Direct Assessment Methodology for a Software Testing Course

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Abstract: It is important for educational institutions to have the latest and most up-to-date curriculum, experienced faculty members, and a good reputation if they are to achieve high rankings internationally. Student results and student satisfaction also play an important role in achieving a good ranking, and a key part of the assessment of students are instruments such as assignments, quizzes, and exams, that is, *direct assessment*. In this paper, we present a direct assessment (by instructor) method for students in a software testing course at an institution of higher education in Saudi Arabia and identify the problems that cause failure or poor learning outcomes.
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1. Introduction

Improvement is the most important factor for any educational institution. For this purpose, all institutions are keen to hire good, experienced faculty members and also to maintain and update their curriculum to meet the requirements of the industry and of students' lives. To attract students to an institution, it is important to maintain high program standards. One aspect of this is effective assessment of students, and assessment procedures should be continually reconsidered and improved where possible.

In general, assessment should consider what students have learned and what they can do with it.Also, it is important for instructors to assess only material that has been explicitly taught to students and also assess them as per their knowledge. (Rust, 2002)Various methods and techniques are used for assessment, and interest in their effectiveness is growing with the increased focus worldwide on individual student outcomes (SOs) and course outcomes (Cos)(Eqbal Darandari, 2013).Old methods of assessment have been linked with student learning behavior, ability, and achievement.

Assessment should be measured in term of SOs with reference to COs and improved continuously on the basis of comparison. In this paper, we will consider assessment of students by their instructors (that is, *direct assessment*) in a particular class setting and will analyze the results in terms of average level of SOs and percentage of students achieving a satisfactory level for each SO. We will take a Software Testing and Validation course as the site of our research.

2. Material and Methods

Identification of students' weaknesses and of ways to help them improve should always be an objective during assessment. Computerized test–based systems are more effective for capturing the knowledge level of students and thus the problems faced by them and their instructors. Antal and Koncz(2011) developed and tested a self-assessment system including a knowledge diagram providinga graphical view of student assessment results over time. This system was very attractive, as the students were free to choose what type of exam to take and asked to use it for self-assessment. This system also provides the opportunity forinstructors to predict exam outcomes.

(Ghiatău et al., 2011)considered practical problems faced by students in the sciences and in the humanities during assessment, especially of written examinations. Their investigation showed that science students are more in favor of increasing assessment frequency than those in the humanities, and that students new to university are more in favor of continuous assessment than those who are some way into their university career. Increasing the frequency of examinations increases students' motivation towards over ride on the contents of assessments. The most important areas that need to be covered by assessment criteria are analysis of academic background, universities' traditional systems for assessment, number of students, and academic major.

Peterson and Irving (2008) investigated secondary school students' perceptions of assessment and feedback. Overall, students were satisfied with assessment and feedback and encouraged this method, as they found it very interesting and helpful.

They also found that students did not think assessment would make their school accountable, but teachers did.

Segers and Tillema (2011)studied the shift from assessment *of* learning to assessment *for* learning in the high school context. They focused on formative and summative assessment and on the points of view of teachers and students, using a questionnaire method. Their results showed that teachers were not able to distinguish between formative and summative purposes of assessment. In contrast, students were able to understand difference between formative and summative assessment. Unlike teachers, they also understood that assessment methods can affect school accountability as well as improve the learning process.

3. Student Outcomes (SOs)

As explained by Bucciarelli (2009), theAccreditation Board of Engineering and Technology (ABET) is a private organization that accredits post-secondary education programs in computing, engineering, applied sciences and engineering technology. ABET provides various SOs and states that they should be chosenin accordance with the class syllabus and should be mapped across COs. ABET defines two types of SOs: General SOs and Specific SOs for Engineering courses. This mapping makes it easier to judge and compare students' results. In our example course, the following are the SOs described in the syllabus.

I. **SO (a):** Ability to apply knowledge of mathematics, science, and engineering.
II. **SO (b):** Ability to design and conduct experiments, as well as to analyze and interpret data.
III. **SO (k):** Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
IV. **SO (l):** Ability to analyze, design, verify, validate, implement, apply, and maintain software systems.
V. **SO (o):** Ability to manage the development of software systems.

4. Course Outcomes (COs)

Course Outcomes play an important role in assessment of students learning and the improvement of courses. COs are not defined by ABET, but should be defined and formally approved by individual departments with input from faculty members. They should be based on the SOs defined by ABET. In our example course, the following SOs are defined and included in the syllabus.

1. Understand the importance of software testing in the software development lifecycle. **[SO (l)]**
2. Understand and distinguish between different types of tests unit testing, integration testing, system testing, etc. **[SO (l)]**
3. Develop a test plan for a specific software project. **[SO (b)]**
4. Understand and use different techniques for software testing. **[SO (k)]**
5. Understand and apply functional testing. **[SO (l)]**
6. Understand and apply structural testing. **[SO (l)]**
7. Understand and apply mutation testing. **[SO (l)]**
8. Understand reliability assessment. **[SO (a)]**
9. Organize and manage the testing process. **[SO (o)]**
10. Use different techniques for software testing. **[SO (k)]**
11. Use software testing tools and international testing Standards. **[SO (k)]**

Table 1maps COs to SOs.

Table 1. Mapping Between COs and SOs

	SO (a)	SO (b)	SO (k)	SO (l)	SO (o)
CO (1)				√	
CO (2)				√	
CO (3)		√			
CO (4)			√		
CO (5)				√	
CO (6)				√	
CO (7)				√	
CO (8)	√				
CO (9)					√
CO (10)			√		
CO (11)			√		

5. Methodology

We used direct assessment for the evaluation of student learning capability. This methodology is consideredthe best way to assess students, and provides better results than other methods. We used two assessment measures:

i. Average score achieved by students for each outcome covered by the course.
ii. Percentage of students achieving a satisfactory level or an exemplary level. The four levels were: 1) Unsatisfactory (50%) or lower, 2) Developing (50%–70%), 3) Satisfactory (70%–90%), and 4) Exemplary (above 90%).

Class achievement levels were set by the proportion of studentsindividually achieving these outcomes at the satisfactory or exemplary level,as shown in Table 2.

Table2. Outcome Measuring Criteria

Exceeds Expectations	Meets Expectations	Progressing Towards Expectations	Does Not Meet Expectations
(EE)	(ME)	(PE)	(DNME)
Above 80%	70%–80%	60%–70%	Below 60%
Continue the good work	Continue the good work	Attention is required to some elements	Immediate action is required to resolve issues

Our example course covers five SOs, shown in table 3, with priority levels defined by the department in consultation with faculty.

Table 3. Student Outcomes

Outcome	Outcome Description	Priority
(a)	Ability to apply knowledge of mathematics, science, and engineering.	Medium
(b)	Ability to design and conduct experiments, as well as to analyze and interpret data.	High
(k)	Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	Medium
(l)	Ability to analyze, design, verify, validate, implement, apply, and maintain software systems.	High
(o)	Ability to manage the development of software systems.	Low

5.2 Direct Assessment of Achievement of Course Outcomes and Student Outcomes

The course implemented several direct assessment instruments: various quizzes, a midterm exam, and a final exam. These were formulated with reference to the defined SOs, as shown in detail in table 4.

Table 4. Direct Assessment for Each SO

	Outcome (a) 16 Marks	Outcome (b) 29 Marks	Outcome (k) 9 Marks	Outcome (l) 35 Marks	Outcome (o) 11 Marks
Quizzes	Q1			Q1	
Marks	10			10	
Midterm		Q2, Q3		Q4	Q1
Marks		20		15	5
Final	Q5	Q3	Q4	Q2	Q1
Marks	6	9	9	10	6
Total	16	29	9	35	11

5.2.1 Average Score for Each SO

Table 5 shows maximum and average number of marks for each SO.

Table 5. Average Score for Each SO

	SO (a)	SO (b)	SO (k)	SO (l)	SO (0)
Planned	16	29	9	35	11
Actual	14.31	23.69	7.31	29.54	7.15
%	94.87%	81.70%	81.20%	84.40%	65.03%

These averages are visualized in figure 1.

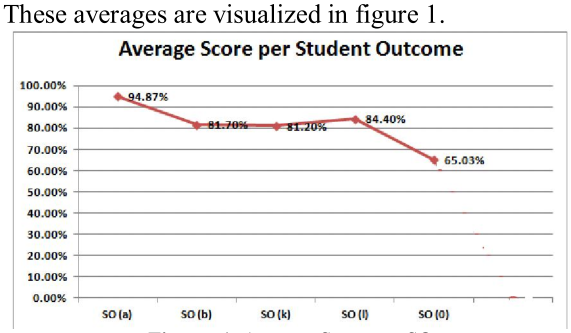

Figure: 1. Average Score per SO

The final results on the basis of these marks are shown in table 6.

Table 6. Average Direct Assessment Results by Achievement Level

Student Outcomes	Outcome Importance	Final Result (based on direct assessment)
SO (a)	M	EE (average score above 80%)
SO (c)	M	EE (average score above 80%)
SO (k)	H	EE (average score above 80%)
SO (l)	H	EE (average score above 80%)
SO (o)	L	PE (average score between 60% and 70%)

5.2.2 Percentage of Students Achieving Satisfactory or Exemplary Level for each SO

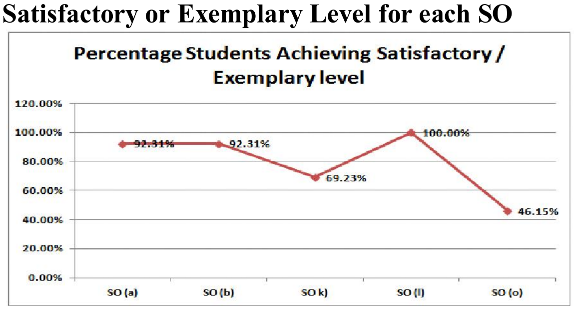

Figure: 2. Satisfactory Exemplary Level for Direct Assessment In this section,we consider the percentage of students achieving the satisfactory or exemplary level for each SO during direct assessment, as shown in figure 2.

These results are tabulated in Table 7.

Table 7. Percentage of Students Achieving Satisfactory or Exemplary Level for each SO

Student Outcomes	Outcome Importance	Final Result (based on direct assessment)
SO (a)	L	EE (average score above 80%)
SO (c)	H	EE (average score above 80%)
SO (k)	M	PE (average score between 60% and 70%)
SO (l)	H	EE (average score above 80%)
SO (o)	M	DNME (average score below 60%)

6. Results and Discussion

The results showedthat on average, students were satisfied and that they averaged more than 80% on each SO except (o), where the result was less than 70% but more than 60%—still considered acceptable. Thus, only a few changes were required either to the teaching methodology or to the curriculum to achieve expectations. On this basis, it seems that satisfactory or exemplary level was achieved at excellent rates for SOs (a), (c), and (l), at a good rate for (k), but at a poor rate of less than 60% (that is, scoring DNME), and in fact, less than 50%, for (o).This shows the need for immediate action to update the curriculum or teaching methodology to address the ability to manage the development of software systems.

Thus, these methods (calculating average per SO and number of students achieving Satisfactory or Exemplary levels) can be seen to provide usable data that can be used to assess student learning and improve the curriculum.

Conclusion

Good ranking and good reputation are important for educational institutions, and solid assessment is an important part of achieving them.Hopefully, the assessment method presented here will help instructors and institutionsmake decisions for the betterment of student learning and also for the benefit of the institution.

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