Making learning outcomes and competencies truly relevant for the practical course design and delivery: insights for university-level computing program educators

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Abstract

While many university-level Engineering programs worldwide seem to have a formal definition of learning outcomes (or competencies, or student outcomes, or performance indicators, or educational objectives), in many cases, those formal constructs do not have any substantial (and practical) impact on the course design and delivery lifecycle. This conference paper reports on selected curriculum and course design and delivery experiences made within the Bachelor of Science (Information Systems Management) degree program (BSc (ISM)) offered by the School of Information Systems (SIS) at the Singapore Management University (SMU). This paper introduces the readers to the Learning Outcomes framework defined at the school, highlighting the role of learning outcomes defined at the program level and the role of course-level competencies. This contribution particularly focuses on the course designers' efforts to establish a clear and effective linkage between the learning outcomes competencies to the actual course design, implementation and delivery. While this conference contribution reports on experiences made within the frame of an Information Systems program, the applicability of the best practices described in this paper is very broad and might be interesting to many Engineering educators seeking for systematic approaches in effectively linking learning outcomes and competencies defined at program, track or course levels to the actual education practice.

Keywords: *Program-level learning outcomes, course competencies, course design, competencies and learning outcomes relevance*.

1. Introduction

It seems that many Engineering programs worldwide have a formal definition of educational objectives, learning outcomes, competencies, performance indicators or similar constructs. Frequently, the definition of those constructs is triggered by activities such as potential accreditation, external visits or reviews, certifications or licencing. However, once formulated, endorsed by the school or faculty management and officially published on the web site of the particular university, school or faculty, those constructs completely lose their relevance for the educational practice, teaching and learning in those educational institutions. Most students (and – frequently – even faculty members) do not even seem to be aware of the existence of such definitions – and do not see how and why there should be any relation between those constructs and the actual teaching and learning process.

In this conference contribution, the author presents an example of how such – initially – formally defined constructs may be productively used in the teaching and learning process and how such constructs may deeply impact the actual course design and delivery.

The paper unfolds the following manner.

In section two of this paper, the author undertakes a brief literature review of how competencies- and outcomes-based teaching and learning approaches have been used up to date in university-level

education. Particular focus is put on understanding how an effective linkage might be established between any kind of outcomes formally defined for a specific course, track or program and the actual course, track or program design and delivery.

Section three introduces the reader to the Learning outcomes framework defined at the School of Information Systems, Singapore Management University. The author provides a brief historical review of the development and evolvement of this framework. Moreover, this section shows the rationale for developing this framework and explains how it forms the principal backbone of the teaching and learning ecosystem at the School.

Section four presents a set of practical examples on how the Learning outcomes framework (along with its main elements – competencies and learning outcomes) are productively used in the course design and delivery process. Using selected core courses of the Bachelor of Science (Information Systems Management) degree program as examples, the author shows how competencies (which are defined at the course level) might be used to make the course more relevant, more transparent and more attractive to students.

Section five concludes with a set of best practices in defining and using program-level learning outcomes and course-level competencies in computing programs. While this conference contribution reports on experiences made within the frame of an Information Systems program, the applicability of the best practices described in this paper is very broad and might be interesting to many Engineering educators seeking for systematic approaches in effectively linking learning outcomes and competencies defined at program, track or course levels to the actual education practice.

2. Learning outcomes and competencies in university-level computing education: a literature review

Outcomes-based education is not new. The concepts of learning outcomes, competencies, educational objectives have been around for several decades. Outcomes-based education is focusing primarily on the process of learning instead of on the process of teaching.

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. [1] [2] As explained by the leading advocates of the Outcomes Based Education, learning outcomes have a great influence on the curriculum design process and they determine the process of the assessment design and implementation. [3] As expressed by Spady: "Outcome-Based Education means clearly focusing and organising everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences. This means starting with a clear picture of what is important for students to be able to do, then organising the curriculum, instruction, and assessment to make sure this learning ultimately happens." [4] Principally, the outcomes-based learning and teaching approach is specifically designed to promote more effective learning at all levels. [5]

While there is no one single model describing the essence of the outcomes-based education, it seems that the majority of research done in this area primarily supports the view that OBE "share[s] an emphasis on systems-level change, observable, measurable outcomes and the belief that given time, all students can learn". [6]

When studying the nature and effectiveness of the outcomes-based education, Spady [4] described four essential principles:

- Clear focus on culminating outcomes of significance.
- Expanding opportunities of learner success through drill and practice.
- Great expectations of learners to succeed through mastery of steps leading to objective attainment.
- Designing curriculum that enables the performance of behavior outcomes.

Further research in this domain has confirmed the importance of those principles. [7] In fact, the current research clearly shows that outcomes-based education and learning-by-doing is by far the most effective way to acquire a particular skill, ability or proficiency. [8]

3. Learning outcomes framework implemented at the School of Information Systems, Singapore Management University

The origins of the Learning Outcomes framework implemented at the School of Information Systems, Singapore Management University, date back to the year 2003. It was drafted at the very outset of the initial curriculum of the BSc (ISM) program, prior to the intake of the pioneer freshman batch. [9]

After several revisions, in the year 2008, the learning outcomes framework arrived at its first stable state. The framework was based on three main constructs: first level learning outcomes, second level learning outcomes and third level learning outcomes. First level learning outcomes were eight very high-level constructs describing very general topic areas relevant for future Informations Systems and Information Technology professionals. The second level learning outcomes represented a small set of sub-concepts associated with the first level learning outcomes. The third level was mainly added for clarification reasons – to explain each of the second level learning outcomes more in detail. The following list represents the eight first level learning outcomes:

1. Integration of business and technology in a sector context
2. IT architecture, design and development skills
3. Project management skills
4. Learning-to-learn skills
5. Collaboration (or team) skills
6. Change management skills for enterprise systems
7. Skills for working across countries, cultures and borders
8. Communication skills

As explained above, for each first level learning outcome, several second level learning outcomes were defined, and each second level learning outcome has several third level learning outcomes attached to it. The following listing represents an example of one full three-level construct for one of the learning outcomes (i.e., learning outcome number 2 and 2.1.):

2. IT architecture, design and development skills
   2.1. System requirements specification skills
   Ability to:
   a) Elicit and understand functional requirements from customer
   b) Identify non-functional requirements (performance, availability, reliability, security, usability etc.)
   c) Analyse and document business processes

The main rationale of designing and implementing a learning outcomes framework at the program level was the desire to make the learning and teaching environment at the school as effective and transparent as possible. Thus, the major aspects of the framework implementation were concerned not only with defining those learning outcomes but also with achieving a true buy-in among faculty members, students, alumni and industry partners.

While the defined learning outcomes framework proved to be a very useful tool at the program level (enabling a high level view on the areas and topics covered by the entire BSc (ISM) program and allowing faculty members to target specific areas in their courses), its usefulness seemed to be limited at the individual course level. Even learning outcomes at level three seemed to be too detached from actual course contents and actual course topics. A real observability and measurability of the learning outcomes at the course level could still not be achieved.

These insights led to a new revision round of our learning outcomes framework in 2010. To achieve course-level relevance and to provide a tool for connecting high-level learning outcomes with the actual course content and course delivery, the concept of course competencies was introduced. For all core as

well as elective courses within the program a set of core competencies was defined specifically focusing on topics, skills and knowledge delivered in the particular course. Those core competencies were directly linked to the second level learning outcomes (or – expressed in other words – those core competencies addressed selected second level learning outcomes). In addition to the core competencies construct, two other types of competencies were introduced – prerequisite competencies and advanced competencies. Prerequisite competencies were skills or abilities which the students were supposed to possess when entering a given course, and advanced competencies were skills or abilities which only a smaller set of top students were able to learn and achieve in a given course (through advanced exercises provided by the teaching staff, self-learning etc.).

The following listing exemplifies a selected set of competencies assigned to the second level learning outcome "System requirements specification skills". This set of competencies is extracted from the core competencies list defined for a third year senior core course of the BSc (ISM) program called "Enterprise Web Solutions".

2. IT architecture, design and development skills
    2.1. System requirements specification skills
        - *Document server architecture for an enterprise portal based on a given business case.*
        - *Explain the basic steps of an enterprise portal planning process.*
        - *Explain the most important considerations which need to be taken into account when developing search requirements for the enterprise portal.*
        - *List the most important end-user facing search features in enterprise portals.*
        - *Create a portal topology document for an enterprise portal based on a given business case.*
        - *Perform basic user needs analysis and document the outcomes of this analysis when designing and implementing an enterprise portal.*
        - *Write-up implementation specifications for a custom WebPart based on a given business case.*

While the program-level learning outcomes are wide and rather generic IS and IT-related topics, the competencies (represented in italics in the above listing) are very specific and concrete skills and abilities which the students are expected to possess when completing the course.

The second version of the Learning Outcomes framework has now been in use since 2010. All courses of the BSc (ISM) program have their competencies (core, advanced and prerequisite) consistently defined, and those competencies are extensively used in the course design and delivery process. Currently, the next revision round of the Learning Outcomes framework is being prepared – namely, closer and more effective alignment of the initial learning outcomes with the Student Outcomes as defined by the American Accreditation Board for Engineering and Technology (ABET) [10]. To achieve this alignment and to build upon widely accepted best practices and best experiences, our initial concept of learning outcomes will be merged with the ABET concept of student outcomes. Moreover, a set of "Performance Indicators" will be developed for each of the Students outcomes, and those performance indicators will take place of the current second level learning outcomes. Our preliminary investigation shows that the overwhelming majority of course-level competencies can be easily mapped to the newly created performance indicators, this way fully retaining one of the most important components of our initial Learning Outcomes framework. Thus, the third revision of our Learning Outcomes framework seems to represent a process of further, natural and systematic evolvement rather than a complete new state.

4. The role of learning outcomes and competencies in the course design and delivery lifecycle

As briefly highlighted above, the core competencies are defined at the course level and represent a set of skills, abilities and knowledge which the students taking the course are expected to acquire and be able to demonstrate when graduating from the course. Although the core competencies are course-specific their enforced linkage to the second level learning outcomes (which are defined at the BSc (ISM) program level) is representing an essential tool in making the program-level learning outcomes relevant and important for the design, implementation and delivery of individual courses of the BSc (ISM) program.

Although the use of core competencies in the actual course design, implementation and delivery process is very unique for every single course within the BSc (ISM) program, there are several best practices which have been developed at the School and which are consistently used across most of the courses of the BSc (ISM) program. This section of the paper introduces the reader to these best practices and presents selected examples demonstrating the practical application of those best practices.

4.1. Core competencies and their role in the course design process

The core competencies have proven to be an effective vehicle to drive the course design and implementation process. While the initial course design usually happens around a rather small set of selected high-level themes and topics, the definition of low-level competencies associated with each of those high-level themes forces the course designers to think through each of the delivered topics and themes to a very detailed and very specific level. While it is certainly relatively simple and easy to declare that, for example, in week 5, the lecture and all the associated class activities will be covering a topic such as "Business process (re-)engineering", this topic is of a far too generic nature to give any meaningful insights to students (and also to the teaching staff) what exactly the students are expected to gain through attending this specific class. Moreover, the title of the topic does not provide any insights as to any specific abilities or skills which the students will be developing during this class.

The following listing provides a set of competencies defined for the "Process Modelling and Solution Blueprinting" core course of the BSc (ISM) program, and these competencies are specifically addressing the topic "Business process (re-)engineering" in this course:

- *Apply the business process engineering methodology for representing process, identifying issues and suggesting changes.*
- *Collect data for the Dynamic Analysis and identify relevant simulation parameters using the collected data.*
- *Create Organizational, Location, Collaboration and Workflow models for a given business scenario.*
- *Select business process models particularly suitable to document specific As-Is and To-Be scenarios and give justification why the particular models have been selected.*
- *Define the purpose of all BPM phases, the input required in each of the phases and the output produced in each of the phases.*
- *Explain the purpose of Business Process Modelling notations and various tools used to model business processes.*
- *Derive performance targets for a specific business process and associate the derived performance targets with suitable measurement metrics.*
- *Describe the purpose of Organizational, Collaboration, Location and Workflow models and identify the key attributes, key components and the advantages of their use.*
- *Select business process models particularly suitable to document specific As-Is and To-Be scenarios and give justification*

The concreteness and clarity of the competencies associated with this topic is evident. Logically, to ensure that all the listed core competencies are fully covered in the respective class, the course designers are required to very specifically look at every single lecture item, class exercise or laboratory component used in this particular class and clearly map the defined competencies to the class activities. While this low-level mapping and checking naturally requires additional effort and is associated with substantial additional workload for the teaching faculty, the clarity which is established through making extensive use of competencies in the course design process is undeniable. Moreover, this clarity may also considerably contribute to the way how students perceive the specific course and how clear they are about what is taught in this course and what outcomes are expected from the students in this specific course.

4.2. Core competencies and their role in the assessment process

Similarly to the course design process, core competencies defined at the course level may play an essential role in creating and defining assessment components for a specific course. In addition, core

competencies may also be used as a very powerful tool for students to prepare for assessments, exams, reviews or assignments.

Assessment components in a course are supposed to provide two-way information to the involved parties – on the one side, assessments help the teaching staff to understand if the students are actually learning what they are supposed to learn, and, on the other side, assessments are aiding the students to check how successful they have been in absorbing and internalising the contents delivered through a specific course. Thus, the design of an assessment component (and any associated documentation, preparation guidelines, grading rubrics) must be clearly and easily usable for both purposes.

While asking students to prepare for a bi-weekly laboratory test in a foundation programming course, it is certainly common to use statements such as: "We will be doing a lab test on loops and conditional statements next week. Please review all the material which we have covered in the past three weeks". The usefulness of such statements for both, creating a laboratory test which fulfils this purpose as well as preparing for such a test is, however, very limited.

The example below shows a list of core competencies defined for the IS Software Foundations course of the BSc (ISM) program. These competencies have been associated with the topics "Loops" and "Conditional Statements" of this course (and they have been linked back to the second level learning outcome "Implementation skills" and first level learning outcome "IT architecture and development skills"):

2. IT architecture, design and development skills
    2.3. Implementation skills
    - *Define and use a class in Java (constructor, getters, setters and methods with business logic).*
    - *Use conditional if-else constructs in Java to control whether a statement list is executed.*
    - *Use conditional switch statements in Java to implement a given number of possible execution paths.*
    - *Use single and nested looping constructs (for/while/do while) in Java code to enforce repeated code execution.*
    - *Use the class ArrayList or the array data structure for managing collection of similar class of objects in Java code.*
    - *Use looping and decision constructs to solve problems associated with ArrayLists.*
    - *Use Java API documentation to independently solve simple programming problems.*

The usefulness of the core competencies shown above when designing as well as preparing for a test is evident.

Firstly, the creation of the laboratory test can happen in a far more streamlined and effective manner since all tasks and exercises created for this laboratory component need to be clearly linked to some of the mentioned core competencies. It is easily possible to involve more than one teaching staff member in designing this particular assessment component as it would be possible to effectively agree on the specific set of competencies which need to be addressed by specific tasks or exercises of that assessment component. An effective overall check of the created assessment component is also possible by reviewing the covered competencies and ensuring that all involved core competencies are covered in a balanced and effective manner.

Secondly, the preparation guidelines for the laboratory test can be designed in a very functional and clear manner. Instead of asking students to "review" the previously covered material, they can be asked to specifically focus on the selected set of competencies. The preparation becomes more targeted, students can seek for more specific help and assistance, and they can use more aligned self-study means.

Core competencies of the course may also play a very important role in designing (and preparing) for the final assessments or final exams of a course. While elaborating and designing the final exam paper, it might be extremely useful for the course delivery team to scan through the list of the core competencies

of the course and identify the set of competencies which can be (or should be) tested in the final exam. According to the experience of the author of the paper, about 80% of the defined core competencies of a course should be tested (directly or indirectly) in the final exam. This concrete set of selected competencies provides a very solid baseline for creating and setting up final exam questions, exercises or tasks. Similarly, splitting the creation of the final exam paper across several teaching team members becomes easy as it is possible to agree on the set of competencies which each of the teaching team members would need to cover through his set of questions.

Preparation for the exam becomes streamlined for the students, too. Instead of "guessing" what the final exam will actually be about and what kind of skills or abilities it will test, the students are provided with a set of competencies which the teaching team is expecting the students to take away from this course. According to the experiences of the author, the students are very appreciative of this clarity and transparency, and the use of the competencies list in the final exam preparation process becomes more and more popular.

4.3. Core competencies and their role in the course post-mortem revision process

During the course post-mortem debriefing process, the teaching staff of each and every course in the BSc (ISM) program is analysing the process of the course delivery and any challenges or problems encountered during the respective term.

Particularly the need to introduce any new trends or new technologies is frequently associated with the re-examination of the existing competencies in the course. Introduction of new content, however, is not necessarily coupled with the introduction of new competencies (or removal of "old" ones). Principally, competencies defined for any of the BSc (ISM) program courses are representing abilities and skills which attempt to go beyond simple proficiency in specific tools or techniques. Rather than that, they emphasise the "learning-to-learn" principle, they encourage students to self-study and to seek themselves for solutions for "real-world" problems, and they tend to focus on highlighting the underlying principles and concepts instead of building up a mere "technical skill". Consequently, there is frequently no need (or only minor need) to change, adapt or even remove competencies to incorporate new contents, trends, technologies, approaches, or strategies.

4.4. Core competencies and their role in establishing credibility, applicability, accountability and transparency in the course

As already highlighted above, the competencies defined at the course level are representing a very useful tool in establishing a considerable transparency in the course. Instead of confronting the students exclusively with "high-level" topics and themes describing the contents of the course, an additional set of "low-level" competencies (or abilities, or skills, or capabilities) is offered showcasing the expected outcomes of the course in a more specific, more explicit, more tangible manner. Thus, the course requirements and the expected course output become more transparent to students.

While the defined set of course-level competencies (which, in turn, are closely linked to program-level learning outcomes) helps to a very great extent to make learning and teaching more effective and more transparent, this set of competencies enforces, of course, a great portion of accountability. Course-level competencies are clear, transparent, tangible statements. This is what students expect from the course. Thus, the teaching staff becomes very clearly accountable for delivering what the formulated competencies promise to deliver. Each and every lecture, class activity, laboratory component, project, exam can be easily checked and monitored if and how adequately the associated course competencies get covered in those course components. This ability of course-level competencies to considerably enhance accountability of the teaching staff might be specifically interesting for the school, faculty, university management.

Moreover, this specific set of course competencies seem to contribute to a great extent to the perceived applicability of the course. Considering the extreme professional pressure, the fast-paced changes in the

"real-world", the extremely dynamic environment in the Information Technology industry, students are more than ever interested in the applicability of the skills gained through the courses they attend and they spend their time with. While "high-level" descriptions, synopses, themes, topics etc. may give a good "first-glance" sense of what a particular course is about, these "high-level" statements are not apt to provide the students with deeper and more substantial information on the contents of the course and the skills acquired in the course. Contrary to that, competencies defined at the course level are extremely suitable in communicating to students what exactly they will be learning in this course and how all these competencies acquired in the course are related to the expertise, skills and knowledge currently required in the industry. This, in turn, enhances the credibility of the teaching staff, the course, the program, and the educational institution in general.

5. Conclusion

This conference contribution described selected course design and delivery experiences made within the frame of the Bachelor of Science (Information Systems Management) degree program (BSc (ISM)) offered by the School of Information Systems (SIS) at the Singapore Management University (SMU). This paper presented the Learning Outcomes framework designed and implemented at the school, particularly focusing on the role of the course-level competencies in the course design and delivery process.

Using selected courses as examples, this conference contribution has shown how a systematic approach in elaborating and defining a set of course-level competencies might positively impact the performance of the teaching staff, as well as the students' experiences in the course.

While the definition and subsequent integration of such competencies in the course delivery process produces a considerable workload for the teaching staff, the use of such competencies helps to establish more transparency for the teaching team members, helps to showcase to students the applicability and relevance of the course, and helps the management of the school, faculty or university in establishing a clear accountability for the contents delivered within the frame of specific courses.

While this conference contribution reports on experiences made within the frame of an Information Systems program, the applicability of the best practices described in this paper is very broad and might be interesting to many Engineering educators seeking for systematic approaches in effectively linking learning outcomes and competencies defined at program, track or course levels to the actual education practice.

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