



A Learning Outcomes Assessment Level Dashboard Based on Standard Terminology

Dr. Khalid W Khawaja, American University in Dubai

Dr. Khawaja is currently the associate dean of the School of Engineering and an associate professor of Computer Engineering at the American University in Dubai. In his tenure at AUD, he spearheaded ABET and UAE MOHESR accreditation of various graduate and undergraduate programs. He is an established expert on the use of Java technologies in enterprise applications. His research interest is in the area of Enterprise Computing and Architecture and its usage in Education Systems.

Work-in-Progress: A Learning Outcomes Assessment Mapping Level Dashboard Based on Standard Terminology

Abstract:

Continuous improvement of education programs hinges greatly on the assessment of program and course learning outcomes. Great effort and attention has been given to the identification of various elements that embody a strong program assessment process from establishing measurable learning outcomes at the course and program levels to the mapping and the assessment details. Computer dashboards that provide quick summary of the learning outcomes achievement level in real-time during the learning sessions can be very useful for learners, educators, and administrators. However, a dashboard that does not use a concise terminology to describe the mapping level at which we have been able to assess a particular program can eventually produce unreliable results. This paper is an attempt at creating a dashboard that is based on a terminology that focuses on the level of learning outcomes assessment as determined by the level of assessment mapping to learning outcomes. The terminology uses three basic assessment level quality attributes: coverage, validity, and focus. Established algebraic function quantifiers are used for nomenclature to describe achieved assessment mapping level of learning outcomes. Assessment types are classified as a Function or not and then are further classified as Onto, Onto-Many, Onto-All-Many, Many, All-Many or none. This classification is done both at the course level as well as the program level where the program level is further divided into Program and Program-Curriculum. The details of this dashboard using the standard classification are presented.

1 Introduction

Basing the improvement of education programs on the assessment of learning outcomes has become a fundamental element of accreditation. For example, the Computing Accreditation Commission (CAC) of the Accreditation Board for Engineering and Technology (ABET) expects applications to demonstrate proper assessment and evaluation of the outcomes through an established process that must show a feedback loop causing a sustained improvement⁽¹⁾. It is customary to map course outcomes to Program Outcomes^(2; 3; 4). Results from course outcomes assessment is then used as one of the exhibits for showing program outcomes achievement. Fixing issues that are identified with the assessment of learning outcomes usually requires several iterations. Early detection of issues can save enormous amount of effort and can shorten the improvement cycles. Dashboards that manage various aspects of the education experience are abundant today. Most share the goal of creating a transparent environment promoting early detection of potential problems. However, despite the heavy reliance on learning outcomes assessments to evaluate various programs, no dashboard focuses on the early issues with learning outcomes mapping at all levels. This work focuses on the creation of an enterprise level dashboard that reveals issues associated with the level of learning outcomes assessment mapping of a monitored program. In other words, it will identify how much valid mapping and assessment is being done therefore increasing the quality of reported results.

This paper will start with shedding some light on the complexity that we have to deal with followed by a presentation of the terminology that will be utilized in the dashboard. A layout of the system hosting the dashboard follows. The dashboard details are then presented followed by concluding remarks.

2 System Complexity

The need to develop some map to assess program outcomes impact was argued well in ⁽⁴⁾. Earl, et al, stated that outcomes mapping “offers a participatory methodology that can help programs develop a system that can meet both accountability and learning needs” ⁽⁴⁾. Accountability in an education program learning outcomes achievement starts with courses and their learning outcomes. The pervasiveness of computer technology and its mobility has opened new venues for tracking learning outcomes achievement that involves complex relationships ⁽⁵⁾. Figure 1 shows the required mapping for this environment. Establishing course learning outcomes must be followed by a mapping exercise of these outcomes to the program level. Various course assessments can then be performed per these learning outcomes. Scores can be tracked for each student on each course learning outcome. Achievement at this level can then be used to assess achievement at the program level provided that proper mapping exists from course learning outcomes to program learning outcomes. Other tools can be used to directly assess achievement in program learning outcomes like exit exams and surveys. The number of these relationships and the layers it goes through introduces significant complexity in establishing the assessment mapping status of a particular program. It is even more difficult to compare and contrast programs or efficiently describe progress made within a program. Furthermore, any intent to use technology and automation to aid in the processing of the assessment level is well received but is hampered by the fact that no concise terminology is available to describe the most basic of deficiencies in a concise view like a dashboard view. Therefore, a key element to a productive dashboard must be the establishment of a concise terminology.

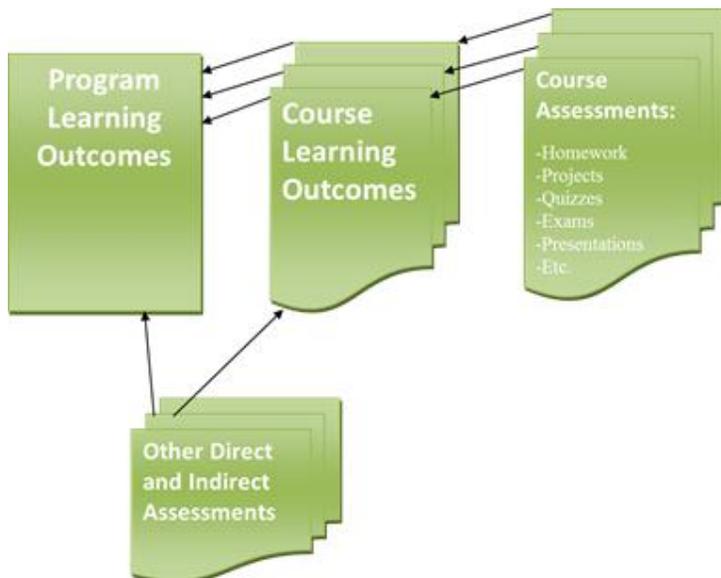


Figure 1. Relationship that must be tracked for continuous improvement of a college program

3 The Terminology

3.1 Coverage, Validity, Focus

Creating quality instructional material has been looked at by many. For example, the most recent work by Merrill through the Component Display Theory and Component Design Theory (CDT) lays the ground for creating material that can adapt to variations in learning styles⁽⁶⁾. CDT emphasizes the need to focus on a set of quality objectives or learning outcomes (accomplished through Knowledge Objects). The pillars of quality outcomes are well studied and perhaps the most widely accepted framework is embodied in the Bloom's Taxonomy⁽⁷⁾. This paper assumes properly phrased outcomes in all courses as well as at the program level with adequate instructional material to cover them and also assumes that these outcomes follow a well-established framework like Bloom's Taxonomy. Scientific Management Theory and Continuous Quality Improvement (CQI) have all emphasized the need to assess learning and assess its quality for continuous improvement^(3; 8). Establishing a terminology for describing the overall learning outcomes assessment quality is too big of a task to perform in a single iteration. The goal of this work is just to establish a terminology for the level of learning outcomes assessment mapping. In other words, it answers the question: how much reliable learning outcomes assessment has been done? In order to accomplish that, we need to identify the attributes of such goal. The following small subset of assessment level specific quality attributes that are mapping centric has been identified:

1. **Coverage:** emphasizing an education that is learning outcomes centric is well established⁽⁹⁾. Establishing learning outcomes that are eventually not assessed and evaluated is an obvious shortcoming. Therefore emphasizing an assessment that covers all outcomes is the first obvious key quality indicator of the level of assessment mapping.
2. **Validity:** concern over the validity of an assessment of a learning outcome is a concern that has been addressed and resolved by some through the proposal of an assessment redundancy scheme. Thomas, et al, summarized the idea by stating that "when multiple threats to the validity of measures emerge, use multiple sources of data generated by multiple methods of analysis to meet them. If the different measures seem to lead to similar conclusions, then the level of uncertainty in the results is reduced"⁽¹⁰⁾. Therefore, emphasizing an assessment that measures a learning outcome through several tools is another key indicator of the level of assessment mapping.
3. **Focus:** the type of assessment tools that are used is a concern whenever learning outcomes assessment and its quality is presented^(3; 4; 11). One indicator that we can rely on here is the number of learning outcomes covered by a particular tool. It is clear that the more outcomes we target with a particular assessment tool the less focus we will have because more resources and attention will be required to make sure that enough and equal attention is given by the assessment tool to every learning outcome it covers. Therefore, emphasizing an assessment with individual assessment tools that are focused on individual outcomes is a third key indicator of the level of assessment mapping.

The following section will introduce the definition of some terms that are gleaned from Algebra, hence are quickly understood by people with basic algebraic background. It will allow us to effectively and in very few terms communicate the status of programs, compare and contrast programs, and assess the progress of a program. This will be possible since the

terminology will give a sense of achievement for a particular program in terms of the three attributes identified here in this section. Collectively, these can form the core elements of a concise dashboard.

3.2 Classification of Learning Outcomes Assessment Mapping Level

If we focus on the mapping from assessments to learning outcomes, we can divide assessment into two categories:

One-to-one Course Assessment Tool: a course assessment tool that is used to assess one and only one course learning outcome.

One-to-many Course Assessment Tool: a course assessment tool that is used to assess more than one course learning outcome.

The above classification of assessments can then be used to classify course learning outcomes into the following 4 categories:

One-to-One Course Learning Outcome: a course learning outcome that is assessed by one and only one one-to-one course assessment tool.

One-to-many Course Learning Outcome: a course learning outcome that is assessed by one and only one one-to-many course assessment tool.

Many-to-one Course Learning Outcome: a course learning outcome that is assessed by more than one course assessment tool and all are one-to-one course assessment tools.

Many-to-many Course Learning Outcome: a course learning outcome that is assessed by more than one course assessment tool and at least one of the assessments is one-to-many course assessment tool.

Note that the “many-to” status is achieved by having more than one assessment. This threshold of one can be changed to any constant number per established program criteria. Figure 2 demonstrates the classifications at this level. A parallelogram is used to represent outcomes. Squares are used to represent assessments, e.g. in the context of a course this can be homework, quizzes, questionnaires, etc. Empty parallelograms or squares are reserved for the course level while shaded shapes are reserved for the program level. Note that no correlation is done between various assessment items. The focus at this stage is simply on the quality of the mapping.

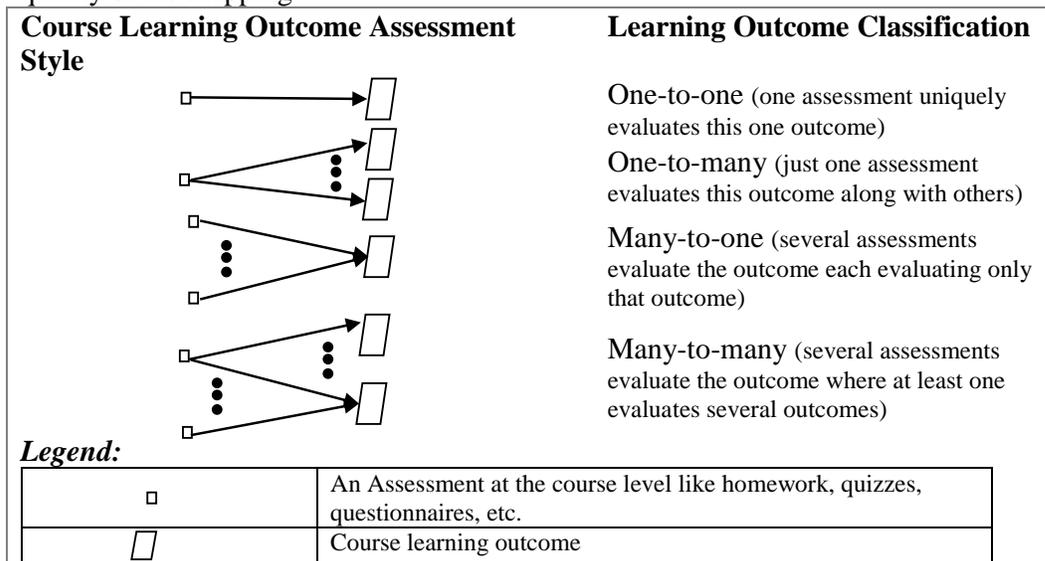


Figure 2. Classification of course learning outcomes into 4 types depending on their assessments

We will now use the above definitions to establish an algebraic view of a mapping exercise that can then align with the Coverage, Validity and Focus attributes. First, we will use the algebraic definition of a function that can be found in many algebra books ⁽¹²⁾. We will assume the set of course assessment tools to be the domain A, while the set of course learning outcomes to be the co-domain B. We can then make the following definition:

Function Course Assessment: *An assessment of a course where all the course assessments have been mapped to a course learning outcome and none of the assessed learning outcomes is one-to-many or many-to-many (They are either one-to-one or many-to-one)*

This definition deals with assessment **focus**. In the case of a Function assessment, each assessment we made in this course is uniquely mapped to one and only one learning outcome signaling highly focused assessment exercises.

Next, we will use the definition of the “onto” functions to make the following definition:

Onto Course Assessment: *An assessment of a course where all the learning outcomes of the course have been individually assessed by at least one course assessment tool.*

This element deals with assessment **coverage**. Onto course assessment signals an assessment that attempts to assess and evaluate all stated outcomes.

Exception: Note that in Algebra the Onto status requires the satisfaction of the Function status. However, the definition of the Onto course assessment in this work uses the Onto term even if the Function status is not obtained. For example, the existence of an assessment in a particular course that covers several learning outcomes will deem the course assessment not to be a function. However, if all the learning outcomes have been assessed, we will still refer to that course assessment to be Onto.

Focusing on the assessment cardinality, we can establish the following definitions:

One-to-one Course Assessment: *A course assessment where all the assessed course learning outcomes are one-to-one.*

Many Course Assessment: *An assessment of a course where some of the assessed course learning outcomes are many-to-one or many-to-many.*

All-Many Course Assessment: *An assessment of a course where all the course learning outcomes are many-to-one or many-to-many.*

Note that if the course assessment we are dealing with is also a Function, then the many-to-many learning outcome is excluded in the above two definitions.

The above cardinality definitions deal with assessment **validity**. For example, if triangulation is enforced (as argued in ⁽¹⁰⁾), the *Many-to* prefix status for any learning outcome is not achieved unless there are 3 or more assessments identified for the outcome. This classification then would signal the level of triangulation that has been achieved and therefore the validity of the measurements.

Figure 3 summarizes all the possibilities for a Function Course Assessment: Function, Function Onto, Function Many, Function All-Many, Function Onto-Many and Function Onto-All-Many. Note that all the assessments in the figure are one-to-one (concerned with just one outcome); hence the Function classification and the high focus designation for all the cases. A course assessment that is NOT a function would have an equal number of cases

where in each case at least one of the assessments is one-to-many and the focus is low (for an overall total of 12 cases).

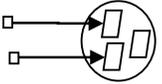
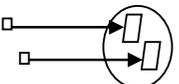
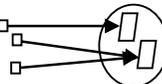
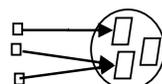
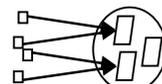
<i>Course Outcomes Assessment Style</i>	<i>Course Classification</i>	<i>Coverage, Validity Focus</i>
	Function course assessment	Low coverage, low validity, high focus
	Function Onto course assessment	High coverage, low validity, high focus
	Function Onto-Many course assessment	High coverage, medium validity, high focus
	Function Onto-All-Many course assessment	High coverage, High validity, high focus
	Function Many course assessment	low coverage, medium validity, high focus
	Function All-Many course assessment	low coverage, high validity, high focus

Figure 3. Courses carry Function, Function Onto, Function Many, Function All-Many, Function Onto-Many, Function Onto-All-Many, Onto, Many, All-Many, Onto-Many, Onto-All-Many or no classification

Program learning outcomes are classified similar to course outcomes. However, at this level we notice that there is value in having two classification types. One is program-curriculum type and is course centric. It focuses on the number and types of courses that are used to assess a particular program outcome. In this case, the domain A is the set of various courses that map to program learning outcomes through a subset of their course learning outcomes. The other classification is program type and is more general where course evaluations are considered to be a category of many that can also include peer evaluations, industry feedback, various types of questionnaires, etc. The set of all these assessment types is the domain A in this case. The co-domain B for these two classifications is the set of program learning outcomes. The classification terminology in this section will enable all parties that are interested in the evaluation process to establish one common view of the current program outcomes evaluation mapping state.

One-to-one Program Assessment Tool: a program assessment tool that is used to assess one and only one program learning outcome.

One-to-many Program Assessment Tool: a program assessment tool that is used to assess more than one program learning outcome.

A course (or a clearly identified piece of a course) may have all its learning outcomes map to just one program outcome. Similarly, a questionnaire maybe used to assess just one program outcome. These are one-to-one program outcome assessments. When one of these assessment tools is used to assess several program outcomes, they are classified as one-to-many.

In the following definitions whenever we refer to a course we mean a segment of instructions and assessments that clearly services a subset of course learning outcomes. For example, in the context of a college course, this could very well be a clearly identified segment of a course spanning a clearly identified portion of time and covering a subset of the course learning outcomes or it could be the entire course with all its assessments and learning outcomes. In the figures, we will refer to this as a textured parallelogram.

One-to-one Program-Curriculum Learning Outcome: a program learning outcome that is assessed by one and only one one-to-one program assessment tool where all the assessment tools are courses.

One-to-many Program-Curriculum Learning Outcome: a program learning outcome that is assessed by one and only one one-to-many program assessment tool where all the assessment tools are courses.

Many-to-one Program-Curriculum Learning Outcome: a program learning outcome that is assessed by more than one program assessment tool and all are one-to-one program assessment tools where all the assessment tools are courses.

Many-to-many Program-Curriculum Learning Outcome: a program learning outcome that is assessed by more than one program assessment tool and at least one of the assessments is one-to-many program assessment tool where all the assessment tools are courses.

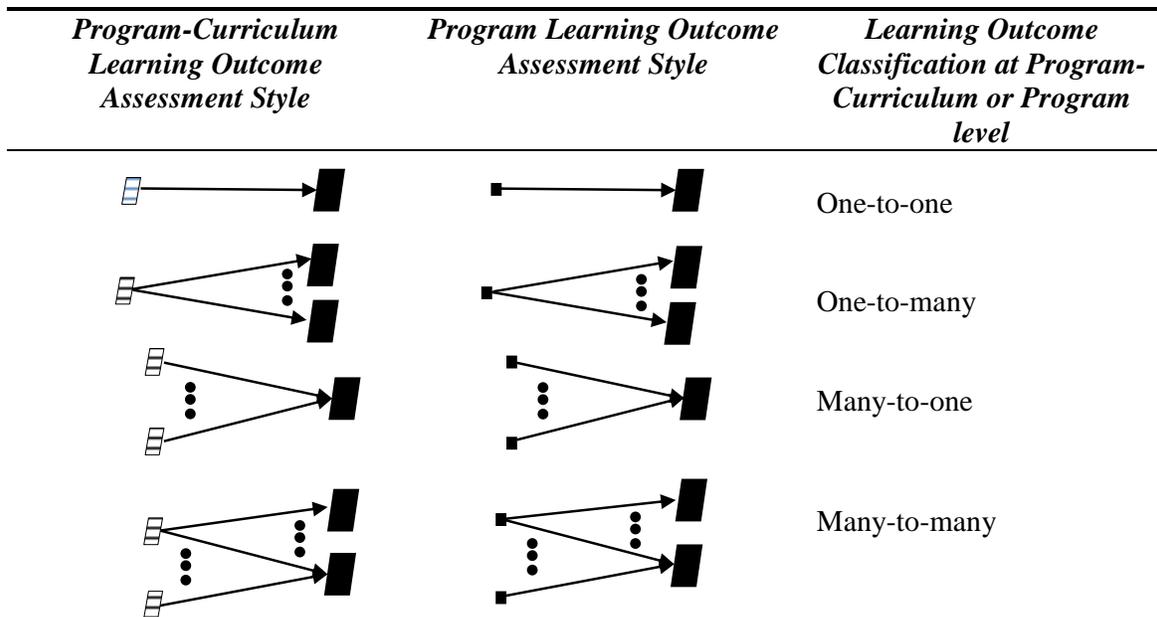
One-to-one Program Learning Outcome: a program learning outcome that is assessed by one and only one one-to-one program assessment tool.

One-to-many Program Learning Outcome: a program learning outcome that is assessed by one and only one one-to-many program assessment tool.

Many-to-one Program Learning Outcome: a program learning outcome that is assessed by more than one program assessment tool and all are one-to-one program assessment tools.

Many-to-many Program Learning Outcome: a program learning outcome that is assessed by more than one program assessment tool and at least one of the assessments is one-to-many program assessment tool.

Figure 4 demonstrate this classification.



Legend:

	In this context this is an assessed subset (not just one) of course learning outcomes that are identified to map to a program outcome
	An assessment category that is used to assess a program learning outcome. A set of courses that are used to evaluate a program learning outcome or an exit exam for graduating students evaluating specific learning outcomes are good examples.
	Program learning outcome

Figure 4. Classification of program learning outcomes into 4 types depending on their assessments

We now can classify program-curriculum and program assessments:

Function Program-Curriculum Assessment: An assessment of a program where every course has been mapped to a program learning outcome and none of the program learning outcomes is one-to-many program-curriculum or many-to-many program-curriculum (in this case each assessment we made for this program is uniquely mapped to one and only one learning outcome)

Function Program Assessment: An assessment of a program where every program assessment has been mapped to a program learning outcome and none of the program learning outcomes is one-to-many program or many-to-many program.

Onto Program-Curriculum Assessment: An assessment of a program where all the learning outcomes of the program have been individually assessed by at least one program-curriculum assessment tool.

Onto Program Assessment: An assessment of a program where all the learning outcomes of the program have been individually assessed by at least one program assessment tool.

The same exception for the Onto term as it pertains to functions applies here at the program level as it applied at the course level.

One-to-one Program-Curriculum Assessment: A program-curriculum assessment where all the assessed learning outcomes are one-to-one.

One-to-one Program Assessment: A program assessment where all the assessed learning outcomes are one-to-one.

Many Program-Curriculum Assessment: An assessment of a program where some of the assessed program learning outcomes are many-to-one program-curriculum or many-to-many program-curriculum.

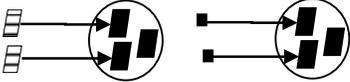
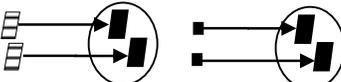
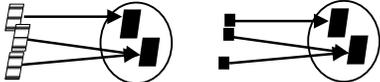
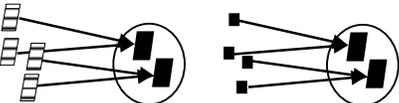
Many Program Assessment: An assessment of a program where some of the assessed program learning outcomes are many-to-one program or many-to-many program.

All-Many Program-Curriculum Assessment: An assessment of a program where all the program learning outcomes are many-to-one program-curriculum or many-to-many program-curriculum.

All-Many Program Assessment: An assessment of a program where all the program learning outcomes are many-to-one program-curriculum or many-to-many program.

Again, just like the classification of course learning outcomes assessment, the Onto classification addresses **coverage**, the *Many and All-Many* classification addresses **validity**, and the Function classification addresses **focus**.

Figure 5 demonstrates these definitions for a Function program assessment. Note that all the assessments in the figure are one-to-one (concerned with just one outcome); hence the Function classification and the high focus designation for all the cases. An assessment that is not a Function would result in low focus designation.

<i>Program Outcomes Assessment Style</i>	<i>Program Classification</i>	<i>Coverage, Validity Focus</i>
	Respectively, Function program-curriculum and Function program assessment	Low coverage, low validity, high focus
	Respectively, Function Onto program-curriculum and Function Onto program assessment	High coverage, low validity, high focus
	Respectively, Function Onto-Many program-curriculum and Function Onto-Many program assessment	High coverage, medium validity, high focus
	Respectively, Function Onto-All-Many program-curriculum and Function Onto-All-Many program assessment	High coverage, High validity, high focus

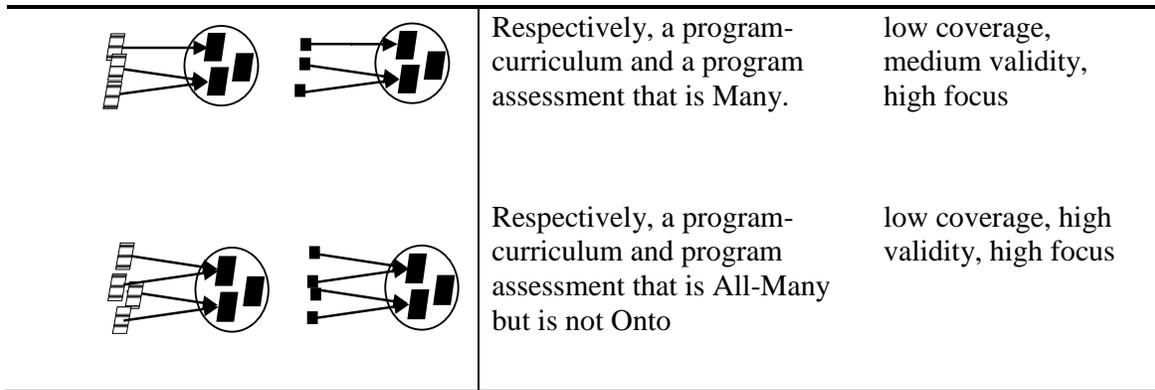


Figure 5. Classification of program-curriculum and program level assessments

4 The System

Figure 6 shows the architecture of the enterprise system that is currently under development to support the learning outcomes dashboard presented in this paper. The system is based on the Java Enterprise Edition technology stack. The Spring MVC framework is used as the base for the architecture while the Hibernate framework is used to facilitate all database communications. The architecture allows for easy variation in client types, e.g. browsers, mobile applications, etc.

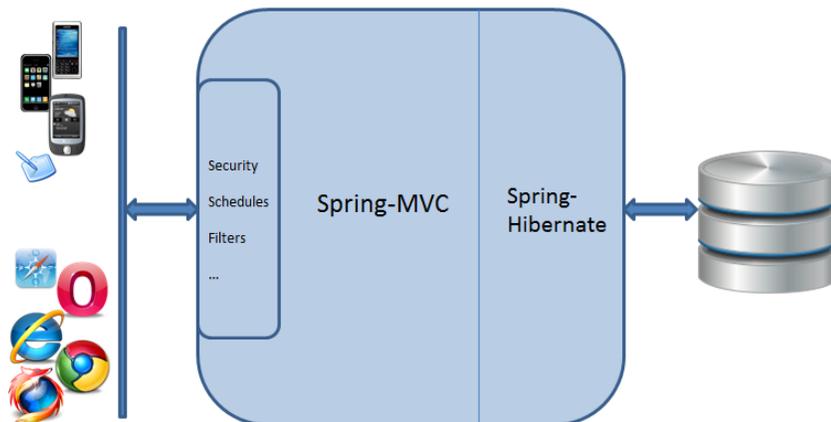


Figure 6. Dashboard enterprise system architecture

In addition, the architecture allows for secure multi-role and multi-user system access. The system currently supports three basic roles: program coordinator, faculty, and student.

The program coordinator has the following responsibilities:

- create program learning outcomes
- create program courses and their learning outcomes
- create program level assessments
- map course learning outcomes and program assessments to program learning outcomes

The faculty role has the following responsibilities:

- create course assessments

- map course assessments to course learning outcomes

The student role views results pertaining to individual progress within courses.

The system provides all the facilities for the various roles to accomplish the above tasks. For example, web pages accessible to program coordinators can be used to create courses, course learning outcomes, and program learning outcomes. Other pages allow the mapping of course learning outcomes to program outcomes. As the program coordinator and the faculty roles engage in the creation of the courses, the assessments and the mappings, the dashboard provides all the roles a feeling for the quality level of the mappings. The next section is going to present the learning outcomes mapping level dashboard which is the main focus of this work.

5 The Dashboard

A dashboard should provide a concise view of the mapping work at login. The coverage, validity, focus definitions that are established in this work are used as the base for creating this dashboard. Figure 7 shows the dashboard coverage-validity-focus (CVF) chart that the coordinators see upon login. It shows the level of coverage, validity and focus that has been completed in the program mapping up to this point.

The percentage in each category is calculated as follows:

Coverage: the percentage of program learning outcomes that have course learning outcomes or program assessments mapping to them. A 100% coverage gives the chart an *Onto* designation.

Validity: The percentage of mapped program learning outcomes that are many-to-one or many-to-many. A 100% validity will give the chart an *All-Many* designation. A non-zero value will give it a *Many* designation or a threshold that is greater than zero and less than 100 can be set beyond which the *Many* designation is given.

Focus: The percentage of mapped program learning outcomes that are not one-to-many or many-to-many. A 100% focus gives the chart a *Function* designation

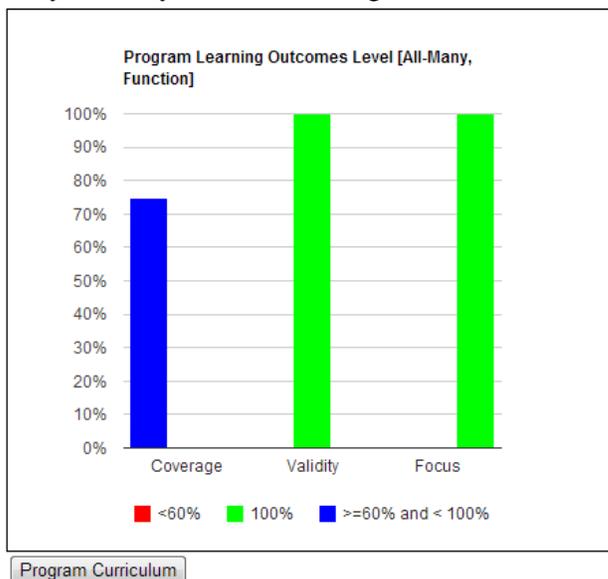


Figure 7. Program Learning Outcomes Level dashboard chart that is All-Many and a Function.

Clicking on the Program-Curriculum button toggles the display to the Program-Curriculum Learning Outcomes Level dashboard CVF chart which basically removes any direct program assessments from the data and focuses on the level of mapping from course learning outcomes to the program learning outcomes. Figure 8 shows an example.

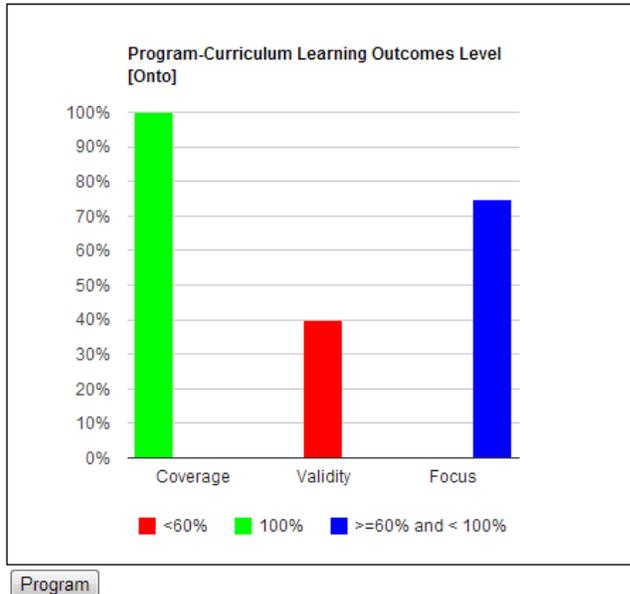


Figure 8. Program-Curriculum Learning Outcomes Level dashboard chart that is Onto with low validity.

Clicking on any of the bars in the CVF chart yields a detailed table that shows the courses, their learning outcomes and their mapping to the program outcomes. Figure 9 shows a segment of this table from a program-curriculum CVF chart. The content of the table will be the same for all three bars. However, the highlighted rows and columns are going to be different. For example, assume that the courses shown in Table 1 to be the complete domain. Program LO1, Program LO2 and ProgramLO5 columns will be highlighted if the user has clicked on the coverage bar to focus on the learning outcomes that still need some mapping. Clicking on the validity bar would show the table with Program LO2 and Program LO6 being highlighted to focus the attention on mapped outcomes that are assessed by just one tool. Clicking on the focus bar would show the table with the first row of the CSCI 210 course being highlighted since it is a course learning outcome with a mapping to two program learning outcomes.

Course	Outcomes	Program LO1	Program LO2	Program LO3	Program LO4	Program LO5	Program LO6
CSCI 140	Identify and describe the different components of a computer system				X		
	Identify the difference between human and computer abilities in solving problems				X		
	Analyze problems and describe them in a way that can be solved using a computer		X				
	Design and implement solutions to solve computational problems using Python						
CSCI 210	Discuss important network standards in their historical context				X		X
	Describe the responsibilities of the Application, Presentation, and Session layers				X		
	Explain how a packet is routed over the Internet and describe the techniques used in both the Transport and Network layers				X		

Table 1. A detailed table of mappings to program learning outcomes

Faculty members are presented with a similar dashboard chart for each course they teach. It provides coverage, validity and focus reading on the mapping of the course assessments to the course learning outcomes. For example, Figure 9 tells the faculty of this particular course that he still has to develop assessments for 25% of the outcomes. It also tells him that only 50% of assessed outcomes are assessed by more than one tool (threshold is set to 2). Finally, he is informed that high level of focus is exercised so far since no assessment is used to evaluate more than one outcome. This provides a very quick overview of the level of work that has been completed and the level of work that remains to be done. By clicking on any of the bars, the detailed table will inform the faculty of the exact outcomes that do not have any or enough assessment.

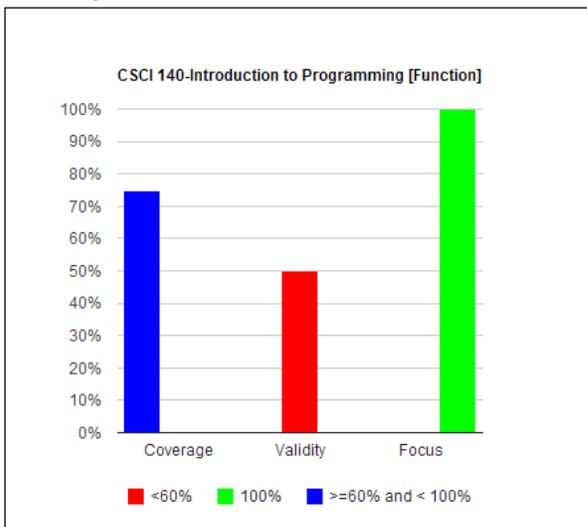


Figure 9. Course Learning Outcomes Level dashboard chart that is a Function with low validity.

Students get a similar dashboard chart that shows them the level of coverage, validity and focus they have completed based on the assessments that they have already taken. In other words, once the faculty of a course logs a score for a student in an assessment, the score is used in the data that generates the student’s CVF chart. Note that the actual score is irrelevant in this context for all roles.

6 The Assessment Process Using the New Terminology

Using the classifications that are defined in previous sections, a particular program learning outcomes assessment mapping process can now be described concisely using an agreed upon terminology. Consider a program assessment that is described as follows:

The program assessment is Onto-All-Many Program-Curriculum and Onto-Many Program. Both are Functions if we take out the Capstone course. The Capstone course assessment is All-Many and is not a Function.

Figure 10 is a representation of the description.

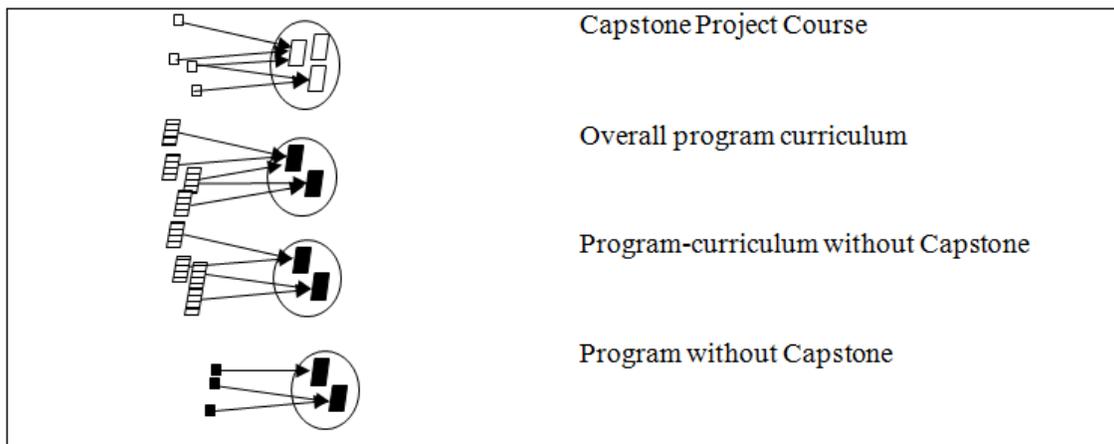


Figure 10. A representation of assessment situation at a fictional program. Note the compactness of the representation and the ability to utilize it in various communications.

What we understand:

This program has been designed in such a way that each course (or clearly identified pieces of all the courses) participating in the assessment with the exception of the Capstone focus on one and only one program learning outcome. We may consider this to be a high focus program-curriculum. However, the exception that is made in the capstone project course where the students are assessed on several program outcomes must be looked into. Every program outcome is assessed by more than one course (high coverage and high validity Program-curriculum). However, some of the program outcomes are assessed by *only* the courses and no other tool, which is an issue that may require attention (high coverage medium validity program). Again, excluding the capstone, the program assessment has High focus.

Now looking at the capstone, not all the outcomes of the capstone are assessed. This could be an issue for a course that carries the weight of a Capstone. While multiple assessment tools are used for the assessed outcomes, some are used to assess multiple learning outcomes,

which also could be an issue if too much imbalance exists and an outcome is largely assessed with a single tool. The Capstone has low coverage, low focus and high validity signaling a need for more attention in this area.

The investigation and presentation of each of the issues flagged here will likely consume significant space. We think that having the description presented above that uses the terminology presented in this paper as a prologue can change how we view and compare assessment levels. In addition, any software tool that aids in tracking learning outcomes assessment at any level can be more effective with a dashboard that uses this terminology.

7 Conclusion

In this work a dashboard system that tracks program learning outcomes mapping quality vis-à-vis course learning outcomes is presented. Learners are continuously aware of their status and administrators are continuously aware of program progress and all are immediately alerted to any deficiency.

8 Bibliography

1. **Computing Accreditation Commission-ABET.** Criteria for Accrediting Computing Programs Effective for Evaluations During the 2011-2012 Accreditation Cycle. [Online] 30. October 2010. www.abet.org.
2. *Effective Course-Based Learning Outcome Assessment for ABET Accreditation of Computing Programs.* **Yue, Kwok-Bun.** s.l. : Journal of Computing Sciences in Colleges , Volume 22 Issue 4, April 2007, p 252-259.
3. **Marilee J. Bresciani, Megan Moore Gardner, and Jessica Hickmott.** *Demonstrating Student Success : A Practical Guide to Outcomes-Based Assessment of Learning and Development in Student Affairs.* s.l. : Stylus Publishing, 2010. 9781579225155.
4. **Sarah Earl, Fred Carden and Terry Smutylo.** *Outcome Mapping : Building Learning and Reflection into Development Programs.* Ottawa, ON, CAN : IDRC Books, 2001.
5. *Closing the Training Loop with Enterprise Technologies and Solutions.* **Khawaja, Khalid W.** Bonn, Germany : IBIMA, Managing Information in the Digital Economy: Issues and Solutions, 2006, pp. 716-719.
6. *A Task-Centered Instructional Strategy.* **Merrill, M. David.** 1, 33-50, s.l. : Journal of Research on Technology in Education, 2007, Bd. 40.
7. *A Revision of Bloom's Taxonomy:An Overview.* **Krathwohl, David R.** 4, s.l. : Theory into Practice, 2002, Bd. 41.
8. *Continuous Quality Improvement in Higher Education.* **Robert V. Hogg, Mary C. Hogg.** 1, 35-48, s.l. : International Statistical Review, 1995, Bd. 63.
9. **Guest Editor:, David Shape.** *On the Horizon, Focusing the Institution on Student Learning Outcomes.* s.l. : Emerald, 2007. 1074-8121.
10. **Brenda Thomas, Tracy Lightcap and Linda Rosencranz.** Taming the hydra: A triangulation approach to assessing an interdisciplinary core curriculum. [Online] 2005. www.usca.edu/essays/vol152005/EinE5.pdf.
11. *Assessing Student Performance Outcomes in an Information Security Risk Assessment, Service Learning Course.* **Dark, Melissa J.** Salt Lake City, Utah, USA : SIGITE'04, October 28-30, 2004.

12. **Sengadir, T.** *Discrete Mathematics and Combinatorics*. s.l. : Pearson Education India, 2008. 8131771032.