9-2016

Leveraging Competency Framework to Improve Teaching and Learning: A Methodological Approach

Venky SHANKARARAMAN
Singapore Management University, venks@smu.edu.sg

Joelle ELMALEH
Singapore Management University, joellee@smu.edu.sg

Citation

SHANKARARAMAN, Venky and ELMALEH, Joelle. Leveraging Competency Framework to Improve Teaching and Learning: A Methodological Approach. (2016). *Education and Information Technologies*. 21, (5), 1299-1327.

Available at: https://ink.library.smu.edu.sg/sis_research/2519

Leveraging Competency Framework to Improve Teaching and Learning: A Methodological Approach

***Abstract*— A number of engineering education programs have defined learning outcomes and course-level competencies, and conducted assessments at the program level to determine areas for continuous improvement. However, many of these programs have not implemented a comprehensive competency framework to support the actual delivery and assessment of an individual course. This paper highlights how a competency framework can be used across the life cycle of a course to effectively deliver and assess course content, and give valuable, timely feedback to students thus, improving teaching, student motivation and learning. A framework for leveraging course competencies during course design and delivery is presented, and addresses the following five phases of a course, namely, content design, assessment design, content delivery and assessment, assessment results analysis and feedback, and content review. Using a large first-year core course of the BSc (Information Systems Management) program, at School of Information Systems, Singapore Management University, Singapore—called Information Systems Software Foundation (ISSF)—as an example, this paper shows how course competencies support the framework's five phases. Data from a student survey indicates that the framework has contributed to enhancing their motivation to learn, provides enhanced learning experiences in terms of helping students prepare for each assessment, providing better feedback by raising awareness of what they know and do not know, and revisiting topics that relate to competencies that have not been fully acquired. Results from interviewing instructors revealed that the competency framework provides valuable and timely feedback on how students are performing, and additionally what changes are required to both the content and method of delivery in order to improve teaching. This contributes towards more effectively closing the "teaching and learning loop".**

***Index Terms*— Competency Framework, Course Life-Cycle, Assessment, Delivery and Feedback**

1. INTRODUCTION

Specification and continuous assessment of learning outcomes and competencies have become a central focus in undergraduate and postgraduate engineering and business education. In order for a program to be accredited, the Accreditation Board for Engineering and Technology (ABET), requires that it has defined student outcomes and an effective process for the periodic review and revision of these student outcomes. Furthermore, it requires that the program regularly use appropriate, documented processes for assessing and evaluating the extent to which student outcomes are being attained (ABET 2013). In order to assess learning outcomes, institutions have defined program learning outcomes at different levels of granularity so that higher-level program learning outcomes can be refined into course-specific learning outcomes or competencies. The competencies are then measured in the individual course assessments. An aggregation of these measures provides valuable input for continuous improvement of a program. This approach has been adopted by a number of institutions (Larson & Harrington 2012), (Wang et al. 2008) mainly for satisfying accreditation requirements such as for ABET (Anwar et al. 2012), (Batterman et al. 2011), (Burge & Leach 2010) and (Wang et al. 2008). Although this approach provides a valuable mechanism for a program's continuous improvement, in many cases, the learning outcomes and competencies are not fully leveraged when designing and delivering content or when giving feedback to students in the context of a specific course within the program. One reason for this is the lack of a formal framework outlining how competencies can be used during the life cycle of a course. In this paper, the authors present a Course Life Cycle and Competency (CLCC) framework to show how competencies can be used during the various life cycle phases of a course. Additionally, the experience gathered in implementing this framework in an undergraduate programming course is shared.

The paper is organized as follows. The following section presents a concise literature review on outcome-based education, competency-based learning, and specifically in computer science and information systems program. Section 3 presents the Course Life Cycle and Competency (CLCC) framework for leveraging course competencies during course design and delivery. This framework addresses how competencies are leveraged in the five phases of a course: content design, assessment design, content delivery and assessment, assessment feedback, and content review. Using the Information Systems Software Foundation (ISSF) course, Section 4 shows how the Course Life Cycle and Competency framework is applied in the design and delivery of this course. This section discusses how the competencies defined for the course are used in the design of detailed course content and laboratories (labs), and the design of the assessment components of the course; how the competencies impact student preparation for course assessments; how course-level competencies are used in the course post-mortem debriefing process where the acquisition of competencies are discussed and appropriate actions taken for those competencies that majority of students failed to acquire; and what role the competencies play in reviewing and redesigning hands-on practical course components. Section 5, using the results of the student and instructor survey, presents an evaluation of the effectiveness of the Course Life Cycle and Competency framework as applied to the ISSF course. In Section 6, based on the evaluation, three significant benefits of using the CLCC framework during the course life cycle are highlighted, namely enhanced student motivation, targeted student feedback, and better student performance. In Section 7 we present the education tools that are used to support the CLCC framework. The final section presents some of the conclusions, and drawbacks of our approach, and suggests future research work.

2. RELATED WORK

Outcome-Based Education

The origins of learning outcomes and competencies can be traced by to early work done by Spady (Spady 1994) in the area of outcome-based education (OBE). Spady has highlighted that in outcome-based education the focus is on structuring everything in an educational system around what a student is "able to do" at the end of the learning experience. He identifies two important requirements: (a) developing a clear set of learning outcomes; (b) establishing conditions and opportunities to encourage students to achieve those outcomes. In this context outcomes are clear learning results that a student demonstrates at the end of program. Spady has proposed the OBE Pyramid which comprises five levels "Paradigm" of operation, two key "Purposes", three key "Premises", four operating "Principles", and five generic domains of "Practice". For more details on these levels the reader may refer to is (Spady 1994). The Outcomes Based Education (OBE) became most prominent in countries such as the United States, Australia and South Africa where it was employed to facilitate educational reforms (Malan 2000), (Killen 2007). Though initially this approach was widely used at primary and secondary schools, there is increasing interest in applying this to higher education. For example, Hejazi and Janzen propose that outcomes-based education could positively impact the issues of learning quality and mobility in higher education institutions in Canada (Hejazi & Janzen 2011).

Competency-Based Learning

Following on from outcome-based education, more recently, in response to the challenges of the 21st century, a considerable transformation of higher education is currently taking place, where the quality of higher education programs is being more and more assessed in terms of goals and outcomes (Hussey 2008). In this context of transformation, another notion is being used more and more frequently, namely, the notion of "competency". This approach is closely related to OBE. Van der Horst & McDonald propose six critical components of competency based learning namely explicit statement of learning outcomes and competencies with respect to the required skills and concomitant proficiency; a flexible time frame to master these competencies, a variety of instructional activities to facilitate learning, testing of the required outcomes, certification based on demonstrated learning outcomes and adaptable programmes to ensure optimum learner (Van der Horst & Mcdonald 1997). Similarly to the concept of learning outcome, there are many different interpretations of the notion of competency but no definition is universally accepted.

As described by Boyatzis, competencies are characteristics hidden in individuals that lead to effective and excellent results in jobs (Boyatzis 1982). According to Parry, competency is "a cluster or related knowledge, skills, and attitudes that reflects a major portion of one's job (a role or responsibility), that correlates with performance on the job, that can be measured with well-accepted standards, and that can be improved with training and development"(Parry 1997). Rychen and Salganik define competency "as the ability to successfully meet complex demands in a particular context" (Raychen & Salganik 2003). For the purpose of this paper, we adopt the definition of competency as defined by (Passow 2012): "Competencies are defined as the knowledge, skills and abilities in the context of a specific domain (object-oriented application development, cloud computing, etc.) that enable a student to take an effective action or make sound decisions". The knowledge here includes factual, conceptual, procedural, and meta-cognitive, as defined by (Anderson et al. 2001).

Competency-based learning programs have been part of education systems in different countries for several decades but most have been implemented in the professional or vocational training sector (Donaldson et al. 1995). More recently, higher education institutions have attempted to reshape their programs with a more professional orientation. For example, Passow proposes that education should focus on competency-level training and assessment and make students "industry ready" (Passow 2012).

Some institutions have advanced further where it is possible for students to earn degrees by demonstrating competencies alone. For example, at DePaul University's School for New Learning at Illionis, USA, a Bachelor of Arts degree program is offered both online and on the ground, and is based on a competence framework of 50 competence statements (Kelin-Collins 2012).

Competency-Based Learning in Computer Science and Information Systems Program

In Computer Science and Information Systems programs, the dual challenges of continuous evolvement of the discipline and the issue of appropriate employment of graduating students have driven the need for external accreditation process such as ABET, which requires evaluation of and improvements to curriculum and continuous assessment of student learning (Pinto 2010). Competencies provide a structured approach for implementing continuous assessment of outcomes (Larson & Harrington 2012). This urgency is reflected in the restructuring of the Model Curriculum for Information Systems which is driven by changes in high-level organizational needs and graduate capabilities (Topi, 2010). The revised Model Curriculum now links curriculum content and structure to graduate capabilities or competencies.

Moyo-Acerado et al., propose competency models for operations manager, user interface designer, and application developers using a combination of Holland's RIASEC model, the Values Search model and surveys from industry experts. These competencies then help students determine the track of specialization according to their values, interests, knowledge, and skills (Moyo-Acerado et al. 2014).

(Espinosa-Curiel et al. 2011) have develop a framework that defines the competencies for seven roles involved in a software process improvement initiative and defines the level of expertise required by each role for each competency.

The "BABELnot" project which involves collaboration across a number of universities in Australia is aimed at developing a competency framework for programming courses. It further attempts to develop a method for mapping exam assessment to a set of competencies (Lister et al. 2012).

Some studies have focused on using competency-mapping approaches to understand what students actually learn. For example, McNamara proposes the competency mapping method for evaluating student competency in a first year programming course using the technique of cluster analysis and multi-dimensional scaling. The method is used to present a map of what students actually learn by assessing their competency through the marks gained in various assessments (McNamara 2004).

Johnson describes a process for defining competencies for a Computer Information Systems program and mapping them to the existing curriculum. This research further addresses the issues of designing and implementing feedback mechanisms that measure the achievement of the competencies and utilize the results in an attempt to improve program effectiveness (Johnson 2000).

Pinto examines the curriculum design for computer science which is based on competencies that are customizable for individual student (Pinto 2010). He further describes how the competency based framework is used to assess student learning on Database Management in a Masters in Computer Application (MCA) Degree Program.

Ahmed et al., describe a process of developing an instrument to assess the competency in Information and Communication Technology among postgraduate students in a Higher Learning Institution (Ahmed et al. 2013). Their approach is based on application of the performance-based assessment and the task-based assessment within the seven domains in the 21st Century ICT Competency Model (ETS 2008) to determine the competency level among students.

Daigle et al., highlight the importance of competency assessment for motivating faculty to foster "continuous improvement" in student learning (Daigle 2007). They put forward a learning outcome process for the assessment of an undergraduate course in Accounting Information System. They argue that evidence of student learning is observed, through triangulation of multiple direct measurements, supplemented by indirect measures such as student self-assessments of their competency.

However, very little work has been done in exploring how competencies can be used across the entire life cycle of a course (Baumgartner & Shankararaman 2013) and (Johnson 2000). In this paper we focus on this gap and offer a first-year undergraduate computer programming course as an example of how a competency-based approach can be applied across the various phases of a course life cycle.

3. Course Life Cycle and Competency Framework

As highlighted above, many Computer Science, Information Technology or Information Systems education programs appear to have learning outcomes or competencies defined for their programs. However, in many cases, those learning outcomes or competencies are not fully leveraged in a systematic way when designing, delivering or revising a course within the program. Frequently, those learning outcomes or competencies are only defined to be published on a university's or school's web site or to be incorporated into, for example, documentation used to obtain a specific accreditation. In this section, we therefore, present the Course Life Cycle and Competency framework to show how the competencies can be used during the various life cycle phases of a course.

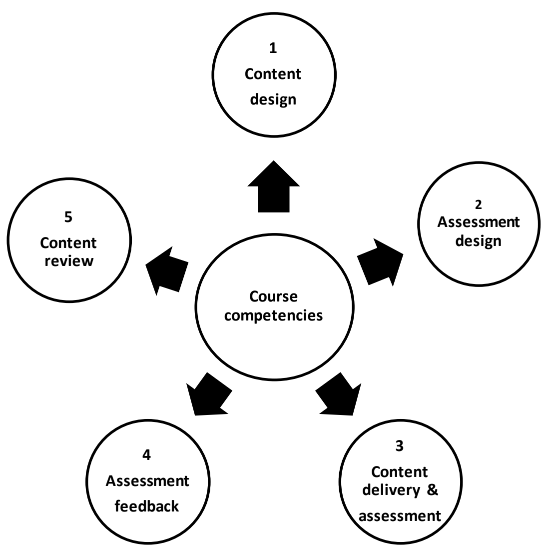


Figure 1: Course Life Cycle and Competency (CLCC) Framework

Figure 1 presents the Course Life Cycle and Competency framework, consisting of five phases, namely content design, assessment design, content delivery and assessment, assessment feedback, and content review.

In practice, many of these phases are highly iterative, involving a lot of small iterations. The following section describes how the course-level competencies are related to each of these five phases.

Content Design Phase

During this phase, based on the competencies, the course team decides on the topics and hands-on labs that will provide opportunities for the student to acquire the competencies, and course assessments and projects that will demonstrate the acquisition of the competencies. For each topic, the detailed content is developed along with methods for delivering that content. The hands-on labs objectives are defined, appropriate tools to be used in the labs are selected and detailed lab sheets are prepared. For the course assessments, the number and type of assessments are identified and only the high-level design is completed at this stage. In addition, at the end of this phase, mapping of all the competencies against the topics, labs, project and assessments is completed. This map helps the course team to ensure 100% coverage of the competencies, both in terms of helping students to acquire them and also in terms of providing the necessary opportunity for assessing the acquisition of those competencies.

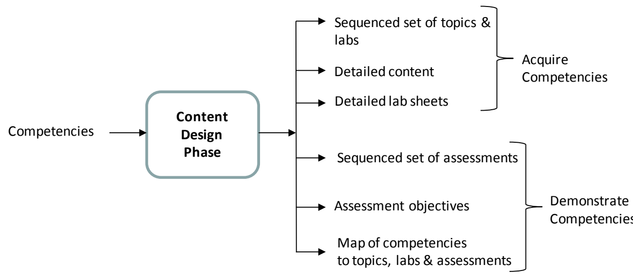


Figure 2: Content Design Phase-Inputs and Outputs

Assessment Design Phase

During this phase, the details of each assessment are developed. This is done with the help of the assessment-to-competency mapping. For example, let us assume that assessment A1, a quiz, is meant to demonstrate the acquisition of competencies C1, C3 and C5. The set of questions for the quiz are then designed to ensure they address the competencies C1, C3 and C5. Each question is then mapped to one or more competencies. For example, question Q1 may be mapped to C1 and C3, whereas question Q2 may be mapped to C5. The grading scheme and rubrics are also set for each assessment.

In addition, a threshold is set for each question to facilitate the analysis of the results later on during the feedback phase. Above that threshold the related competencies for that question are considered as acquired. For example, since Q1 is mapped to C1 and C3, a threshold of X marks being awarded to the question Q1 indicates that C1 and C3 are acquired.

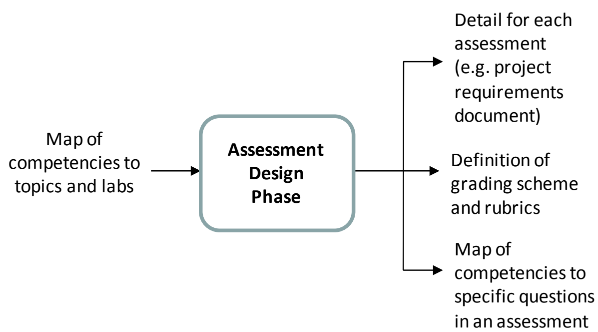


Figure 3: Assessment Design Phase: Inputs and Outputs

Content Delivery and Assessment Phase

During this phase, the prepared content is delivered through a combination of lectures, discussions, hands-on labs, etc. The delivery is spread over a number of weeks, requiring the students to perform in-class and out-of-class work. Before each class, the competencies that are to be covered during that class are explicitly presented to the students. Similarly, before each lab, the competencies that are to be acquired on completion of the lab are also explicitly presented to them. This ensures that each student is aware of what they are expected to learn and how it links to the competencies they are expected to acquire. Thus the ownership of acquiring the competency is transferred to the students, and makes the students more aware that they are responsible for their learning. Additionally, during this phase, assessments are also conducted during some class sessions or alternatively at the end of the course. These assessments include quizzes, written tests, lab tests, final exam, final project, etc. In order to help students prepare for the assessment, rather than being presented with the list of *topics* that will be tested in the assessment, before each assessment, the students are presented with the *competencies* the assessment is expected to test. For example, instead of saying "The next assessment on Week 4 will be a quiz that will be testing topics covered during Weeks 1 to 3", the students are now given the following: "The next assessment on Week 4 will be a quiz that will be testing the competencies C1, C3, C5, C6, etc."

From a student perspective, it shifts the focus from what topics to learn to what competencies should be acquired.

From an instructor perspective, it shifts the focus from what topics the students are to be tested on to what competencies the students should be tested on.

As a result of the emphasis on competency during the content delivery and assessment, the students benefit from the following:

- A better understanding of competencies that are to be acquired during each week of the course
- A better understanding of competencies that are to be tested in a particular assessment

This helps the students to be better prepared for the assessments.

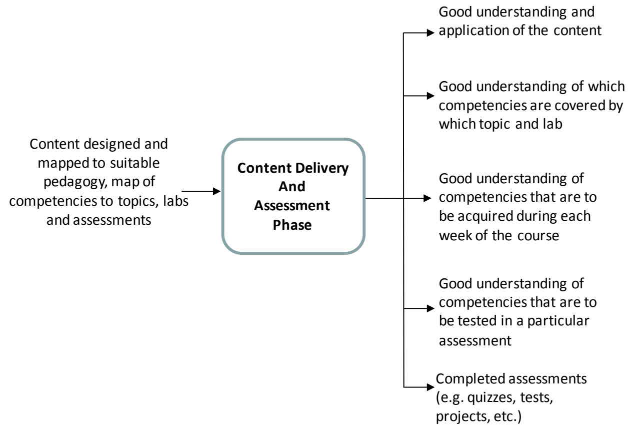


Figure 4: Content Delivery and Assessment Phase: Inputs and Outputs

Assessment Feedback Phase

During this phase, the instructor analyses the assessment scores and present feedback to the students. This is done immediately after the assessment is marked. The standard practice of presenting the scores, averages, etc., is adopted. In addition, and more importantly, a detailed walkthrough of the cohort competency acquisition map is conducted. The map contains the different competencies assessed in the particular assessment and for each competency, whether it was acquired or not acquired. The question thresholds set during the Assessment Design Phase are used to determine which competencies are acquired or not acquired.

For the questions, where the score is below the threshold, the related competencies for that question are considered as not acquired. In this case, a detailed walkthrough of the common mistakes is conducted through a collaborative session with the student's participation.

Though the feedback is given at the cohort level, individual students will know their own mark for specific questions, and hence indirectly can identify the competencies they have fully acquired or not acquired.

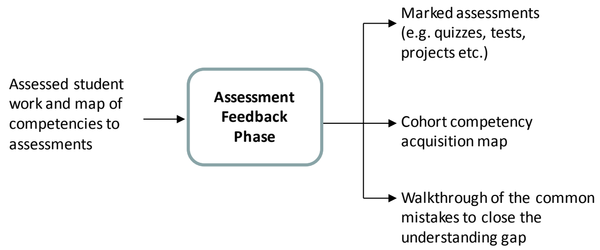


Figure 5: Assessment Feedback Phase: Inputs and Outputs

Content Review Phase

During this phase, the course team conducts a detailed analysis of the various assessments in the course and the competencies that have been acquired or not acquired. For those competencies that are seen as acquired no additional work is necessary. For competencies that have not been acquired, the course team reviews the content covered, the labs, and the assessments associated with those competencies. This review can lead to any of the following: the modifying of course content, the adjusting of content sequencing, the redesigning of labs, or the redesigning of the assessment. In some instances, it can also lead to the redefining of the competencies. For example, if the team feels a particular competency is deemed to be too advanced for that level of student, then removing that competency may be the most suitable action.

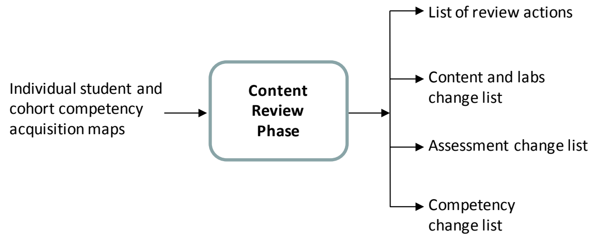


Figure 6: Content Review Phase: Inputs and Outputs

4. IMPLEMENTATION OF THE CLCC FRAMEWORK

In this paper, the authors selected the ISSF course to illustrate the implementation of the CLCC framework and to discuss how this framework contributes to the improvement of course design and delivery.

ISSF is a foundation course of the BSc (IS Management) program delivered in the first semester of the first academic year at the School of Information Systems, Singapore Management University. This course focuses on the fundamental building blocks of a software application. Students learn programming fundamentals through the use of object-oriented programming concepts. As a part of the course, students are required to design, code, and test software applications using the Java programming language.

Each year, about 280 students take the ISSF course and are divided into seven sections of about 40 students each. Each section is managed by two instructors and two teaching assistants (TA). The instructors take the overall responsibility for designing and delivering the course, designing and delivering labs, and supporting student project work, and the TAs assist the students with labs. The entire teaching team is present in all classes, allowing efficient support during class exercises and lab sessions as well as consultations outside of class time.

Content Design Phase

For the ISSF course, about 40 core competencies have been defined. Given the technical nature of the course, these competencies mainly address the program-learning outcomes, namely software and IT architecture analysis, and design and implementation skills. Table I shows an excerpt of this competency matrix.

During the Content Design Phase (as shown in Figure 2), the competency matrix is used to identify the seven topics and the sequencing of these topics as follows: (1) Programming fundamentals; (2) Object manipulation; (3) Class basics; (4) Decision and repetition structures; (5) Class ArrayList; (6) Building Java console applications; and, (7) Advanced class features. For each of these the detailed content is developed together with appropriate delivery methods such as lecture, discussion, and labs. The key tools to be used in the course are selected including Java SDK, DOS prompt and Notepad ++. For ensuring the application of the seven topics identified, seven labs are designed, each lab addressing one topic. This preparatory work is a necessary step to enabling students to acquire the required core competencies.

During the Content Design Phase, the number and type of assessments is also identified, including two quizzes, three lab tests, a project and a final exam.

Table I Excerpt of the ISSF Competency Matrix

Program-level learning outcomes		ISSF Course-specific competency definition	#
2. Software and IT architecture, design and development skills	2.1 …	…	
	2.2 Architecture analysis and Design skills	Apply object oriented concepts and principles such as classes versus objects, single responsibility principle and data encapsulation.	C1
	2.3 Implementation skills	Effectively use Java primitive type variables and constants as well as operators, precedence of operators, widening and narrowing of operand conversions.	C2
		Draw a memory state diagram to derive an output trace.	C3
		Explain the difference between classes and objects and know how to create an object from an existing class using default or specific constructors.	C4
		Write Java code using the Java API (such as method signature, instantiation of objects, objects manipulations via appropriate method calls etc.).	C5
		Perform String objects manipulation using the String class from the Java API.	C6
		Effectively use the "null" Java literal.	C7
		Write conditional constructs in Java (if, if-else, if-else-if, nested-if) to control the path of execution of statements.	C8
		…	CXX

During the Content Design Phase, the number and type of assessments is also identified, including two quizzes, three lab tests, a project and a final exam. The scope and schedule of each assessment is then decided in accordance with the competencies that are to be assessed.

Table II Mapping matrix of competencies to topics, weeks and assessments

Competency #	Topic	Taught in week #	Quiz 1		
			week 4		
			Scope	Focus	Tested
C2	Programming fundamentals	2	√	√	√
C3	Programming fundamentals	3	√	√	√
C4	Programming fundamentals	3	√	√	√
C5	Object manipulation	3	√	√	√
C6	Object manipulation	3	√	√	√
C7	Object manipulation	3	√	√	√
C8	Object manipulation	3	√	√	√
C9	Object manipulation	3	√	√	
C10	Object manipulation	3	√		

Table II shows an excerpt of the mapping of competencies to topics, the competencies covered each week and the corresponding assessments that are used to assess the acquisition of these competencies. However, since a particular assessment cannot test all competencies, three additional columns are introduced namely scope, focus and tested. The “Scope” identifies the topics and competencies that may be included in the particular assessment. These are what the students will be informed about. The “Focus” further identifies the topics and competencies which the teaching team will be focusing on while designing the assessment. The students are not informed of this. Only the “Scope” column is shared with the students, while the “Focus” column is shared with the teaching team. In other words, “Focus” is a subset of “Scope”. For example, in Table II, for Quiz 1, the competencies in “Scope” are C2 to C10, and “Focus” is only on C2 to C9. However, having defined the “Focus”, the instructor is not constrained to test all the competencies included in the “Focus” column. The “Focus” column serves as a guide on the list of competencies that can potentially be tested within a particular assessment. So once the actual questions are completed, the “Tested” column is used to record the actual topics and competencies tested in the particular assessment. In this case only C2 to C8 are “Tested” in Quiz 1. This is done during the Assessment Design Phase.

Assessment Design Phase

When a member of the teaching team starts preparing the design of an assessment, he or she has to revisit the content of the matrix shown in Table II. Having decided the number of questions, he or she designs the content of each question taking into consideration the competencies that are identified as being in scope and focus. Grading schemes and rubrics are also established at this stage and the actual set of competencies tested by each question is recorded in the mapping matrix. In the example shown in Table III, question Q1 of Quiz 1 tests the competencies C2 and C3, question Q2 tests competency C4, question Q3 tests competencies C4 and C5, and question Q4 tests competency C6 to C8.

There is no limit to the number of competencies that can be tested by a question but it is advisable to only test a small number of competencies per question to facilitate the analysis of results and the feedback phase. A competency is declared as tested if at least one question tests that competency. In order to ensure that all competencies are tested, the “tested” column of each assessment (as shown in Table II) is consolidated into one single matrix as shown in Table IV.

The last column shows the number of times a particular competency is tested through the different assessments. This helps the teaching team to get a better view of the number of times a competency has been assessed in the course and thus helps with the design of the final exam (to rebalance the number of times a particular competency has been tested).

Table III Mapping matrix of competencies to assessment questions within one assessment

#	Competency Definition	Quiz 1			
		Q1	Q2	Q3	Q4
C2	Effectively use Java primitive type variables and constants as well as operators, precedence of operators, widening and narrowing of operand conversions.	√			
C3	Draw a memory state diagram to derive an output trace.	√			
C4	Explain the difference between classes and objects and know how to create an object from an existing class using default or specific constructors.		√	√	
C5	Write Java code using the Java API (such as method signature, instantiation of objects, objects manipulations via appropriate method calls etc.).			√	
C6	Perform String objects manipulation using the String class from the Java API.				√
C7	Effectively use the "null" Java literal.				√
C8	Write conditional constructs in Java (if, if-else, if-else-if, nested-if) to control the path of execution of statements.				√

Table IV Mapping matrix of competencies to the various assessments

#	Tested at least by one assessment	Quiz 1	Labtest 1	Quiz 2	Labtest 2	Labtest 3	Exam	
		week 4	week 6	week 9	week 12	week 14	week 15	
		Tested	Tested	Tested	Tested	Tested	Tested	No. of times tested
C2	√	√		√	√		√	4
C3	√	√						1
C4	√	√						1
C5	√	√	√			√	√	4
C6	√	√	√		√	√	√	5
C7	√	√	√		√		√	4
C8	√	√	√				√	3

Content Delivery and Assessment Phase

Each week, the ISSF course is delivered through a three-hour face-to-face class session. The course extends over a 15-week period. Each week, the concepts and principles related to the topic are presented and discussed, followed by class exercises or lab work that highlights the application of the concepts and principles learnt. Before each session, students are presented with the competencies that are to be acquired during the session. This helps the students to focus on what competencies are to be acquired rather than solely what concepts or principles will be covered.

One week prior to every assessment, the competencies that are within the scope of that particular assessment are highlighted. This is meant to help students preparing or revising for the assessment to focus their attention on what *competencies* they will be tested on rather than the list of *topics* they need to cover for the assessment.

Assessment Feedback Phase

During this phase, the instructor grades each assessment and then analyses the assessment scores and presents feedback to the students. This is done immediately after the assessment is marked. Grades are captured and entered into a spreadsheet as shown in Table V.

Table V. Excerpt of the grading result matrix for a particular assessment

Questions within an Assessment	Q1	Q2	Q3	Q4
Maximum marks	2	2	5	6
Question threshold	1	1	3.5	4
Student ID	**Student grades**			
S_1234567890	2	2	4	5
S_1234567891	1	1.5	2	3
S_1234567892	2	2	3	2
S_1234567893	1	1	3	1
S_1234567894	2	2	5	6
S_1234567895	2	1	3	0

In order to analyse competency acquisition, it is essential to capture results of each question or, in some instances, each sub-question. There is a trade-off between capturing elaborate details of the assessment performance versus gaining a level of clarity in terms of competency acquisition by students.

The standard practice of presenting scores, averages, etc., for the whole cohort as well as for each section, is adopted. This gives the teaching team a classic overall picture of how students have performed across the different sections in terms of failure rate, percentage of As, etc. (see Figure 7). However, this information does not help in understanding which competencies have been acquired and those that have not been acquired by the students.

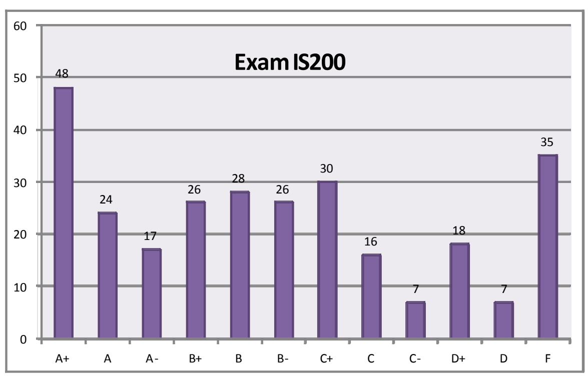


Figure 7: Distribution of students per grade for a particular assessment

In addition, and more importantly, a detailed walkthrough of the cohort competency acquisition map is conducted. The map contains the different competencies assessed in a particular assessment and, for each competency, whether it was acquired or not acquired. In order to gain a better understanding of the competencies acquired, a combination of the following information is used:

- Course competency mapping matrix to topics, weeks, assessments and questions (Table II and III)
- Course competency coverage across all assessments (Table IV)
- Course assessment detailed results matrix (Table V)

If one question tests only one competency, then it is quite straightforward to use the question score to determine whether the competency has been acquired or not. Usually, a threshold needs to be set, and students achieving above that threshold are deemed to have acquired the competency. However, when one question tests a number of competencies, more judgment is required when analysing the question score to determine the competencies that are deemed as having been acquired. If this set of competencies is small enough or if the competencies of the set are very closely related then the result of the question directly informs the teaching team of the competency acquisition. Multiple Choice Questions (MCQs), for example, are very informative because they are usually well-targeted and relate to one, or at most two, closely related competencies. For questions that are more discursive in nature, sub-questions must be clearly identified and test a small set of competencies.

The results analysis shows the related competency acquisition by students. We look at three sample cases that can emerge from this analysis:

Question result shows a high percentage of students having obtained a full score: In this case, the competency (or set of competencies) that the question is supposed to test, is considered as acquired.

In the ISSF example shown in Figure 8, the question tests the competencies C2 and C3. The specific exercise given was aimed at drawing a memory state diagram to derive an output trace of some Java code provided, involving multiple Java operators (++, --, % etc) on primitive variables. The results for that question showed that 83% of students across the cohort scored the full score. Therefore one can confidently conclude that competencies C2 and C3 are acquired.

C2	Effectively use Java primitive types variables and constants as well as operators, precedence of operators, widening and narrowing of operand conversions.
C3	Draw a memory state diagram to derive an output trace.

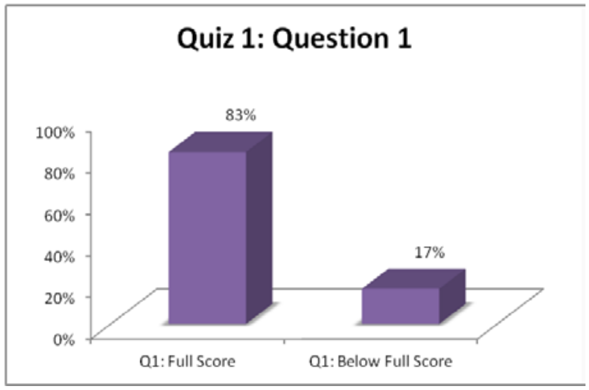
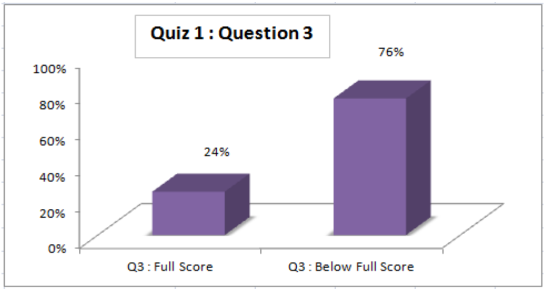


Figure 8: High percentage of full score to a question

Question result shows a low percentage of students having obtained a full score: In this case, a first look may indicate that the competency has not been acquired. However, to get a more accurate view, a further investigation is necessary to find out the distribution of grades below the full score. A histogram is then used to determine the distribution of students versus the score.

In the ISSF example shown in Figure 9, the question tests the competencies C4 and C5. The specific exercise given was to write a class DumbBell, given the provided Java API of a class Sphere and to write a Test class to instantiate DumbBell objects and to produce a particular output.

C4	Explain the difference between classes and objects and know how to create an object from an existing class using default or specific constructors.
C5	Write Java code using the Java API (such as method signature, instantiation of objects, etc.).



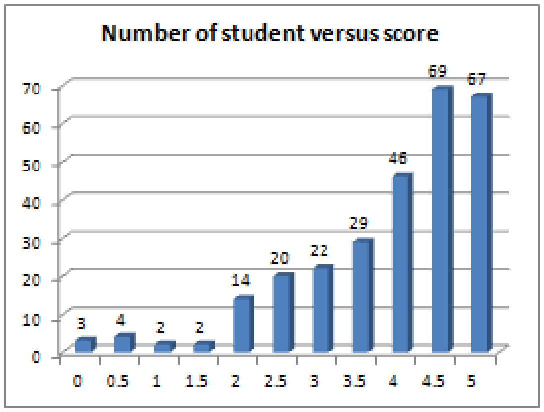


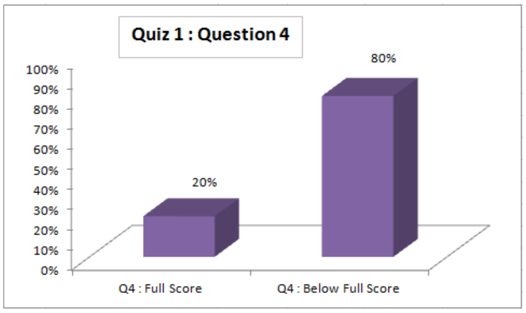
Figure 9: A low percentage of full score for a question

The threshold set during the Assessment Design Phase is now used to determine whether the competencies, tested in a question with a low percentage of full scores, are acquired or not acquired. In Figure 9, the question is out of five marks and the threshold has been fixed to three–and-a-half marks (See Table V). Note that the value of the threshold depends on the question asked and on the associated rubrics. Any student getting below three-and-a-half marks is considered to not have acquired the corresponding competency. Using Figure 9, a quick calculation shows that a majority of students, or 76% of the cohort, has obtained three-and-a-half marks and above, for this question. Therefore the competencies are deemed as acquired.

Question result shows a low percentage of students having obtained a full score: In this case, once again a histogram is necessary to arrive at a conclusion. In the ISSF example shown in Figure 10, the question tests the competencies C6, C7 and C8.

In this question, students were asked to write a method matchString in a Person class that takes in two Person Objects and manipulates the two names of those two persons, given some criteria. This question requires the proper management of the null String literal, to manipulate String objects but most importantly requires problem-solving skills. The question is out of six marks and has a threshold fixed at four marks. As explained earlier, any student getting below four marks is considered to not have acquired the corresponding competency. In Figure 10, a quick calculation shows that 71% of the students got below four for this question. Therefore the competency is deemed as not acquired.

C6	Use the String class from the Java API to be able to perform String objects manipulation.
C7	Effectively use the "null" Java literal.
C8	Write conditional constructs in Java (if, if-else, if-else-if, nested-if) to control the path of execution of statements.



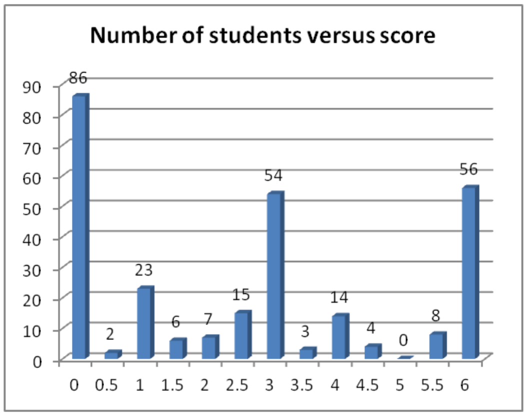


Figure 10: A low percentage of full score to a question

After grading an assessment, the teaching team is then able to establish a list of competencies not acquired as well as common mistakes. The results are presented to students in the class session immediately succeeding the test session. This ensures students are aware of the competencies that are globally acquired (or not) by the cohort. In addition, a detailed walkthrough of the common mistakes is then conducted through a collaborative session involving student participation. During the session, the students are required to identify their mistakes. Since the assessment occurred the previous week, the questions and their answers are still fresh in students' memories so they fully benefit from the review. In summary, this process allows the teaching team to further elucidate the details of specific questions not performed well by students and thus offers another chance for the enhancement of the acquisition of competencies by the students.

Content Review Phase

The implementation of the Course Life Cycle and Competency framework provides the teaching team with valuable and timely feedback on how students are performing, and where they stand with respect to the set of competencies they should acquire.

In some cases, an assessment is failed by a large majority of students. The teaching team must then question itself on the reasons, which may include the following:

- Was the topic related to the "competency that was not acquired" addressed clearly in class?
- Did the teaching team allocate enough time for ensuring students got sufficient hands-on practice to apply the concepts related to the topic?
- Is there a need to change the sequencing of topics delivered?
- Does the topic require a prerequisite competency that has not been covered?
- Is there a need to redesign the labs or redesign the assessment?

For example, during the previous delivery of the ISSF course, in the exam paper, there was one debugging exercise with five mistakes which related to either syntax error, compilation error or logic error that the students had to locate in the provided code. Each mistake was related to a particular competency. For example, "Manipulate efficiently Boolean and relational operators to create complex Boolean variables used in conditional or repetition constructs" or "Use effectively the String class from the Java API to be able to perform Strings manipulations and comparisons etc.".

Among the whole cohort, only one student identified one of the mistakes. The related competency was “Understand and explain the difference between local variables and instance variables in a Java class in terms of scope and default value”. This was bemusing for the teaching team. A further investigation revealed that the topic (scope of a variable) related to the competency had been covered without the details having been explicitly explored, in particular when the variable was used in a do/while loop construct, as was the case in the exam paper. So the teaching team decided to modify the course content to take this point into consideration for the next run of the course. Besides a change of content, this type of situation can lead to changes in the sequencing of the topics delivered or a redesign of the labs or the assessment, etc. In any case, it gives the teaching team the opportunity to improve the current content and/or pedagogy.

5. EVALUATION OF THE FRAMEWORK

The CLCC framework addresses the five phases of a course, namely content design, assessment design, content delivery and assessment, assessment feedback, and content review. Of these five, content delivery and assessment and assessment feedback directly impact students. Therefore, the evaluation of the effectiveness of the competency-based approach during these phases was conducted through a student evaluation survey. For the remaining phases, the evaluation was conducted through informal discussion with instructor involved in the ISSF course.

Evaluation Survey: Students

The evaluation survey comprised five quantitative questions and one qualitative question (see Table VI). A group of 110 first-year students doing the ISSF course participated in the evaluation. Some conclusions from the survey data follow:

- The presentation of the competency list (see Table I) helps the students to gain a better understanding of the knowledge and skills they can expect to gain from the course. About 20% of the students found it “very useful” and 68% found it “somewhat useful”.
- Before each assessment, students read through the list of competencies that they are likely to be tested on and this helps them prepare for the assessment. Of the group, 80% indicated they carefully read the competency list, while 12% found it to be “very helpful” and 75% “somewhat helpful”.
- Use of the competencies clearly helps the students to have a better feel of “what they know” and “what they do not know”. Of the students, 30% found it to be “very helpful” and 60% “somewhat helpful”.
- The use of competencies during the assessment feedback sessions helps to “close the loop” by ensuring the students gained a higher visibility of the exact mistakes they made in the assessment. It also helps students to then focus on competencies that were not fully acquired. The survey showed that 40% found it to be “very helpful” and 55% “somewhat helpful”.

Evaluation Survey: Instructor

Informal interviews were conducted with the instructor teaching the ISSF course. The following is a summary of the conclusions from these interviews:

- During the Content Design Phase, the competencies helped the instructor to structure course topics and assessments and manage the sequence flow. The instructor particularly liked the idea of having a matrix to show the mapping of competencies to topics, weeks and assessments, by ensuring each topic has been covered and each assessment made (Table II). This ensures that all topics are relevant to the competencies that are to be acquired and ensures the assessments cover all the competencies.
- During the Assessment Design Phase, the instructor found the preparation of the matrix of competencies to assessment questions within one assessment very tedious (Table III). But all instructors agreed that the mapping matrix of competencies to the various assessments (Table IV) provided a very useful checklist on the purpose of each assessment. Additionally, it provided a clear view on what competencies were being under-assessed and those that were over-assessed.
- During the Content Delivery and Assessment Phase, the framework helped instructor focus on what competencies are to be acquired by the students rather than solely what concepts or principles shall I cover.
- During the Assessment Feedback Phase, instructor perceived the value of the competency-based approach, in shifting the focus from marks scored in an assessment to helping them really understand what the students had learnt and were capable of doing.
- During the Content Review Phase, instructor found the analysis of competencies acquired and those not acquired provided a good focal point for revising the course content and delivery style.

Table VI. Questionnaire for Evaluation Survey: Students

	Question	Rating/Comments
1	Rate how useful the presentation of the ***competency list*** was in helping you gain a better understanding of the skills and knowledge that are to be acquired in the course	1-2-3-4 Very useful-Somewhat useful-Not very useful-Not at all useful
2	When you were given the ***list of competencies*** before the assessment	
a	Did you read this list or not?	YES/NO
b	If you did read this list, did it help you to prepare for the assessment?	1-2-3-4 Very helpful-Somewhat helpful-Not very helpful-Not at all helpful
3	Did the use of ***competencies*** help to raise your awareness regarding what you know and what you do not know?	1-2-3-4 Very helpful-Somewhat helpful-Not very helpful-Not at all helpful
4	Did the presentation of **test results** along with the review session that explained the ***competencies*** that were acquired and those that were not acquired help to ***"close the loop"*** and clarify doubts on mistakes that you made in the test?	1-2-3-4 Very helpful-Somewhat helpful-Not very helpful-Not at all helpful
5	Give your suggestions on how to ***improve*** the process of using ***competencies*** to support your learning	Comments

6. BENEFITS OF THE FRAMEWORK

We identify the following benefits of implementing the CLCC framework:

Enhanced Student Preparedness

Highlighting the competencies to students one week before each assessment helps them to be better prepared for the assessment through revision. The students are able to ask themselves if they have acquired the required competencies. "Am I able to list ..."?, "Am I able to analyse ..."?, etc. It helps them to gauge what they "know" and are able to "do" at that particular moment, rather than merely going through the lecture materials for Week 1, 2 3 etc. The following is an excerpt from a student's feedback for the ISSF course that highlights this point:

"Basically I use the competencies to identify the areas of ISSF that I need to understand very well. The list of competencies is generally straightforward and concise. It is better this way, so it is not too lengthy and confusing. I simply run through the list and ask myself if I meet those competencies, otherwise, I go back to the notes and lab samples to observe where such competencies were covered. Furthermore, I discuss with a few of my friends to deepen my understanding of the competencies. It is a very good guide for revising ISSF."

Enhanced Feedback to Students

Rather than merely presenting the grades for the assessment, after grading each assessment, the statistics and analysis results on competencies that are acquired or not acquired by the cohort are presented to the students in class. This reinforces the message that assessments are designed with a view to testing whether students have acquired the competencies. Reinforcing the linkage between competencies and assessment enables the students to self-assess their level of competency acquisition and work towards acquiring all the competencies for the course.

Most importantly, the process also allows the teaching team to examine the details of specific questions not performed well by students and thus offers another chance for the enhancement of the acquisition of competencies by the students. For example, during the delivery of the current ISSF course, a detailed analysis of the Labtest1 results enabled the teaching team to realize that students had not fully grasped essential concepts such as writing efficient code using a provided Java API, and how to manipulate reference variables in managing properly the null Java literal value. This observation enabled the teaching team to again clarify the related topics through a collaborative session with student participation, thus, "closing the loop" and improving teaching and learning.

Enhanced Feedback to Teaching Team

In the past, teachers had to rely purely on student grades and marks to decide how well the course content was understood by the student. This approach was ineffective since tracing back from grades to topics was very difficult and, in practice, seldom done. With the implementation of the CLCC framework, the teaching team can gain valuable and timely feedback on how students are performing, and where they stand with respect to the set of competencies they are supposed to acquire. Since there is a clear linkage between competencies and topics, the teaching team is able to focus on topics where competencies are not being acquired and explore alternative pedagogies for enhancing the learning of these topics and competencies. Furthermore, at the end of the semester, the teaching team is able to list all the competencies that were acquired or not acquired and pass this list to the teaching team responsible for subsequent courses to use the set of competencies as pre-requisites.

7. EDUCATION TOOLS SUPPORTING THE CLCC FRAMEWORK

In order to support the program manager and the individual course managers implement the CLCC framework a set of education tools were developed. These tools were designed and implemented by the School of Information Systems to support the program-level curriculum design, in particular the definition of the program-level learning outcomes, the list of foundation and elective courses together with their detailed course syllabus and course-specific competencies that address the program-level learning outcomes. Figure 11 shows the complete ecosystem of the tools supporting the framework.

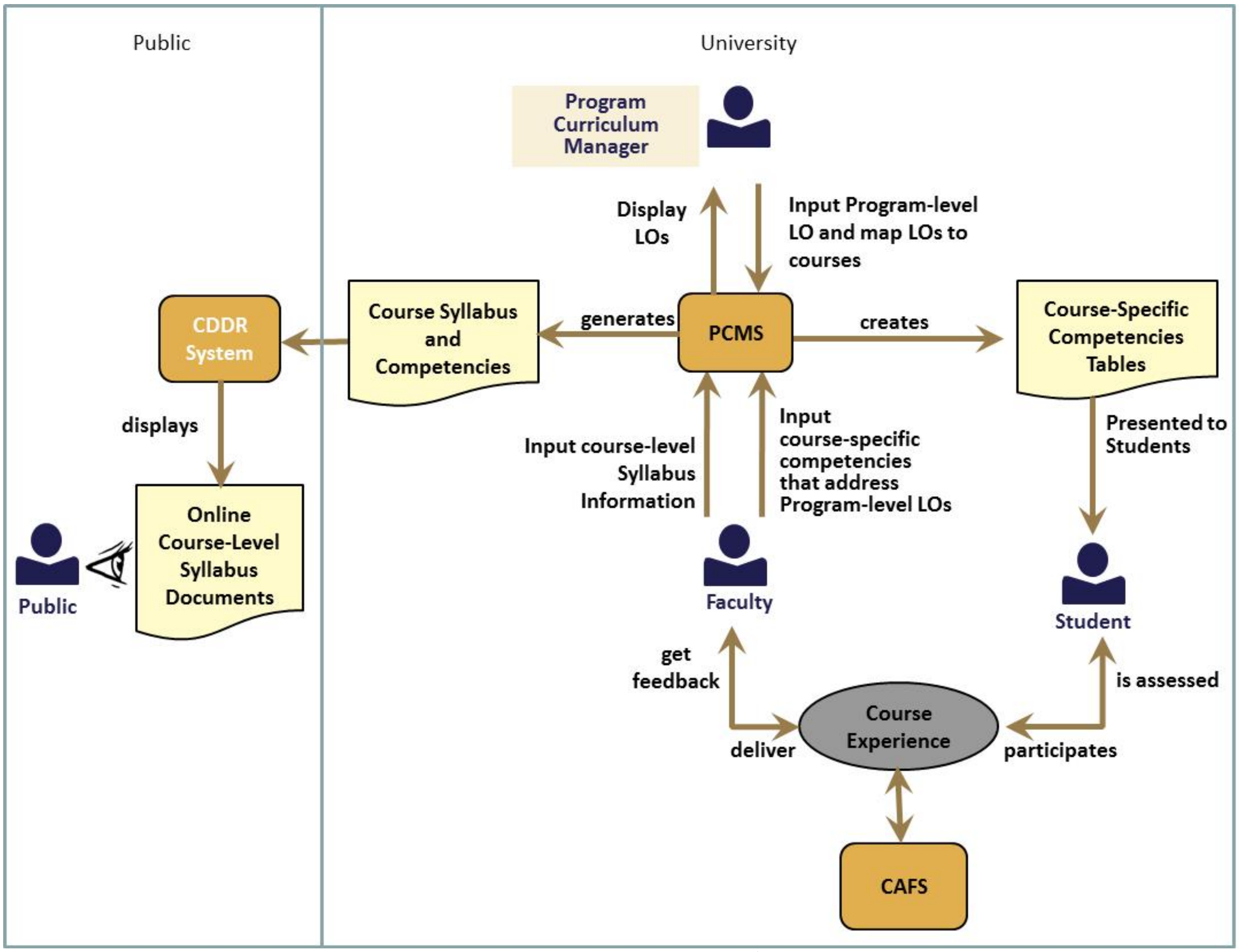


Figure 11: Education tools supporting the CLCC framework

PCMS

PCMS (Program and Curriculum Management System) is an internal web application which is accessible to internal school staff only. Four main sets of functionalities have been embedded into this system:

a. Functionality facilitating program-level learning outcomes management: The Dean's office (usually, the program manager) defines the set of learning outcomes for the program. These outcomes define the direction for all courses related to that program and are used by PCMS as the base for course-specific competencies. Additionally, the program manager upon discussion with the individual course managers will map the learning outcomes to specific courses, depending on if the particular learning outcome is addressed in the given course.
b. Functionalities facilitating course-level competencies management (number 1 in Figure 12): Competencies management is a comprehensive set of features enabling the teaching staff to create and manage competencies for all courses of the

program. Two different "views" are introduced in the system: Learning Outcomes view (i.e., competencies organised by Learning Outcomes of the program – as shown in Figure 13) and Course Topic view (i.e., competencies organised by Course Topics – as shown in Figure 14). Depending on their preferences, the teaching staff members can use either of those two views to enter and to manage the competencies. In addition to managing competencies, the system also requires the teaching staff members to enter selected data about the course assessments – nature of the assessment (individual or group assessment), weightage of the assessment, way of providing feedback to students etc. When managing competencies, it is necessary to associate each of the competencies with at least one assessment component (Figure 13). Once those associations have been established, a report can be drawn to carry out a cross-check if all competencies defined for the course are assessed in at least one assessment component of the course.

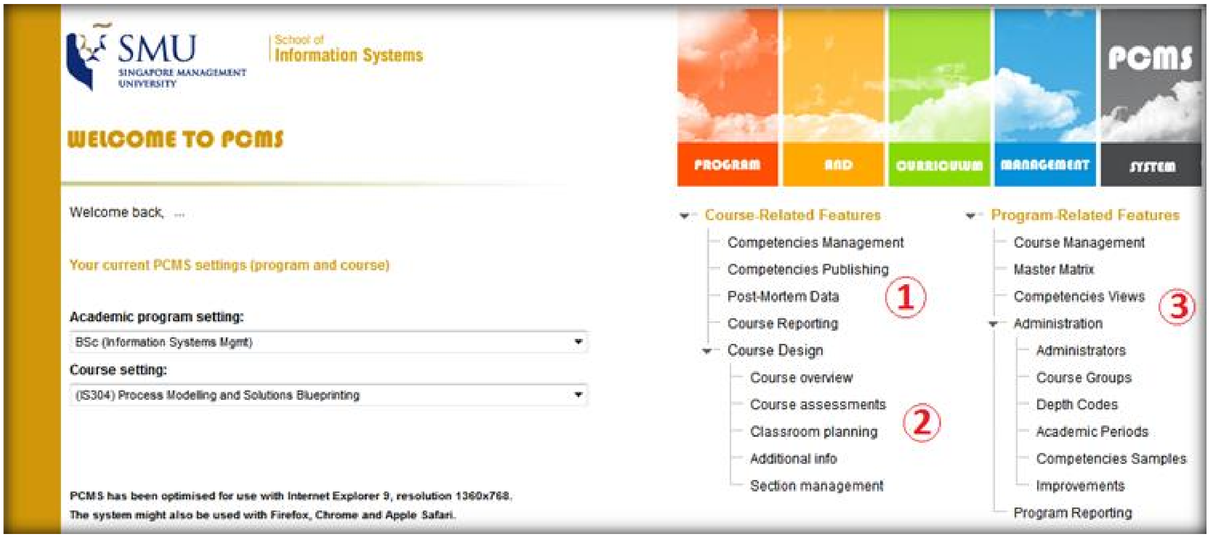


Figure 12: PCMS main page

Figure 13: PCMS competencies management page for the "Learning Outcomes View"

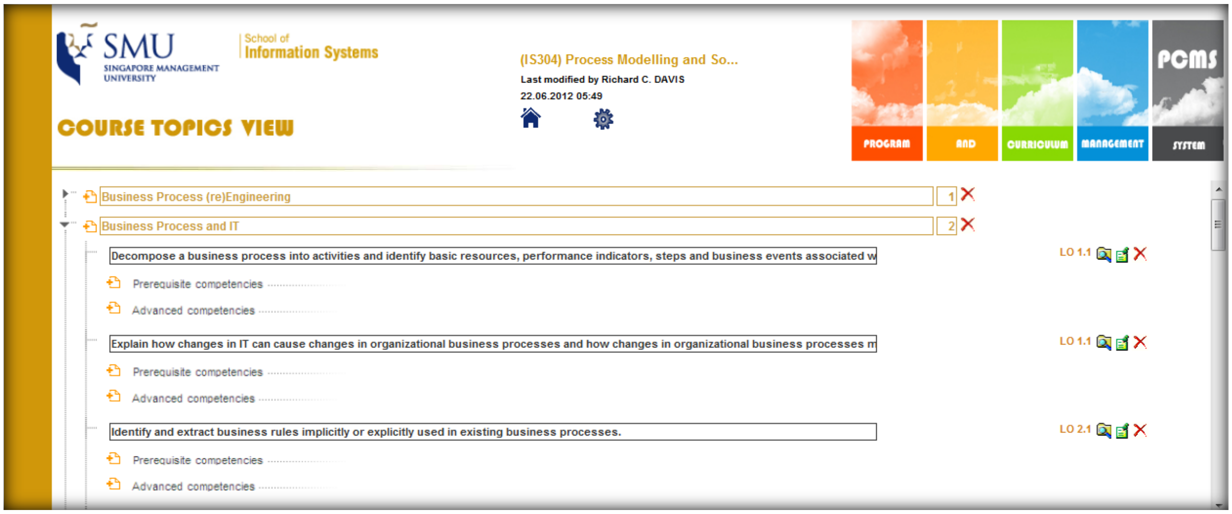


Figure 14: PCMS competencies management page for the "Course Topics View"

c. Functionalities enabling course design management (number 2 in Figure 12): This set of features allows the faculty members to manage all the relevant information regarding the course design using an online interface. The course information presented in this online interface is mainly the course overview, synopsis, prerequisites, objectives and structure, course assessments, classroom planning such as schedule summary as well as weekly schedule. The courses are also allowed to introduce any number of additional custom sections to present any information which are unique and distinguish the courses among each other.

d. Program-related functionalities (number 3 in Figure 12): The final functionalities introduced in PCMS are the program-wide features. These features enable the management of basic course data, extraction of numerous program-level reports and maintenance of master data of the so-called "Master Matrix" (Figure 15). The Master Matrix displays a program-wide summary providing the school management with a global view of the learning outcomes coverage across all required Information System courses.

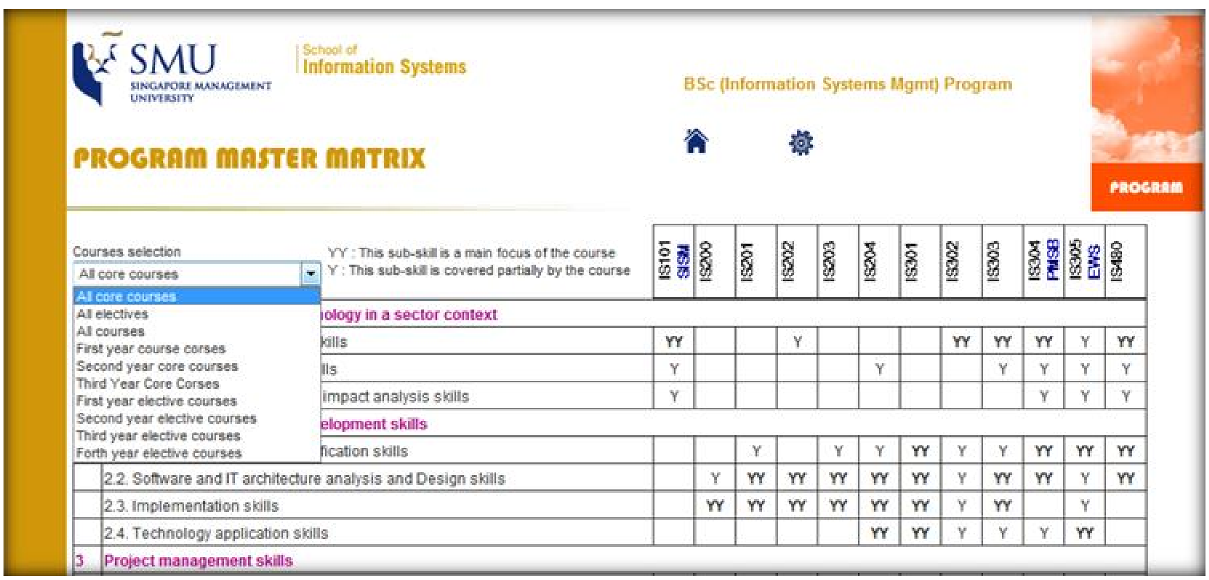


Figure 15: PCMS Master Matrix

CDDR

CDDR (Course Design Document Repository) is a system that serves as a front-end rendering application for course design data which is entered and maintained in the PCMS system. While PCMS is a system which is used internally only, CDDR is an interface which is open to public viewing. Four main sets of functionalities have been embedded into this system namely visualisation of course design information showing the course overview, course planning details, competencies, etc. Figure 16 shows an example of the CDDR displaying the course competencies for a specific course.

Figure 16: CDDR system competencies for an individual course

CAFS

CAFS (Competency and Assessment Feedback System) is a system that supports the various tables and figures described in section 4 of this paper that are used for mapping competency to assessments and then mapping assessment scores to competencies to give relevant feedback to students. Currently this system is implemented using various models in Microsoft Excel. This was a deliberate choice for easily prototyping for assessing the validity of our approach toward competency assessment and feedback. The models have been used and refined over 3 years (6 semesters) and with 2 foundation courses namely Information Software Foundations and Object Oriented Application Development. Given the success of the experiment, we are in the process of incorporating this functionality within PCMS. Table VII shows how we plan to implement the various tables and figures of section 4 into new modules of PCMS. The new features implemented in PCMS will then facilitate the adoption of the CLCC by the teaching teams, generating automatically the cohort competency acquisition map for each assessment.

Table VII. Future plan for incorporating new functionality within PCMS

Models	Current implementation	Future implementation	Comments
Table I – Course Competency Matrix	PCMS	PCMS	No change
Table II – Mapping Matrix of Competencies to Topics Weeks and Assessments	Microsoft Excel	PCMS	New Feature
Table III – Mapping Matrix of Competencies to Assessment Questions	Microsoft Excel	PCMS	New Feature
Table IV – Mapping Matrix of Competencies to the various Course Assessments	Microsoft Excel	PCMS	New Feature
Table V – Detailed Grading Result Matrix for Particular Assessment	Microsoft Excel or LMS if online assessment	PCMS	New Feature
Figure 7 – Distribution of students per grade for a particular assessment	Microsoft Excel	PCMS	New Feature
Figure 8, 9 and 10 – Cohort Competency Maps	Microsoft Excel	PCMS	New Feature

8. CONCLUSION AND FUTURE WORK

This paper presented how course competencies can be used to effectively deliver and assess course content, and give valuable timely feedback to students. The CLCC framework for leveraging course competencies during course design and delivery was presented. This framework addresses the following five phases of a course. It ensures that competencies become an essential part of the learning contract. The CLCC framework enables the course teaching team to regularly use appropriate, documented processes for assessing and evaluating the extent to which the competencies are being attained, thus, “closing the loop” and improving teaching and learning.

However, the implementation of the CLCC framework poses two key challenges: namely extra effort and, as a result, resistance from instructor.

Currently, the implementation of the CLCC framework relies on additional manual work using a spread sheet tool. This requires more data entry into the spread sheet. For each assessment type, the teaching team has to capture the component grades pertaining to a specific question or sub-question within the assessment. Table VII gives an estimation of the number of component grades that have to be captured depending on the assessment type. It also shows an estimation of the extra effort (additional time) required as a result of this additional data entry compared to a classical method where the teaching team would have to enter only one score per assessment per student.

Table VIII. Extra Effort Required in the CLCC Framework

Assessment Type	Average number of component grades (questions / sub-question) to enter per student	Extra effort (time) required to enter all component grades compared to entering only final assessment grade
Quiz	3 to 5	10%
Lab Test	10 to 15	5%
Project	10 to 15	5%
Final Exam	20 to 30	50%

As shown in Table VIII, the extra effort required is not proportional to the number of component grades that must be entered. However, it is observed that the effort required increases for paper-based assessments. When the assessment is paper-based, e.g. a final exam, the marking is first done on paper and then the results are transferred to a spread sheet. When the assessment is online, e.g. lab tests, the teaching team enters the component grades in the online system as they grade, so there is no significant time overhead in using the CLCC framework.

Overall, there is a slight overhead involved in using the CLCC framework. As a result, there could be resistance from the teaching team to the adoption of the CLCC framework.

Future work will be aimed at further developing the CAFS (Competency and Assessment Feedback System) and integrating it with the PCMS (Program and Curriculum Management System) which will alleviate some of the extra effort required in implementing the CLCC framework. Currently, though the spread sheet approach works for a specific course, the integration of CAFS and PCMS will help to link the learning outcomes and competencies across different courses.

From a teaching and learning perspective, though grades are captured for each individual student, the current CLCC implementation focuses on the competency acquisition at the cohort level rather than for each individual student. It would be valuable to capture, for each student, the list of competencies that have been acquired or not acquired within a specific assignment and then a consolidated view across the different assignments of the same course. For competencies that have not been acquired, the students would be directed to specific material that would help them enhance these competencies.

As evident in the survey results, the framework helps both the students and the teaching team. The CLCC framework helps students to be better prepared for assessments, and instructor to gain a deeper understanding of what competencies students have acquired and not acquired. The immediate feedback after each assessment helps students clearly understand their mistakes. Thus, the whole process helps towards the enhancement of both teaching and learning.

In our experience, the CLCC framework works well for a foundation courses such as programming and databases courses that have highly structured content and assessment. Therefore, making it easier to define competencies to a fine level of granularity and develop assessments that can map well to these competencies. However, translating this approach to advanced courses in the curriculum where the content is more open and involves students preparing long essay report or extended projects can be quite challenging. The authors are fully aware of this limitation and are currently prototyping an adaptation of the proposed framework on an advanced course titled “Enterprise Integration”. The authors also fully appreciate the fact that the proposed framework may not be suitable for courses in other more descriptive subject domains such as management or economics.

ACKNOWLEDGMENTS

The authors would like to acknowledge the efforts of the teaching team involved in the design and delivery of the ISSF course in implementing the CLCC framework for this course.

REFERENCES

(ABET 2013) ABET. (2013). 2013-2014 Accreditation Policy and Procedure Manual, ABET.

(Ahmed et al. 2013) Ahmad, M.,Karim, A.A., Din, R.,Albakri, I.S.M.A. (2013). Assessing ICT competencies among postgraduate students based on the 21st Century ICT Competency Model . Journal of Asian Social Science, 28 November 2013, Vol 9, Issue 16, pp32-39.

(Anderson et al. 2001) Anderson, L. W. and Krathwohl, D. R. (Eds). (2001). A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Allyn & Bacon. Boston (Pearson Education Group).

(Anwar et al. 2012) Anwar, M.A., Ahmed, N. and Abdurahem Mohammed Al Ameen. (2012). An Outcome-Based Assessment and Improvement System. Contemporary Issues. Education Research, Volume 5, Number 4, pp 279-293.

(Batterman et al. 2011) Batterman, S.A., Martins, A.G., Antunes, C.H., Freire, F and Da Silva, M.G. (2011). Development and Application of Competencies for Graduate Programs in Energy and Sustainability. Journal of Professional Issues in Engineering Education & Practice. Volume 137, Issue 4, pp 198-207.

(Baumgartner & Shankararaman 2013) Baumgartner, I. and Shankararaman, V. (2013). Actively linking learning outcomes and competencies to course design and delivery: experiences from an undergraduate Information Systems program in Singapore. In the Proceedings of IEEE Global Engineering Education Conference (EDUCON 2013). Berlin, Germany, pp 238-246.

(Boyatzis 1982) Boyatzis, R.E. (1982). The Competent Manager: A Model for Effective Performance.New York: Wiley-Interscience.

(Bruce & Bruce 2010) Bruce, S & Bruce, W. (2010). IS 2010 and ABET Accreditation: An Analysis of ABET-Accredited Information Systems Programs. Journal of Information Systems Education, Vol. 22, No. 4, Winter 2011.

(Burge & Leach 2010) Burge, L.L and Leach, R.J. (2010). An Advanced Assessment Tool and Process. Proceedings of the 41st ACM technical symposium on computer science education. (SIGCSE '10). March 10-13, 2010, Milwaukee, Wisconsin, USA

(Daigle 2007) Daigle, J.R., Hayes,D.C., and Hughes II, K.E. (2007). Assessing Student Learning Outcomes in the Introductory Accounting Information Systems Course Using the AICPA's Core Competency Framework. Journal of Information Systems: Spring 2007, Vol. 21, No. 1, pp. 149-169.

(Donaldson et al. 1995) Donaldson, J., et al. (1995). European Projects for Evaluating Quality in Higher Education: Guidelines for Participating Institutions. Higher Education in Europe, Volume 20, Issue (1/2), pp. 116–133.

(Espinosa-Curiel et al. 2011) Espinosa-Curiel, I.E., Rodríguez-Jacobo, J and Fernández-Zepeda, J.A. (2011). A competency framework for the stakeholders of a software process improvement initiative. In Proceedings of the 2011 International Conference on Software and Systems Process (ICSSP '11). ACM, New York, NY, USA, 139-148.

(ETS 2008) Educational Testing Service. (2008). Digital Transformation: A Framework for ICT Literacy. A Report of the International ICT literacy Panel, Educational Testing Service. Princeton, NJ.

(Hejazi & Janzen 2011) Hejazi, B.M and Janzen, K. (2011). A Transformational Perspective on Quality and Mobility in Higher Education Community College Leadership Program, OISE, University of Toronto.

(Hussey 2008) Hussey, S. and Smith, P. (2008). Learning outcomes: a conceptual analysis. Teaching in Higher Education, 13(1): p. 107–115.

(Johnson 2000) Johnson, D.W. (2000). Competency-Based Educational Program Effectiveness Assessment. Journal of Information Systems Education, Volume 11. Issue No 3-4, pp 127-132.

(Kelin-Collins 2012) Klein-Collins, R. (2012). Competency-Based Degree Programs in the U.S.Council for Adult and Experiential Learning, USA.

(Killen 2007) Killen, R., Teaching Strategies for Outcomes-Based Education. 2 ed. 2007, Cape Town, South Africa.

(Larson & Harrington 2012) Larson, S and Harrington, M.C.R. (2012). "A Survey of ABET Accredited Information Systems Undergraduate Programs in the USA". In Proceedings of the Information Systems Educators Conference, ISSN: 2167-1435,v29, n1961, New Orleans Louisiana, USA

(Lister et al. 2012) Lister, R et al. (2012). Toward a Shared Understanding of Competency in Programming: An Invitation to the BABELnot Project. In the Proceedings of the Fourteenth Australasian Computing Education Conference (ACE2012), Melbourne, Australia, pp53-60.

(Malan 2000) Malan, S.P.T. (2000). The 'new paradigm' of outcomes-based education in perspective. Journal of Family Ecology and Consumer Sciences, 28.

(McNamara 2004) McNamara, R.A. (2004). Evaluating assessment with competency mapping. In Proceedings of the Sixth Australasian Computing Education Conference (ACE 2004). Dunedin, NZ, ACE2004. Australian Computing Society. pp 193-199.

(Moyo-Acerado et al. 2014) Moyo-Acerado, R.,Rabago, L, W.,Tanguilig,B.T. (2014). Competency model for information ssytems specialization track utilizing RIASEC and Value Search Models. In Proceedings of Computer Science & Information Technology (CS & IT) edited by David C. Wyld et al, pp 123-134.

(Parry 1997) Parry, S.R. (1997). The Quest for Competence. Training Magazine, Vol 7, pp 48-56.

(Passow 2012) Passow, H. (2012). Which ABET Competencies Do Engineering Graduates Find Most Important in their Work? Journal of Engineering Education. Vol. 101, Issue 1, p95-118. 24p.

(Pinto 2010) Pinto, Y. (2010). A Strategy, Implementation and Results of a Flexible Competency Based Curriculum. ACM Inroads. Vol. 1, No. 2, pp 54-61.

(Raychen & Salganik 2003) Rychen, D.S. and L.H. Salganik. (2003). Key Competencies for a Successful Life and Well-Functioning Society. Göttingen: Hogrefe & Huber.

(Spady 1994) Spady, W. (1994). Outcome-based education: Critical issues and answers. Arlington, American Association of School Administrators.

(Topi, 2010) Topi, H., Valacich, J.S., Wright, R.T, Kaiser, K., Nunamaker, Junior, J.F., Sipior, J.C., and de Vreede, G.J. (2010). IS 2010: Curriculum Guidelines for Undergraduate Degree Programs in Information Systems, Communications of the Association for Information Systems: Vol. 26, Article 18.

(Wang et al. 2008) Wang, T., Schwartz, D. and Lingard, R. (2008). Assessing student learning in software engineering. Journal of Computing Sciences in Colleges, Volume 6, pp 239-248.

(Van der Horst & Mcdonald 1997). Van der Horst, H and Mcdonald, R. (1997). OBE: A teacher's manual. Pretoria, Kagiso.