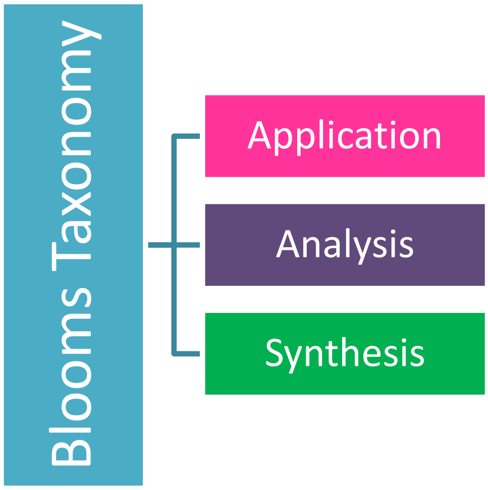


Figure 20: Architecture and Operating Systems – Bloom's Learning Stages Covered

- The module starts in the middle of the learning stages at application and builds till synthesis; it misses out the initial knowledge and comprehension stages which are required for successful application and true understanding of the course content. It does not appear to overlap with any of the learning outcomes for previous modules in the first semester so there appears to be no building upon previously learnt knowledge. It may be the case that these stages are covered in the module but they need to be reflected within the learning outcomes. A review should take place to resolve these issues.
- No repetition of any learning outcome aims

Human Computer Interaction

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 21: Human Computer Interaction - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Human-Computer Interaction	CM2101-01	*Appreciate* the importance and context of HCI and human factors in the software development life cycle.	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

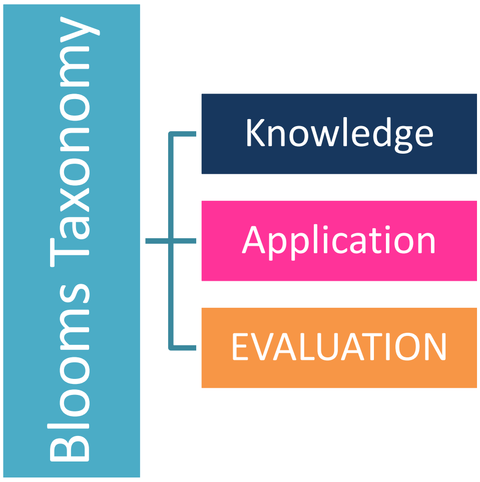


Figure 22: Human Computer Interaction - Bloom's Learning Stages Covered

- The module starts off at knowledge and then jumps straight to the application stage missing out comprehension and then again to evaluation. While it is a second year module the content is a new area for students to cover and has no previous modules to build upon specifically for learning. It therefore makes sense that it starts off at the knowledge stage and builds upon this; however a review should take place into determining whether learning outcomes should be included for the comprehension stage.
- While it is a new subject area which spans only one semester it is also worth looking into whether any of the later stages of learning such as analysis and synthesis are covered within the module as well as evaluation, and if so to include learning outcomes for these.
- No repetition of any learning outcome aims

<u>Database Systems</u>

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

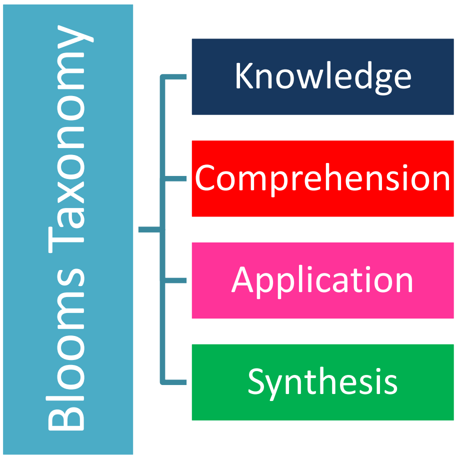


Figure 23: Database Systems - Bloom's Learning Stages Covered

- The module starts off at knowledge and builds to application, skips analysis and then finished at synthesis. Even though this is a second year module there have been no other modules which cover this area before; it therefore makes sense that it builds from the lower levels. The only area which will need review is that it skips past application straight to synthesis missing out analysis.

- No repetition of any learning outcome aims

Object Oriented Applications

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 24: Object Oriented Applications - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Object-Oriented Applications	CM2201-02	*Appreciate* the main features that are needed in a programming language in order to support the development of reliable, portable software.	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

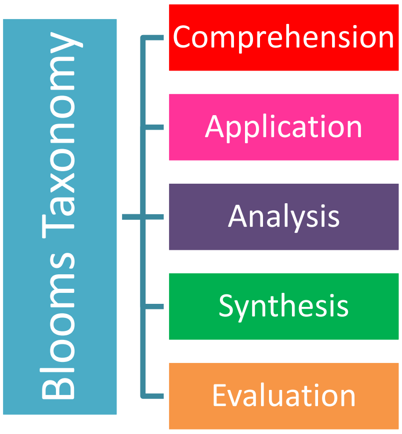


Figure 17: Object Oriented Applications - Bloom's Learning Stages Covered

- The module starts off at comprehension and builds all the way through to evaluation. The only stage that isn't covered is knowledge. This seems right for a second year module as though there is no specified pre-requisite module from first year, the module does build on core knowledge gained from Fundamentals of Java as it uses the java programming language therefore students could already have a knowledge base to build upon.
- No repetition of any learning outcome aims

Scientific Computing and Multimedia

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

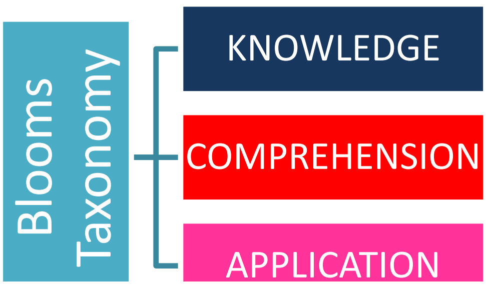


Figure 25: Scientific Computing and Multimedia - Bloom's Learning Stages Covered

- The module starts off at knowledge and builds all the way through to application. As the modules subject area is being introduced for the first time it makes sense to start from the lower levels.
- No repetition of any learning outcome aims

<u>Informatics</u>

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

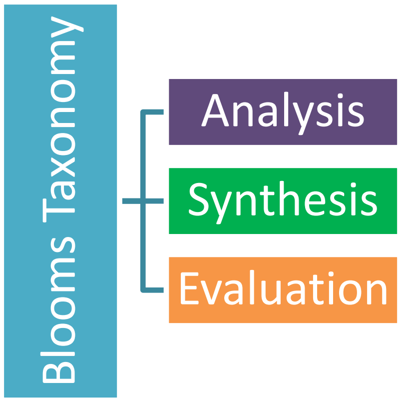


Figure 26: Informatics - Bloom's Learning Stages Covered

- The module starts in the middle at analysis and then moves up to the top levels, there is no reference to any lower level learning stages. This may be because this module is a compulsory module for another degree scheme which comprises of different modules that have links to it, or it may be that the lower level knowledge is something that is not needed to be explicitly stated. However, a review of the learning outcomes is needed to verify whether lower level learning outcomes are required or not.
- No repetition of any learning outcome aims

<u>Advanced Programming</u>

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

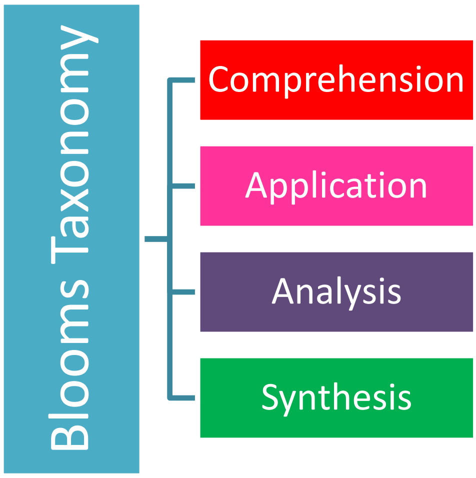


Figure 27: Advanced Programming - Bloom's Learning Stages Covered

- The module's learning starts at comprehension and moves through the stages until synthesis, knowledge and evaluation are missed out. This makes sense as it is a second year module that while introducing new languages does relate in some ways to other modules studied in first year – Fundamentals of Computing with Java; therefore you can assume that the basic knowledge has been covered in that module.
- No repetition of any learning outcome aims

Systems Design and Group Project

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 28: System Design and Group Project – Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Systems Design and Group Project	CM2301-11	*Appreciate* the problems involved in developing a large software system as part of a team.	Appreciate	Verb is associated with the Affective Domain Taxonomy
Systems Design and Group Project	CM2301-12	*Reflect* on the experience of working in a team and their individual contributions to the project.	Reflect	Educational resources classify it as a non-measurable verb

The following learning stages are covered:

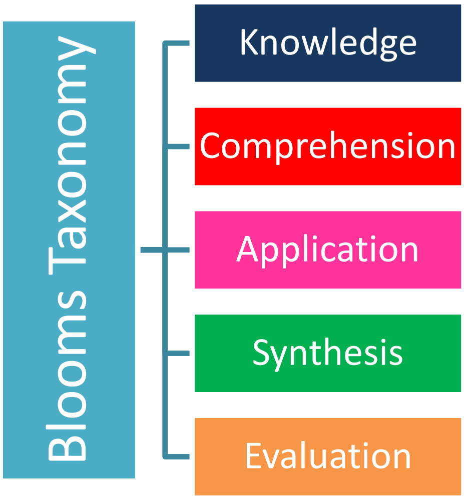


Figure 29: System Design and Group Project - Bloom's Learning Stages Covered

- The module covers all six stages bar the middle one analysis. For a second year module that spans both semesters and focuses on developing a software system completely it should perhaps have learning outcomes that address all stages. A review will be needed to determine whether the analysis stage is being covered or needs to be added in.
- No repetition of any learning outcome aims

Communication Networks and Pervasive Computing

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 30: Communication Networks and Pervasive Computing - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Communication Networks and Pervasive Computing	CM2302-04	*Appreciation* of issues for supporting real time & multimedia traffic over public networks.	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

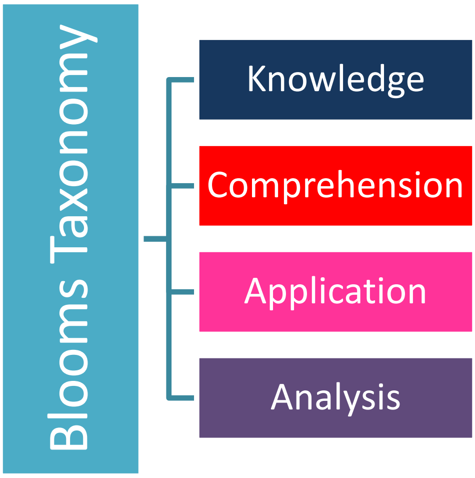


Figure 31: Communication Networks and Pervasive Computing - Bloom's Learning Stages Covered

- The module starts at the very bottom of the learning stages knowledge, and moves through to analysis in the middle. As this subject area is only introduced in second year it makes sense that the learning outcomes are focused around the lower stages. While the module spans two semesters, there is clear divide between first semester and second semester content with different areas within the subject field being covered, it therefore makes sense that the higher learning stages are not necessarily covered.
- No repetition of any learning outcome aims

<u>Algorithms and Data Structures</u>

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

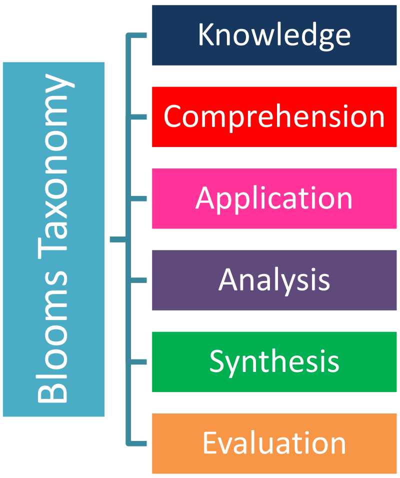


Figure 32: Algorithms and Data Structures - Bloom's Learning Stages Covered

- The module covers all six learning stages which makes sense for a second year module that spans both semesters.
- No repetition of any learning outcome aims

Database Management

- All learning outcomes could be classified by Bloom's Taxonomy

  The following learning stages are covered:

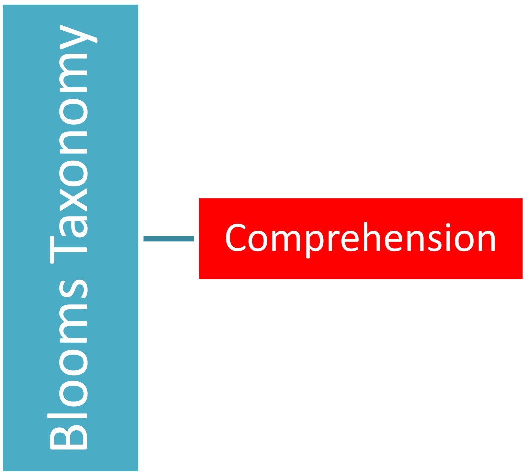


Figure 33: Database Management - Bloom's Learning Stages Covered

- The module only covers one learning stage comprehension which is at the lower end of the taxonomy. As a third year module with a specified pre-requisite module, Database systems it seems incorrect that only one stage of learning is expected. It may be the case that other learning stages are occurring but have not been explicitly stated, a review will be required to determine if this is the case.
- No repetition of any learning outcome aims

Graphics

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

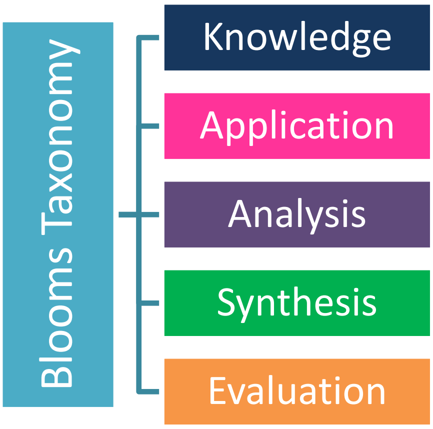


Figure 34: Graphics - Bloom's Learning Stages Covered

- The module covers all stages except for comprehension; this seems to make sense as the module builds upon previous years knowledge from its pre-requisite module Scientific Computing and Multimedia, however as it is based in a more specified field than the previous module it seems correct that it requires the lower stage of knowledge as well.

- The comprehension stage has been missed out which is unexpected considering it is a more specialised area and that the knowledge stage has been included. It should be reviewed to determine whether the comprehension stage is needed.
- No repetition of any learning outcome aims

Image Processing

The following learning outcomes could not be classified by Bloom’s Taxonomy:

Figure 35: Image Processing - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Image Processing	CM0311-01	Be *aware* of the applications of image processing and computer vision.	Aware	Educational resources classify it as a non-measurable verb
Image Processing	CM0311-02	An *appreciation* of the basic image manipulation techniques.	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

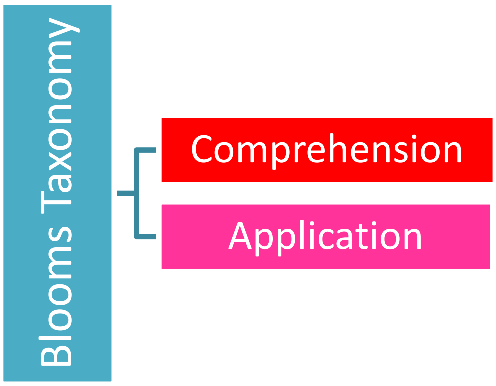


Figure 36: Image Processing - Bloom's Learning Stages Covered

- The module covers only the comprehension and application stage, which as a third year module with the pre-requisite of Scientific Computing and Multimedia seems right as it is building upon the knowledge gained from the previous year. Also as it is a more specialised field it may not cover enough content to reach the higher level learning.
- No repetition of any learning outcome aims

Artificial Intelligence 2

- All learning outcomes could be classified by Bloom’s Taxonomy

The following learning stages are covered:

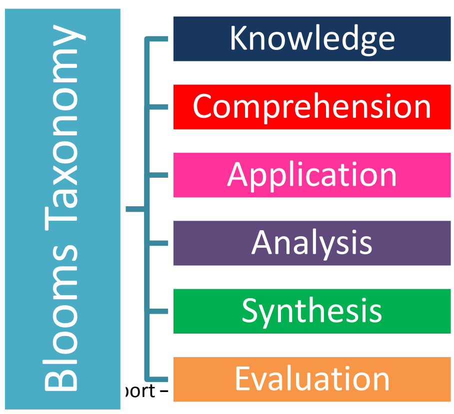


Figure 37: Artificial Intelligence 2 - Bloom's Learning Stages Covered

- The module covers all six learning stages which seems appropriate for a third year module. However, there are no specified pre-requisite modules and as it only spans one semester it could be that not all specified learning outcomes are achieved. It may be that general knowledge gained from the previous two years act as foundation for this module and the achievement of all learning stages. However it will need to be reviewed to determine if all the learning outcomes and stage are covered.
- No repetition of any learning outcome aims

Parallel Processing

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

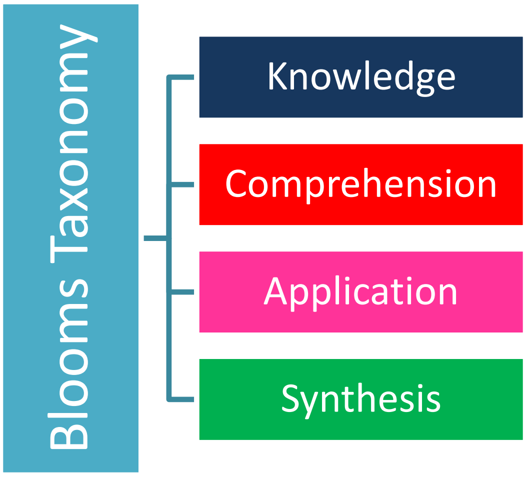


Figure 38: Parallel Processing - Bloom's Learning Stages Covered

- The module starts at knowledge and moves through to application, skips analysis and then finishes on synthesis. Similar to other subjects, while this has a stated pre-requisite module the area is more specialised therefore while previous knowledge will aid, it makes sense that it covers the lower stages of learning as well as higher ones. However, the analysis stage is missed out; it could be that it is covered in other learning outcomes and not been explicitly stated or it could be that it is not covered at all. A review will be needed to determine whether learning outcomes for analysis are included.
- No repetition of any learning outcome aims

Individual Project

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 39: Individual Project - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Individual Project	CM0343-01	*Undertake* a substantial project related to the student's degree programme.	Undertake	Educational resources classify it as a non-measurable verb
Individual Project	CM0343-04	*Exhibit* a sound knowledge in the subject area related to the project.	Exhibit	Verb is associated with the Affective Domain Taxonomy.

The following learning stages are covered:

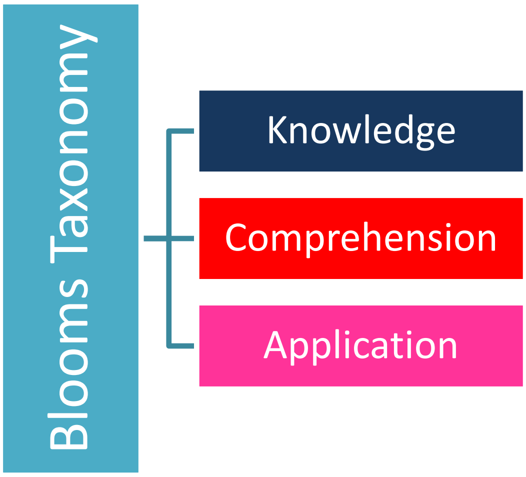


Figure 40: Individual Project - Bloom's Learning Stages Covered

- The module covers the first three stages of the learning taxonomy. As this module is worth 40 credits, spans both semesters of the third year and is the focus point of that year where students demonstrate the knowledge they have gained over the 3 years it should reflect all six learning stages. A review should be carried out on the learning outcomes.
- No repetition of any learning outcome aims

<u>Advanced Database Topics</u>

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

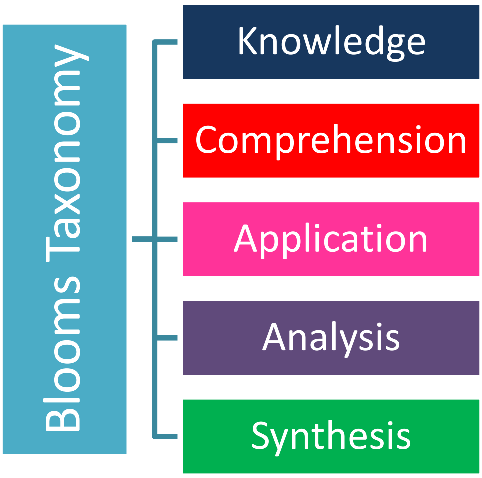


Figure 41: Advanced Database Topics - Bloom's Learning Stages Covered

- All stages bar the last stage, evaluation are covered in the module. As with other modules this makes sense as though it has a pre-requisite module – Database Systems, and the knowledge gained from this module will aid in the learning process , it is specifically looking at multiple different specialised fields within databases therefore not all stages can be fully covered. However, it can cover multiple levels because it is building upon previous knowledge.
- No repetition of any learning outcome aims

<u>Multimedia</u>

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 42: Multimedia - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Multimedia	CM0340-04	Possess an *<u>awareness</u>* of the underlying infrastructure of multimedia systems with relevance to the hardware and software components required.	Aware	Educational resources classify it as a non-measurable verb
Multimedia	CM0340-05	Possess a technical *<u>appreciation</u>* of core multimedia technologies and standards for Digital Audio, Graphics, Images and Video.	Appreciate	Verb is associated with the Affective Domain Taxonomy
Multimedia	CM0340-06	Show an understanding of the derivation from mathematical principles of underlying data compression algorithms. Possess an *<u>awareness</u>* of the underlying compression techniques utilised in common compression formats (e.g. JPEG, GIF, MPEG);	Aware	Educational resources classify it as a non-measurable verb
Multimedia	CM0340-07	Possess an *<u>awareness</u>* of applications of multimedia.	Aware	Educational resources classify it as a non-measurable verb

The following learning stages are covered:

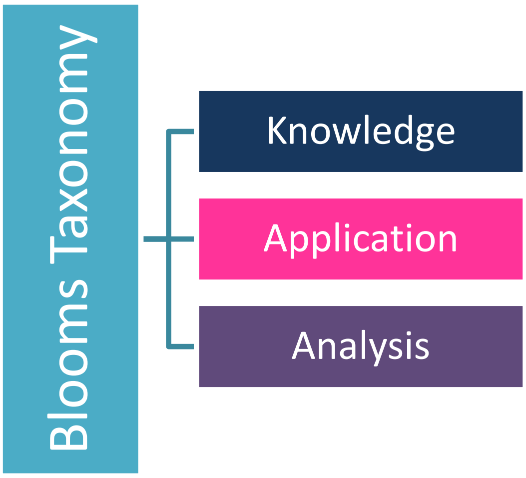


Figure 43: Multimedia - Bloom's Learning Stages Covered

- The module starts at the lowest stage knowledge and then jumps to application and analysis; missing out comprehension and later stages. This module has a pre-requisite module – Scientific Computing and Multimedia, therefore the learning outcomes associated with the knowledge stage could potentially overlap and repeat. However, this module is more specialised and therefore the learning outcomes for knowledge could refer to new concepts. Also the fact that no later stages are covered, when it does build upon previous knowledge may not be in line with what is occurring in the module.
- A review will need to be carried out to determine whether the knowledge stage learning outcomes refer to content that is repeated and unnecessary and also whether any later stages of learning are occurring and therefore need learning outcomes to be clearly stated.
- No repetition of any learning outcome aims; however there are several that could be spilt up into learning outcomes for clarity.

Information Systems Management

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 44: Information Systems Management - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Information System Management	CM0342-01	*Appreciate* how the structure of an organisation affects decision making, co-ordination and information sharing.	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

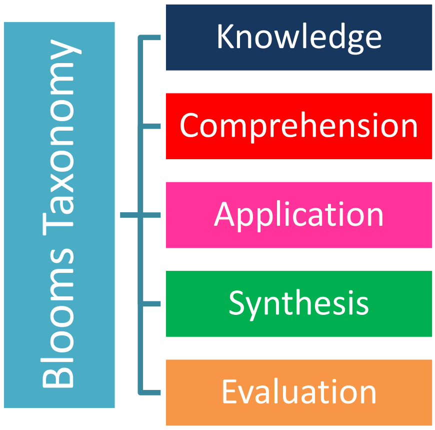


Figure 45: Information Systems Management - Bloom's Learning Stages Covered

- The module covers all six learning stages bar analysis. There are no pre-requisite modules associated with this one however it is a core module and is not a specialised field but deals with general Computer Science topic areas. Therefore knowledge can have been gained over the three years that aids this module. The only stage that is missing is analysis whether this is intended or not will need to be reviewed.
- No repetition of any learning outcome aims

Distributed Systems Technologies

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 46: Distributed Systems Technologies

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Distributed Systems Technologies	CM0356-01	*Knowledge* of state-of-the-art distributed-systems architectures.	Knowledge	Educational resources classify it as a non-measurable verb
Distributed Systems Technologies	CM0356-02	*Appreciation* for different middleware and their interworking.	Appreciate	Verb is associated with the Affective Domain Taxonomy
Distributed Systems Technologies	CM0356-03	*Knowledge* of common security practices within loosely-coupled distributed systems, authentication, transport etc.	Knowledge	Educational resources classify it as a non-measurable verb
Distributed Systems Technologies	CM0356-06	*Knowledge* of the "big picture" in relating distributed computing issues to other themes in computer science, such as performance, security, data structures, etc.	Knowledge	Educational resources classify it as a non-measurable verb

Distributed Systems Technologies	CM0356-07	*Knowledge* of standards in distributed computing, and the impact of standardisation on application programs.	Knowledge	Educational resources classify it as a non-measurable verb
Distributed Systems Technologies	CM0356-08	*Knowledge* of XML technologies, e.g. WSDL and SOAP.	Knowledge	Educational resources classify it as a non-measurable verb
Distributed Systems Technologies	CM0356-09	Fault tolerance in distributed systems	None	No verb associated with the learning outcome

The following learning stages are covered:

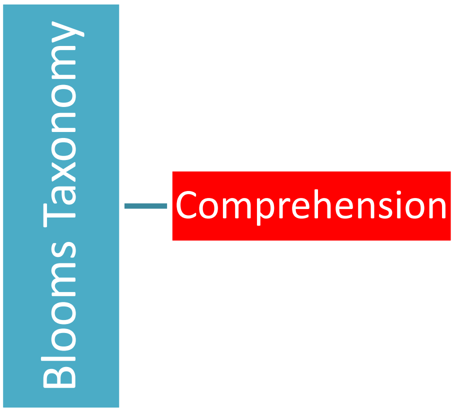


Figure 47: Distributed Systems Technologies - Bloom's Learning Stages Covered

- The only learning stage covered in this module is comprehension. Considering the module has a pre-requisite, Communication Networks and Pervasive Computing the lack of more learning stages seems to be incorrect. The reason for this may be because many of the stated learning outcomes failed to be classified under Blooms Taxonomy. A review will need to be carried out to determine if more learning stages are in fact covered.
- No repetition of any learning outcome aims

Mobile Communications and Meta Heuristics

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

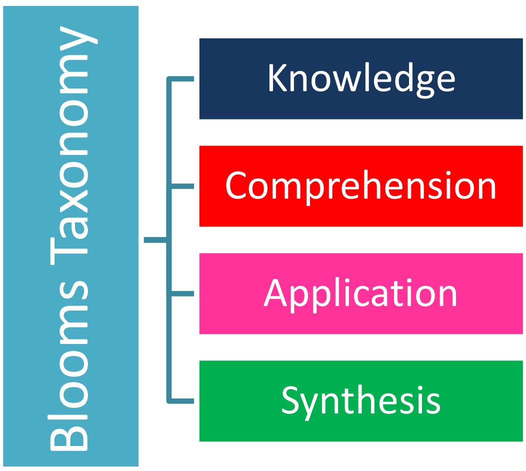


Figure 48: Mobile Communications and Meta Heuristics - Bloom's Learning Stages Covered

- This module starts at knowledge and then moves through to application skips analysis and then finishes at synthesis. While it is a third year module with a pre-requisite, Communication Networks and Pervasive Computing, it a specialised field and as such introduces new concepts and ideas; therefore coverage of the lower stages makes sense. However a review will need to be carried out to determine whether the analysis stage is needed or if any of the learning outcomes stated imply this stage.
- No repetition of any learning outcome aims

<u>Knowledge-Based Systems</u>

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 49: Knowledge-Based Systems - Learning Outcomes Not Covered

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Knowledge-Based Systems	CM0377-03	<u>*Appreciate*</u> the distinction between logical consequence and proof methods.	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

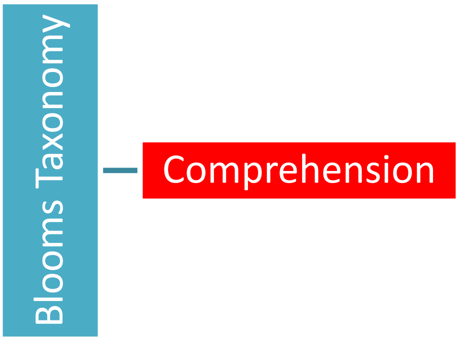


Figure 50: Knowledge-Based Systems - Bloom's Learning Stages Covered

- The module only covers the comprehension learning stage which for a third year module with a pre-requisite of Database Systems does not seem to be correct. Considering it is building on previous knowledge in some respects you would expect some later stages of learning to be occurring. It may be that the topic areas introduced are more specialised and therefore later learning is not expected, however a review will need to be carried out to determine if later stages of learning are required.
- No repetition of any learning outcome aims

<u>Knowledge Management</u>

- All learning outcomes could be classified by Bloom's Taxonomy

The following learning stages are covered:

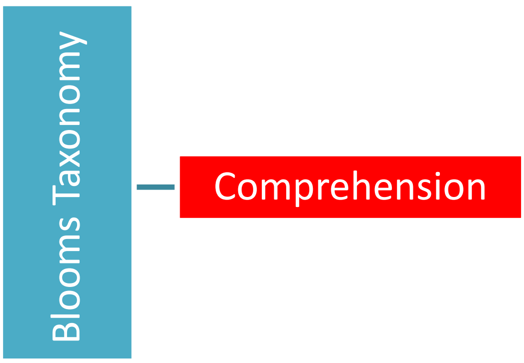


Figure 51: Knowledge Management - Bloom's Learning Stages Covered

- The only learning stage covered in the module is comprehension; which considering it is a third year module with two pre-requisite modules from both first and second year it does not make sense that more learning stages are not covered, especially later stages of learning that would build upon the previous knowledge. A review will need to take place to determine whether more learning stages are occurring within the module.
- No repetition of any learning outcome aims

IS Research Techniques

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 52: IS Research Techniques - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
IS Research Techniques	CM0388-03	*Appreciate* and compare a variety of IS research methodologies, and choose appropriate methodology relevant to the research issue or topic.	Appreciate	Verb is associated with the Affective Domain Taxonomy

The following learning stages are covered:

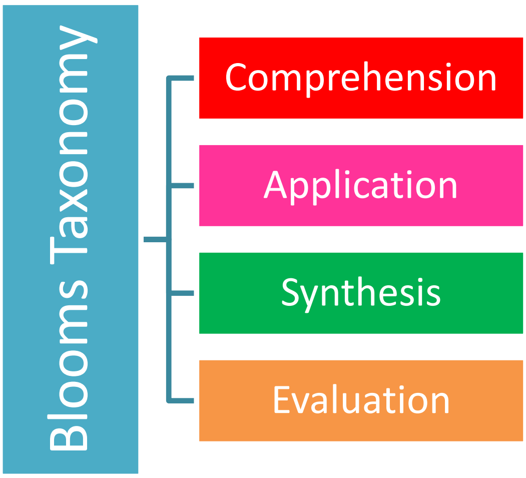


Figure 53: IS Research Techniques - Bloom's Learning Stages Covered

- The module covers all stages bar knowledge and analysis, considering the module is centred around more general skills rather than subject specific, students could already have knowledge that they can use as a basis for this module. However the analysis stage is also missed out which could be because the learning is implied within other learning outcomes or that it is not required.
- A review will be needed to determine whether learning outcomes are needed for the analysis stage.
- No repetition of any learning outcome aims

Computer Forensics

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 54: Computer Forensics - Learning Outcomes Not Classified

Module Title	MNumber	Learning Outcome	Selected Verb	Conclusion
Computer Forensics	CM0390-01	Evaluate the principles of computer forensic analysis and *appreciate* where and how these principles should be applied.	Appreciate	Verb is associated with the Affective Domain Taxonomy
Computer Forensics	CM0390-03	Evaluate the legal and procedural issues and be *aware* of the documentary and evidentiary standards expected in presenting investigative findings in a court of law.	Aware	Educational resources classify it as a non-measurable verb
Computer Forensics	CM0390-05	*Knowledge* and understanding of file structures both in a Linux environment and Windows, disk structures, use of a range of forensic tools and techniques.	Knowledge	Educational resources classify it as a non-measurable verb
Computer Forensics	CM0390-06	Rules of evidence.	None	No verb associated with the learning outcome
Computer Forensics	CM0390-07	Security logging and pattern matching for detection.	None	No verb associated with the learning outcome
Computer Forensics	CM0390-08	The link between technology and business processes in the context of gathering evidence.	None	No verb associated with the learning outcome
Computer Forensics	CM0390-09	The investigator's duty to the courts.	None	No verb associated with the learning outcome

The following learning stages are covered:

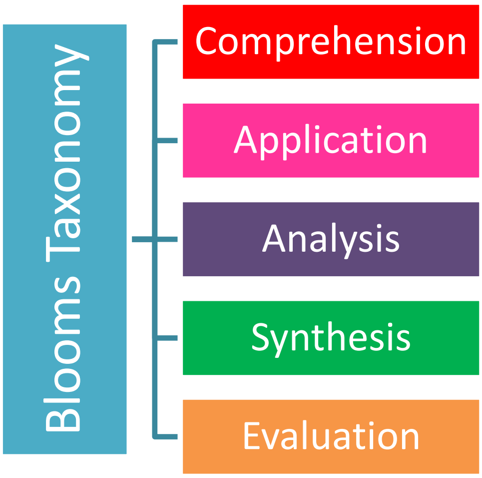


Figure 55: Computer Forensics - Bloom's Learning Stages Covered

- All stages bar the knowledge stage are covered in this module. Considering this is a specialised subject area that has not been covered at any other point in the course you would expect to find learning outcomes that are associated with the knowledge stage. The reason this stage may not have been covered is due to the fact that several of the learning outcomes could not be classified by Bloom's Taxonomy. However a review will need to be made to address this.
- No repetition of any learning outcome aims

3.6.2. Year

Once each individual modules taxonomy was analysed a taxonomy for each year was constructed which stated the modules within that year and then for each module which of the six learning stages were covered within it. These were used to determine what the overall pattern of learning was within a year and whether the learning stages that were covered changed from year to year (i.e. knowledge was built upon). All the taxonomies referred to within this section can be found in Appendix 8.

Year 1

The overall impression from the first year modules was that the general learning path ran from comprehension to synthesis covering more or less all of the learning stages with very little coverage of evaluation. This makes sense as it is about students at this stage grasping concepts and learning how to apply them, evaluation comes later with more competence. The lack of learning outcomes that related to the knowledge stage however does not reflect what would be expected, especially when most of the modules state that no previous knowledge is required.

Year 2

Again, similar to the first year pattern, the second year modules run from knowledge to synthesis with a few more modules also covering evaluation. The modules that include the evaluation stage are in subject areas that build upon knowledge that has been gained from previous years, and while it may not be a specific link between the two modules it aids the learning process (i.e. the Systems Design and Group Project module is similar to the Developing Quality Software module from year 1; students can therefore have acquired knowledge and skills for this year 1 module that can be applied to the year 2 module, however it has not been stated as any pre-requisite module and there is no specific link between the two modules)

The other point of interest from this is that the knowledge stage is stated in a lot more modules in year 2 than it is in year 1. The majority of the modules that include this learning stage are modules that introduce a new subject area so it therefore makes sense that they should cover the knowledge stage. However it is worth noting that this is what should be happening in the year 1 modules too.

Year 3

In this year a lot of the modules are optional which provides learning in specialised areas of computer science, as such many of the modules in this year deal solely with the lower stages of learning such as knowledge, comprehension and application. This is understandable as students are unlikely to have covered these areas before. A couple of the modules build through all of the six stages which is perhaps due to them having pre-requisite modules associated with them and so building upon previous knowledge.

Another observation is that several modules have learning outcomes that are just associated with the comprehension stage. While these are specialised subject areas you would expect to see learning outcomes that cover more than one stage especially for modules in the third year.

Overall there is no obvious trend that can be observed where knowledge is built on from year to year (i.e. Year 1 modules focus on the Knowledge and Comprehension stages of learning, Year 2 on Application and Analysis and Year 3 on Synthesis and Evaluation). This is perhaps due to new subject areas being introduced each year instead of one specific area being built and expanded on through the three years. In this way students are not building upon previous years knowledge but learning about a broad range of subject areas, hence why learning is focused on the lower stages of learning across all three years.

Due to this observation the initial plan of mapping the different learning that occurs if different optional modules are taken has not been done because students are learning about a broad range of topics and subject areas rather than picking a specific path of learning. It is doubtful that anything would be discovered if the optional module paths were mapped.

3.6.3. Pre-requisite Modules

Another way in which modules relate to one another is through the specification of pre-requisite modules; that is, modules which are required to have been studied before you can study another module. These modules are used as a way of ensuring a basic level of knowledge and understanding in key concepts before the start of the new module. The relationship between these modules is therefore being assessed to determine if there is an obvious building upon knowledge and learning that can be found and also to double check that the learning outcomes between these modules do not overlap in any way.

Database Management – Database Systems

Figure 56: Pre-requisite Module Comparison Table - Database Management and Database Systems

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Database Management	3		✓					None
Database Systems	2	✓	✓	✓		✓		None

- No apparent link between the two modules and the idea of building upon learning. Possible that the knowledge gained from the pre-requisite module aids but is not explicitly required for understanding the course content.
- No overlapping of learning outcomes was found between the two modules

Graphics – Scientific Computing and Multimedia Applications

Figure 57: Pre-requisite Module Comparison Table - Graphics and Scientific Computing and Multimedia Applications

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Graphics	3	✓		✓	✓	✓	✓	None
Scientific Computing and Multimedia Applications	2	✓	✓	✓				None

- A link can be observed between the two modules where the graphics module appears to build upon learning from the other module – year 2 module covering lower stages of learning, year 3 module covering higher stages of learning.
- No overlapping of learning outcomes was found between the two modules

Image Processing – Scientific Computing and Multimedia Applications

Figure 58: Pre-requisite Module Comparison Table - Image Processing and Scientific Computing and Multimedia Applications

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Image Processing	3		✓	✓				None
Scientific Computing and Multimedia Applications	2	✓	✓	✓				None

- A potential link can be observed between the two modules where the Image Processing module builds upon learning from the Scientific Computing and Multimedia Applications module.
- No overlapping of learning outcomes was found between the two modules

Parallel Processing – Algorithms and Data Structures

Figure 59: Pre-requisite Module Comparison Table - Parallel Processing and Algorithms and Data Structures

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Parallel Processing	3	✓	✓	✓		✓		None
Algorithms and Data Structures	2	✓	✓	✓	✓	✓	✓	None

- No apparent link between the two modules and the idea of building upon learning. Possible that the knowledge gained from the pre-requisite module aids but is not explicitly required for understanding the course content.
- No overlapping of learning outcomes was found between the two modules

Advanced Database Topics – Database Systems

Figure 60: Pre-requisite Module Comparison Table - Advanced Database Topics and Database Systems

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Advanced Database Topics9	3	✓	✓	✓	✓	✓		None
Database Systems	2	✓	✓	✓		✓		None

- No apparent link between the two modules and the idea of building upon learning. Possible that the knowledge gained from the pre-requisite module aids but is not explicitly required for understanding the course content.
- No overlapping of learning outcomes was found between the two modules

Multimedia – Scientific Computing and Multimedia Applications

Figure 61: Pre-requisite Module Comparison Table - Multimedia and Scientific Computing and Multimedia Applications

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Multimedia	3	✓		✓	✓			None
Scientific Computing and Multimedia Applications	2	✓	✓	✓				None

- Potential link between the Multimedia module and the Scientific Computing and Multimedia Applications modules with building on learning.
- No overlapping of learning outcomes was found between the two module

Distributed Systems Technologies – Communication Networks and Pervasive Computing

Figure 62: Pre-requisite Module Comparison Table - Distributed Systems Technologies and Communication Networks and Pervasive Computing

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Distributed Systems Technologies			✓					None
Communication Networks and Pervasive Computing	2	✓	✓	✓	✓			None

- No apparent link between the two modules and the idea of building upon knowledge. Possible that the knowledge gained from the pre-requisite module aids but is not explicitly required for understanding the course content.
- No overlapping of learning outcomes was found between the two modules

Mobile Communications & Meta Heuristics – Communication Networks & Pervasive Computing

Figure 63: Pre-requisite Module Comparison Table - Mobile Communications and Meta Heuristics and Communication Networks and Pervasive Computing

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Mobile Communications and Meta Heuristics	3	✓	✓	✓		✓		None
Communication Networks and Pervasive Computing	2	✓	✓	✓	✓			Nones

- Possibly a link between the Mobile Communication and Meta Heuristics module and the year 2 module of building on learning.
- No overlapping of learning outcomes was found between the two modules

Knowledge Based Systems – Database Systems

Figure 64: Pre-requisite Module Comparison Table Knowledge Based Systems and Database Systems

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Knowledge Based Systems	3		✓					None
Database Systems	2	✓	✓	✓		✓		None

- No apparent link between the two modules and the idea of building upon knowledge. Possible that the knowledge gained from the pre-requisite module aids but is not explicitly required for understanding the course content.
- No overlapping of learning outcomes was found between the two modules

Knowledge Management – Database Systems & Web Applications

Figure 65: Pre-requisite Module Comparison Table - Knowledge Management, Database Systems and Web Applications

Module	Year	Kno	Com	App	An	Sy	Eva	Overlapping Learning Outcome
Knowledge Management	3		✓					None
Database Systems	2	✓	✓	✓		✓		None
Web Applications	1		✓	✓		✓		None

- No apparent link between the three modules and the idea of building upon knowledge. Possible that the knowledge gained from the pre-requisite module aids but is not explicitly required for understanding the course content.
- No overlapping of learning outcomes was found between the three modules

3.6.4. Programme

The programme learning outcomes have been split up into the four categories of learning that the school has determined and a taxonomy was produced for each one. Each of these taxonomies were analysed to find where learning outcomes could not be classified, if there was overlap between any learning outcomes, what were the learning categories that where covered by each of these four areas and if all six stages of Bloom's Taxonomy were covered. All taxonomies referred to here can be found in Appendix 9.

Knowledge and Understanding

- All the learning outcomes could be classified by Bloom's Taxonomy

The learning stages that are covered for this category are as follows:

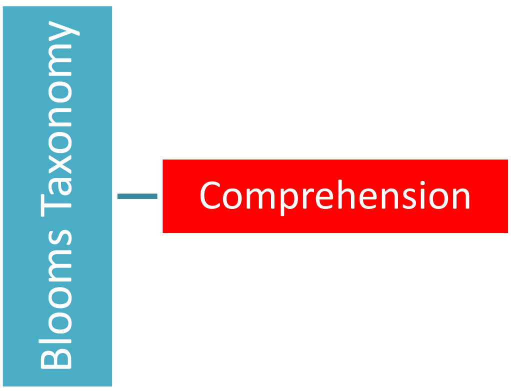


Figure 66: Programme: Knowledge and Understanding - Bloom's Learning Stages Covered

- This seems to fit with the title of the learning category and it makes sense that modules should cover the lower stages of learning in their course content, especially when no prior knowledge is required. Perhaps the knowledge stage should be included in this section as well.
- No repetition of learning outcome aims

Discipline Specific including Practical Skills

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 67: Programme: Discipline Specific including Practical Skills - Learning Outcomes Not Classified

Programme	PNumber	Learning Outcome	Verb	Conclusion
Programme Outcomes	G400-13	*Recognise* and specify the constraints, requirements and trade-offs in the design of computer systems	Recognise	Educational resources classify it as a non-measurable verb

The learning stages that are covered for this category are as follows:

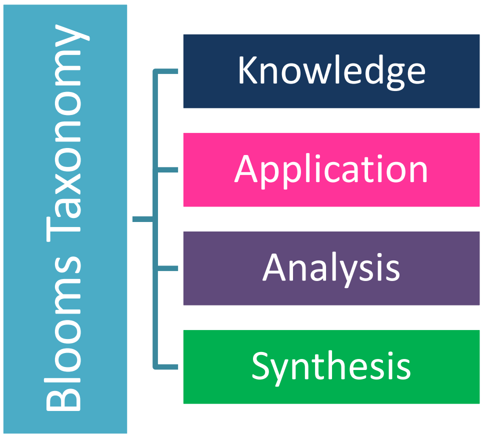


Figure 68: Programme: Discipline Specific including Practical Skills - Bloom's Learning Stages Covered

- These all seem to fit with what you would expect for this category as they deal with the application and synthesis stages which are often centred around practical skills. The knowledge stage is also covered within this area which was missing from the above category.
- No repetition of learning outcome aims

Intellectual Skills

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 69: Programme: Intellectual Skills - Learning Outcomes Not Classified

Programme	PNumber	Learning Outcome	Verb	Conclusion
Programme Outcomes	G400-09	*Sustain* a critical argument, both in writing and through presentation.	Sustain	Educational resources classify it as a non-measurable verb

The learning stages that are covered for this category are as follows:

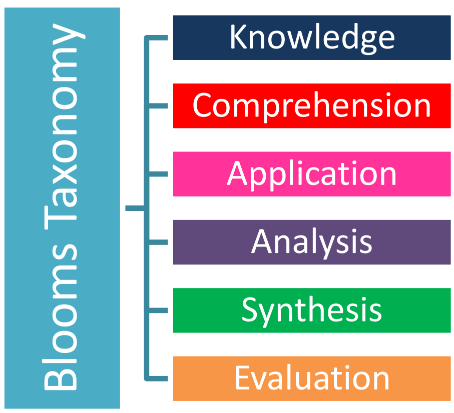


Figure 70: Programme: Intellectual Skills - Bloom's Learning Stages Covered

- This category covers all six stages of Bloom's which fits with the category description as for Intellectual skills you would expect higher levels of learning to occur but you also need the foundations of knowledge to be covered so you can build up to these
- No repetition of learning outcome aims

Transferable Skills

The following learning outcomes could not be classified by Bloom's Taxonomy:

Figure 71: Programme: Transferable Skills - Learning Outcomes Not Classified

Programme	PNumber	Learning Outcome	Verb	Conclusion
Programme Outcomes	G400-16	*Work* effectively in a team and as an individual	Work	Verb is associated with the Affective Domain Taxonomy.
Programme Outcomes	G400-18	*Appreciate* opportunities for career development and lifelong learning by participating in the University's Personal and Career Development Programme	Appreciate	Verb is associated with the Affective Domain Taxonomy.
Programme Outcomes	G400-18	Appreciate opportunities for career development and lifelong learning by *participating* in the University's Personal and Career Development Programme	Participate	Verb is associated with the Affective Domain Taxonomy.
Programme Outcomes	G400-20	*Undertake* independent study.	Undertake	Educational resources classify it as a non-measurable verb

The learning stages that are covered for this category are as follows:

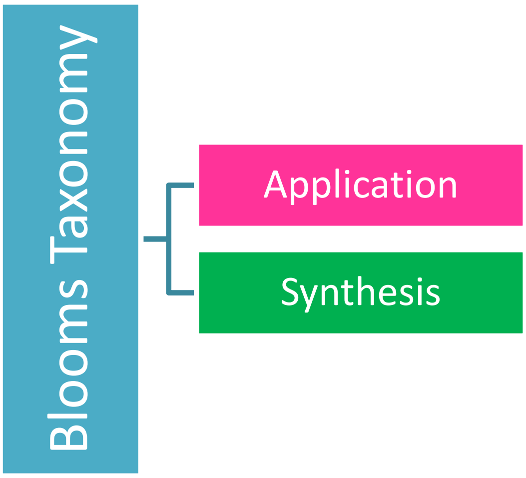


Figure 72: Programme: Transferable Skills - Bloom's Learning Stages Covered

- Only application and synthesis are covered by this category, this is perhaps due to many of the learning outcomes not being able to be classified by Bloom's Taxonomy. However the learning stages that are covered again fit with the definition for the category as you would expect transferable skills to focus more around with middle stages as these tend to be the more practical skills.
- No repetition of learning outcome aims

Overall the programme learning outcomes and the categories seem to appropriately reflect the learning required and cover all six of Bloom's stages.

3.6.5. Conclusions of the Analysis

Overall, the majority of modules appear to cover a significant range of learning stages that appropriately reflect the expected learning of the student. However, there are gaps within modules were expected learning outcomes have not been included to reflect certain expected stages of learning. In some cases this may have been because several of the learning outcomes stated for the module could not be classified under Bloom's Taxonomy, in others it may also be the case that the learning is occurring within the module but learning outcomes have not been specifically stated to reflect this. In the former case the learning outcomes that could not be classified should be reviewed by the module leader and updated to reflect the appropriate learning stage for that learning outcome and the module. In the latter case, learning outcomes should be created to include this learning stage.

As observed from the year taxonomies analysis there is no obvious building upon of knowledge year on year that you would perhaps expect. However the main reason for this seems to be that a broad range of subject areas are covered over the three years which do not specifically build upon previous years modules. However, as observed by the pre-requisite analysis where there have been specific links between modules there is no definite pattern observed of knowledge being built upon. In several cases, this is because while the modules do cover the same subject area the latter modules are in more specialised fields, therefore the pre-requisite module's knowledge is required to form a base for the student as knew concepts and ideas are introduced that require lower learning stages to be covered as well.

However, there have been instances where modules with pre-requisites do relate to the same subject field with no specific specialism but there has been no observable building upon of knowledge between them. It has been noted in these instances that the latter module has failed to have learning outcomes that cover several learning stages, instead just focusing on the one stage. In these cases it has been recommended that a review take place to determine whether only one learning stage is all that is required or if the learning outcomes should be updated to reflect several learning stages.

The analysis of the programme learning outcomes determined that they do cover all of Bloom's learning stages and that the way the school has spilt them up into four distinct categories best reflects the learning stages you would expect to find within that category. Overall they seem appropriate programme learning outcomes for the Computer Science degree programme and reflect what the required overall learning of the student is.

3.6.6. Overall Taxonomy

One of the main aims of the project was to produce an overall taxonomy that would both highlight the different stages of learning as indicated by Bloom's Taxonomy and be more specific to the Computer Science Degree programme. While throughout the analysis it has be easier and clearer to break down the overview into both module specific taxonomies and a year taxonomies, an overall taxonomy would potentially help with the creation and review of learning outcomes as it would provide a quick overview of all the learning outcomes and how they are classified according to the learning stages. This would then allow lecturers to determine where they feel specific learning fits best and how that complements other learning at that level and across the module.

This overarching taxonomy was developed so that at the higher level you had each of the six stages of Bloom's Taxonomy, next would be all the verbs that had been reclassified and made unique to one learning stage as outlined in Section 4.3 Mapping to Blooms Taxonomy. After these then the objects that each learning outcome was made up of would link to the verb that classified it. The taxonomy could develop further to link the object to the actual learning outcome, however, it was clearer and easier to read when cut off was at the object level. The taxonomy can be found in Appendix 10b as a table, and a sample diagram can be seen in Appendix 10a.A full diagram of the taxonomy was not developed due to the volume of verbs and objects; however the sample demonstrates the main idea of the taxonomy.

While analysis has been conducted into the programme learning outcomes it was decided not to include these within this overall taxonomy as they are more general ones describing all the aspects the Computer Degree Scheme should cover. It had been thought that another taxonomy could be produced that would classify each module into the learning category area it seemed to best fit, however on further analysis it was determined that each module contained a mixture of each of the four programme categories learning outcomes and therefore could not be just placed into one category. In the end it has been decided to keep the two sets of learning outcomes separate as while the programme learning outcomes form the hierarchy of the Computer Science degree programme they cannot be specifically mapped to modules, they are too general. However it is informative to know that the programme learning outcomes do conform to Blooms Taxonomy and set the standard for modules.

4. Student Feedback Analysis

This section details the analysis of all student data and from the findings makes some generalised conclusions.

4.1. NVivo

Once all the student feedback data had been collected the biggest question was how to analyse this data in order to find common patterns, ideas and themes. While the data collected from the surveys was mostly quantitative data - which could be easily analysed, the focus groups posed more of challenge as it was all qualitative. It was also important to find the relationships between the two sets of data and where ideas or themes back each other up or where there were differences. After discussions with my supervisor, it was decided that NVivo would be used to help me organise and analyse the data and find those links and relationships.

“NVivo is software that supports qualitative and mixed methods research. It lets you collect, organise and analyse content from interviews, focus group discussions, surveys and audio.” (QSR International, 2012) It allows you to deeply analyse data using search, querying and visualisation tools, while annotating as you go along for easier more effective analysis (QSR International, 2012).

A new project was set up for the Student Feedback analysis, and all the data collected was uploaded into the project – transcripts from the focus groups, data sets from the surveys and also individual word documents containing each modules learning outcomes which could then be linked to from the student feedback data (see Figures a, b, c and d in Appendix 11). Once all the data had been uploaded analysis could be carried out linking all the different sources together in one place.

4.2. Module Feedback Analysis

Feedback on modules was gathered in two ways; through focus groups that promoted general discussion about modules and the associated learning outcomes and through the use of a survey which got students to rate each learning outcome according to different criteria.

As discussed in the Interim report the focus groups were carried out in the autumn semester and transcripts were made from each of the sessions (see Appendix 12). The biggest problem with the focus group data was that there was not enough of it; it was hard to get students to participate and when they did, time constraints meant that not all of them could be in a session with other people. This therefore meant that some of the focus groups were held more as interviews, which was not what was intended as they failed to provide much detailed insight. Despite these challenges, there were some conclusions that could be drawn. The spring semester was then about analysing the transcripts along with the surveys to find any universal themes or patterns within the data.

The survey that was designed at the end of autumn semester and mentioned in the interim report evolved from the original question design to one were the questions would gain more insight and understanding from the students (see Figures a, b and c in Appendix 13). This was partially through experience from the focus groups and the data received from those and through discussions with my supervisor about the best way to structure and convey the questions.

Once the survey had been created it was sent out around week 3 of spring semester and was left open till week 8 for students to fill in. Promotion of the survey was done through posting in Facebook groups and sending emails around (see Figure d and e in Appendix 13). The response rate, 43 students, was not as high as was expected, and there was not feedback given for all modules. However, while a larger data set could have provided greater insight, the data that was collected still proved to be informative.

The biggest challenge with this data was that due to the multiple different questions which were asked for each individual module, the data set was too large to be stored in a Google Docs spreadsheet. At first this, seemed to mean that the data gathered could only be viewed at the Summary page (see Figure f in Appendix 13); however it was later discovered that it could be downloaded as an Excel file. This file still had to be broken down though when importing into NVivo, as it was too big for that software as well. It was therefore separated out by year and each year’s data set was individually imported (see Figure g in Appendix 13).

While the data from the surveys was fairly easy to analyse as it was all quantitative the focus groups were a lot harder as they consisted of qualitative data where students discussed at length the pros and cons of the module and the learning outcomes associated with it. NVivo helped by allowing key points to be highlighted and coded under specific different nodes so that all points related to an area could be viewed in one place which made it easier to pick out relationships and themes.

More work perhaps could have gone into the analysis of the student data as even though there were not a lot of responses the feedback was rather detailed. However due to time constraints and being unfamiliar with the software being used this was not possible. However, the results that were gathered have been summarised and are displayed in Appendix 14. Only results where more than one student commented on the module have been included as it was felt that generalisations cannot be made about a module from just one person’s opinion.

The overall feedback from students was positive, with them recognising the importance of the modules and there context within the Computer Science degree programme. The majority of learning outcomes for modules were considered to be understandable, covered, relevant and achievable. There were obviously a few instances where this was not the case and these have been highlighted in the summary and then detailed below. The focus groups proved to be useful in providing extra comments and details about the degree programmes and the main aspects that the students liked or disliked.

Overall, while the feedback that was received was interesting and provided some key insights into the modules due to the low rate of return for the surveys and lack of participants for the focus groups it is hard to generalise too much from this data. It acts more as general feedback for the module than being of any real material value for this project. More data would need to be collected before it could be really useful (see Section 7).

4.3. Opinions on Learning Outcomes Analysis

Originally, there had been only one survey design which contained both specific questions about individual modules and some more general ones about the use of learning outcomes by the students. However, this made for one very big survey so following the advice of my supervisor the original survey was spilt into two; one gathering all the data about specific modules and the other a smaller survey gaining some insight into learning outcomes as a general topic.

The structure and design of this survey was very simple, asking only 3 questions which students could simply tick boxes for (see Figure h in Appendix 13). The power in this was discovering what the overall opinion of learning outcomes is among students and the general use, if any, that the student has for them. Through this steps could be recommended to ensure that learning outcomes are then available and tailored for the way students use them.

Again the response rate for this survey was only 46 students, which is disappointing, especially considering that it took less than a minute to complete. However, the data can certainly start to highlight the trends that occur amongst students and determine the best course of action for the display and use of learning outcomes.

The advantage of this survey was that it was only small so it could be both easily stored within a Google Docs spreadsheet and then later imported into Nvivo for analysis.

Most of the data from this survey was fairly self-explanatory and trends could be picked out easily from analysis. The three questions asked centred around whether students actively used Learning Outcomes, were they had seen them displayed and what they thought the main uses of learning outcomes were; Appendix 15 displays the results from this.

The main points of interest from the results showed that while students are aware of learning outcomes, can identify what they are and where to go to find them, the majority of them fail to understand their true benefit and do not utilise these when studying or revising. The majority of students indicated that the main benefit of learning outcomes was in introducing them to what they were going to learn, however the next highest ranked benefit was in helping students to monitor their progress. Only one student stated that there were no benefits to be gained from learning outcomes.

Overall, it is clear that students are aware of learning outcomes and recognise the benefits they can provide; however the majority fail to utilise these when studying. The benefits of learning outcomes should be more clearly promoted and emphasis made on how understanding and appreciating learning outcomes can improve students overall awareness of the learning process.

5. Results of Learning Outcome Analysis

The main objective of this project was to determine what learning was occurring within modules and across all three years and from this to provide suggestions for improvement to module learning outcomes. Sections 4 and 5 of this report have detailed the different analysis stages that have occurred and summarised the conclusions; from these 5 main points have been raised:

Revised Blooms Taxonomy

As highlighted in section 4.4 one of the main difficulties first encountered was that there were many discrepancies between different educational institute's versions of Bloom's Taxonomy. Different versions would classify verbs at different stages or classify them under multiple different stages. This leads to confusion as to which stage a learning outcome intends for the student to be able to achieve. It was decided that to simplify matters each verb would belong to one category in order to fully understand and determine what the intended learning stage is when classifying learning outcomes.

As an aid for this project therefore a revised version of Bloom's Taxonomy was created which classified each verb only once, this helped to produce clearer module taxonomies and determine the learning path that was occurring within each module.

This taxonomy can also prove useful for future reference when reviewing or creating new learning outcomes as it will provide a uniform template for lecturers to follow. The revised taxonomy can be seen in Appendix 3.

Table of Unclassified Learning Outcomes

When conducting the module analysis it was found that many of the learning outcomes associated with modules were unable to be classified under Bloom's Taxonomy. This was found to be because of one of three main reasons:

- That the verb is actually used to reference the Affective Domain's Taxonomy (see Section 2 and 7 for more information) which does not mean that the learning outcome is incorrect, just that it is referring to a different kind of learning.
- That the verb was not measurable. This is where the verb is felt to be too vague for determining what learning level should be for students.
- There is no verb in the learning outcome. This is not a learning outcome therefore but more a statement; a verb will need to be added to the statement to determine what the required learning level is to be – the previous table can help with this.

In order to be affective for students, these learning outcomes - except for the ones associated with the Affective Domain, need to be rewritten to align them with the standard format of a Bloom's classifiable learning outcome. The complete list of unclassified learning outcomes can be seen in Appendix 16.

Learning Stages missed within Modules

Bloom et al. (1956, p16) stated that the learning process that occurs within the Cognitive Domain is one that moves from the simple to the complex; that students learn by building upon their knowledge through all six of the learning stages. When analysing the modules the different learning stages that were covered within a module where mapped out to clearly show how the learning was progressing, what the starting and ending point was and whether it was building on any previously defined knowledge. It was noted that several modules either skipped a stage or started/ended at a stage that was not expected.

It is worth noting that where learning stages have been missed for modules that even if the content is taught the learning outcomes should still be stated as that is their purpose and they act as guidelines for understanding expected learning behaviours.

It may be that in the cases of some modules the learning expected was stated but in a Bloom's unclassifiable way. If this is the case then the learning outcome should be rewritten so that a complete picture can be seen. This could explain why some of the modules covered so few learning stages.

The modules where it is thought learning stages have been missed should be reviewed by the module leader to determine whether the learning stage is covered already but not stated or if they learning stage is required. Learning outcomes for a module should be reviewed each year to determine their appropriateness and whether they still reflect the correct learning path. Appendix 17 contains a complete list of the modules with learning stages missing as well as which stage(s) are thought to be missing.

<u>Overlapping Learning Outcomes</u>

Another important area surrounding modules and their learning outcomes is to determine whether expected results of learning overlap between modules as this could indicate that there is undesired repetition of learning and course content within modules. This was specifically looked at between modules which had stated pre-requisite requirements as often these modules expand or extend upon what has been taught previously. While some repetition of content can be positive as it helps cement knowledge, if content is repeated too much between these modules it can have negative effects as well. However, analysis of these pre-requisite modules found no overlap between the learning outcomes that were stated; this does not mean it does not occur simply that the specified learning outcomes address different areas. To truly determine if overlap was occurring within these modules analysis of the course material would have to be carried out but this is beyond the scope of this project.

As well as overlap between learning outcomes of different modules each module was individually analysed to determine if there was overlap between learning outcomes that were stated within that module. Again there were no major issues found however a couple of learning outcomes for modules were highlighted as having potential problems. The table below lists these and the issue:

Figure 73: Overlapping Learning Outcomes

Module	Learning Outcome 1	Learning Outcome 2	Issue
Profession Skills	Effectively use a variety of tools for professional communication including presentation	Select an appropriate style, mode and method of communicating information to different audiences	Fairly similar learning outcomes could perhaps be incorporated into one
Multimedia	Show an understanding of the derivation from mathematical principles of underlying data compression algorithms. Possess an awareness of the underlying compression techniques utilised in common compression formats (e.g. JPEG, GIF, MPEG);;	N/A	No overlapping learning outcomes but this could be split down into two separate learning outcomes for clarity.

In these instances it is recommended that the module leader review the specific learning outcomes to determine whether they should remain as they are or be revised.

Table of Unclassified Programme Learning Outcomes

Similar to the above section for module learning outcomes it was discovered that not all of the programme learning outcomes could be classified under Blooms Taxonomy. Again this was found to be because of one of two reasons:

- That the verb is actually used to reference the Affective Domain's Taxonomy (see Section 2 and 7 for more information) which does not mean that the learning outcome is incorrect, just that it is referring to a different kind of learning.
- That the verb was not measurable. This is where the verb is felt to be too vague for determining what learning level should be for students.

While these learning outcomes are not used by students as guidelines for their study they do determine the overall learning for the course and therefore should be reflective of the learning stages. Appendix 16 contains the complete list of unclassified Programme Learning Outcomes.

6. Future Work

Moving forward from this project there are three distinct areas that can be of further interest. Firstly conducting learning outcome analysis for all of the other degree programmes within the School of Computer Science & Informatics, secondly to conduct further research into the two other areas of learning that Bloom proposed – the Affective Domain and the Psychomotor Domain; and lastly to further develop the student research area so that it is more comprehensive.

As has been shown within this project, research and analysis of the learning outcomes for the Computer Science degree scheme highlighted where learning outcomes were not being fully articulated, failed to be written properly, contrasted with what was actually being taught and above all highlighted the learning path and stages that were occurring over the 3 years of study. It proved to be a useful study into how these can be improved and from it resources were developed that could aid in the future development of learning outcomes.

This study only focused on the modules and programme learning outcomes that were associated with the Computer Science degree scheme, and while there are several cross over modules, other degree schemes have their own modules. It could therefore prove interesting and informative to carry out similar research and analysis on the learning outcomes associated with each of the other degree schemes offered by the School of Computer Science & Informatics.

In doing this a complete picture can be produced of all the learning that occurs within the school. It can highlight all the different areas of learning; map the learning pathways for each degree scheme – showing the different pathways according to optional modules and crossover between different degrees, as well as show how the degree schemes interlink. This will allow students to be better informed when choosing optional modules, understand more fully what the expected learning for each module will be and how that relates to previous years or other modules within the same year, and will highlight to potential employers what the students are expected to understand and know at the end of the degree.

It can also be useful for staff as a way of better assessing what the overall learning on a degree scheme will be, whether two modules overlap in their content and expected learning too much and also whether learning is being built upon correctly i.e. from simple to complex – that a year two module which expects analysis, synthesis and evaluation of material has corresponding modules in first year that develop the knowledge, comprehension and application stages first. It can in this way act as a tool for yearly reviews, to ensure that all learning outcomes are relevant, updated and accurate.

As well as extending the analysis to other degree schemes, another area of interest is in ensuring complete coverage and understanding of all three of the areas of learning – Cognitive, Affective and Psychomotor. While this research project has focused on the Cognitive Domain as it is the most developed and readily utilised taxonomy, the two other areas shed a different light on learning behaviours.

As mentioned in Section 2 the Affective Domain focuses on the emotional learning of an individual and learning outcomes centre around the growth and awareness of attitudes, emotions and feelings which can have a huge impact on learning. It was found in the project that several of the learning outcomes that had been stated for modules were in fact associated with the Affective Domain (see Section 4.6 for more information).

The Psychomotor Domain focuses on the motor skill area and how learning can occur through physical movement and coordination.

Both of these areas could help with the development of new learning outcomes and teaching styles that can enhance the way students learn and understand course content. Once an understanding of all three areas and their link with the schools learning outcomes has been determined they could also be assessed against the idea of learning styles and the development of teaching methods that accommodate the different learning styles students possess.

Lastly, student feedback was collected over the course of the project to determine student's opinions regarding learning outcomes and the learning that was occurring within modules. While a certain amount of data was collected it was not a representative sample as only 13 students attended the focus groups and around 40 responses were received for each of the two surveys sent out. There are roughly around 300 students on the Computer Science Degree scheme, so the data collected represents only around 5% of the students on the course. However, despite this small data set a lot of interesting and informative results were gathered. Several students also commented on how they found the focus groups to be particularly interesting in helping them to deeply think about the modules they were taking, the learning that was occurring and relating the expected outcomes to their own experiences.

It could therefore be an interesting development to carry out further focus groups and research collecting student's opinions on the learning outcomes and what learning was occurring – from their point of view, within the modules. This could be incorporated into the review process each year in this way, as mentioned in the interim report, following Bloom's original observation that students should be involved in the process of setting and determining learning goals.

In carrying out the work detailed above, the School could better develop and enhance their modules and degree programmes to better reflect student requirements, learning behaviours and learning styles and in this way potentially improve the level of learning that is achieved by students.

7. Conclusion

The overall aim of this project was to analyse and report on the learning outcomes associated with the Computer Science degree – both module and programme specific. This analysis was to provide insights into the stated learning for each module and how this related across a year, across all three years and the overall programme. Bloom's Cognitive Taxonomy was used to help structure the analysis and determine the different levels of learning that took place. The results of the project were to then provide recommendations for improvements of module learning outcomes as well as produce a specific taxonomy for the Computer Science degree programme.

The project has altogether been a success with all the aims set out being met. Altogether there were five main recommendations made that would help to improve the structure and usefulness of the learning outcomes; these included:

1. A revised version of Bloom's Taxonomy which classified each verb into one Bloom's Category
2. A list of learning outcomes that could not be classified by Bloom's Taxonomy,
3. A list of modules were learning stages are missing,
4. A list of learning outcomes that overlap, and
5. A list of programme outcomes that could not be classified.

Along with this, a taxonomy was produced that categorised all the objects of the Computer Science learning outcomes with their verbs into the associated learning stage, which can be used as a reference point for classifying future learning outcomes. The resources can also be used for future setting and updating of learning outcomes.

8. Reflection

Looking back over the course of this project 5 key areas stand out as being the most important and challenging in the successful completion of it:

- Time Management
- Work Load
- Contact with Supervisor
- Student Feedback
- The Analysis of Data

I have at some point or another either faced difficulties or failed to take appropriate action when necessary relating to each of these areas. While I feel the results at the end of this project are positive it did have its moments where nothing was going quite according to plan.

The biggest problem I have faced across multiple different projects is time management; it has always been one of my weaker skills and throughout this project I feel I was tested to my limits in ensuring work was completed as required. The hardest part I found was trying to juggle not only this project but also other modules' coursework and a part time job. While the timetable left many hours free for individual study I found balancing assignments tricky, this is mostly due to my desire to complete all coursework to a high standard; I therefore devote many hours to a single assignment leaving little time for project work, especially as my evenings were taken up with work.

One of the ways I tried to ensure that enough time was left for project work was to devote the time in spring semester before Easter to completing my coursework for other modules, this would then leave me three weeks at Easter to analyse the learning outcomes and student data and after Easter to write my report. In theory this seemed like a sensible plan, however I was unable to complete all coursework assignments before Easter and therefore part of my Easter break was taken up with completing those. This reduced and pushed back the time I had for analysis and report writing.

While this did put a strain on the project and reduce the amount of time I initially planned for it, I found that once I started analysis I found connections and relationships quickly and easily within the data; the use of software such as NVivo and SQLite Manager also helped to reduce the amount of time required to analyse data through easy and user friendly GUI's and tools that reduced the amount of work needed by the user to display results and make connections. If it had not been for this software I feel the project would not have been completely as successfully.

It is worth noting also that the time frame as initially laid out in the Initial Plan was unfortunately not followed after first semester. This was mainly due to the fact that spring semesters timetable was unknown at that point and my understanding of the project and its requirements was not fully formed. I do not feel that the plan would have been successfully followed for spring semester even if my time management skills were better as when writing it I did not fully appreciate the level of work required of me.

Another factor that added pressure and increased the overall time needed for analysis was the work load. When I initially was setting out and planning the project, as mentioned before, I had not a complete understanding of the problem and the work that would be carried out. I therefore suggested as an extension to the initial project that I carried out research in to student feedback on the learning outcomes and that this data would be also analysed alongside the learning outcomes. While this side of the project proved to be interesting and in some ways informative it did add a whole other side that was time consuming. I think on reflection it would have been better to have conducted this project without the student side, as there was enough work without it.

Back in autumn semester I had regular contact with my supervisor through meetings, emails and the sharing of documents over Google Docs. In spring semester a similar routine was initially established were I had fortnightly meetings - that could be arranged through a doodle poll, and kept a log of my progress via the shared document on Google Docs (see Figures a and b Appendix 18). However, while I did always let my supervisor know my progress in some form or another, towards the end of spring semester contact was less often. This was due to two reasons: firstly that as mentioned early my plan was to carry out most of my work over the Easter break and to focus on my other modules' coursework during the semester, this meant that there was not much that I needed to discuss with my supervisor towards the end as progress was slow; secondly I have always been a highly independent individual who does not need much by the way of guidance or help when carrying out work. I therefore tend to only need to discuss work when I have a specific problem that I cannot solve on my own. I do not feel my lack of regular contact with my supervisor has affected my project in any negative way however I do think that had I scheduled more meetings I may have been able to manage my project more effectively time wise.

As mentioned in Section 7 the response rate for both my focus group and surveys was not particularly high considering the number of students that study Computer Science. While the analysis and conclusions from the data collected did prove to be informative, more data would have meant that stronger connections and conclusions could be made. Another key point is that the focus groups I developed and held were not as useful or well-planned out as they could have been. Firstly, I did not have enough people to talk about all modules, different students had clashing time constraints that meant some supposed focus group sessions were held more as interviews which failed to provide detailed discussions, and lastly I did not run a pilot study of the focus group that meant certain questions which did not provide any useful data remained in the focus group structure when they could have been discovered and edited out. The one useful thing about the focus group was that it helped with the development of the surveys and in ensuring the questions asked in those were to the point and would provide useful data. Considering this and as mentioned earlier the increased work load it produced, I feel it is the weakest area of my project.

The last biggest challenge of the project was the actual analysis of the data itself. At the beginning of the project I failed to grasp how time consuming and involved the analysis process would be. In fact it was not until actually fully carrying out analysis that I realised just how much time was needed for it. As mentioned early my time management skills were not all together brilliant throughout this project and analysis got pushed back to the very end. While the use of SQLite Manager and NVivo did help I feel that more detailed results could have been formulated if I had allowed myself more time for analysis.

Overall, while the project has had its fair share of challenges and difficulties I feel that despite all of these I have managed to produce an informative report and draw conclusions that fully meet the requirements laid out in both the initial plan and interim report. I feel have also further developed my database skills which is a subject area I am particularly interested in, and have applied many skills I have learnt over the three years of study to this project. I also feel that altogether this is a very useful and relevant project as the results and conclusions drawn from analysis can be utilised by the school to further improve the students learning experience.

As well, due to the nature of the project I decided to produce my own learning outcomes for my individual project which detail what I believe I have learnt from undertaking such a project. These are:

1. Identify an appropriate Educational theory which can help with the analysis of learning outcomes
2. Understand Bloom's Taxonomy and its relationship with learning outcomes
3. Describe the problem and method for solving the problem
4. Identify appropriate tools for solving the problem
5. Develop database which stores learning outcomes for the Computer Science Degree
6. Apply Bloom's Taxonomy theory to Computer Science Learning Outcomes
7. Analyse the learning outcomes from the Computer Science degree to determine the relationships between them
8. Document the analysis process
9. Justify the use of tools for the analysis process
10. Assess the success of the project

9. <u>References</u>

Almerico, G.M. and Baker, R.K. 2004 Bloom's taxonomy illustrative verbs: developing a comprehensive list for educator use. *Florida Association of Teacher Educators Journal,* 1(4), pp. 1-10.

Bloom, S et al. 1956. *Taxonomy of Educational Objectives 1.* New York: David McKay Company. Inc.

Moon, J. 2002. *The Module and Programme Development Handbook.* London: Kogan Page Ltd

QSR International. 2012. *NVivo* [Online]. Available at: http://www.qsrinternational.com/products_nvivo.aspx [Accessed: 15/04/2013]

Wirth, K. and Perkins, D. 2008. *Learning To Learn* [Online]. Available at: http://www.macalester.edu/geology/wirth/CourseMaterials.html [Accessed: 23/04/2013]