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Are Student Self-Assessments a Valid Proxy for Direct Assessments in Efforts to Improve Information Systems Courses and Programs? An Empirical Study

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___Abstract:___

Accrediting agencies in the United States require business schools to conduct ongoing assessment directed at continuous improvement of their instruction. Because direct assessment efforts are usually more time consuming and resource-intensive than indirect assessment, it would be helpful if indirect assessment could be used as an effective alternative, at least on occasion. The validity of one indirect method, student self-assessment, has been debated in the research literature. This study compares results of direct measures and student self-assessments for learning outcomes in an Information Systems course. We find student self-assessments are valid proxies for direct assessment when used with some types of learning outcomes but not others. We discuss possible reasons for the difference and the implications for assessment in Information System programs.

Keywords: accreditation, direct assessment, indirect assessment, learning outcomes, continuous improvement

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I. INTRODUCTION

For most business schools in the United States, assessment is a fact of life. Regional agencies that accredit universities or colleges require every academic program to assess its own effectiveness. Similarly, the Association to Advance Collegiate Schools of Business (AACSB) requires programs seeking its accreditation to conduct self-assessments, just as the Accrediting Board for Engineering and Technology (ABET) does for technology programs in institutions seeking its accreditation.

In the past two decades, accrediting agencies have revised their criteria in ways that increase considerably the time and effort that self-assessment requires. Whereas the agencies once focused on evaluating the components of a program—its courses, faculty, and resources—they now want evidence that the program is effective at providing its students with the knowledge and abilities it claims to impart [Higher Learning Commission, 2007; AACSB, 2008; ABET 2009]. Accrediting agencies have also transformed assessment from an occasional activity to a continuous one. In the past, a program needed to reflect on its effectiveness only when each accreditation review approached, an event that might occur as infrequently as every ten years. Now, a program must create a culture of assessment in which assessment is an ongoing activity [Cooper and Heinze, 2007; Gardiner, 1994]. Further, the program must not only present assessment results to the accreditors but also show that it has initiated improvements in response to what the results disclose. Through these requirements accrediting agencies aim to engage U.S. higher education in continuous improvement, a worthy goal in Information Systems and fields where technological change continues to accelerate [Somerville et al., 2005] and educational outcomes for college graduates can have profound effects on the fate of organizations and nations.

Faced with this substantial increase in the intensive work assessment demands, academic programs in all fields are looking for valid, reliable methods that produce maximum improvement with minimal expenditure of resources. This research report describes efforts at a Midwestern university to explore the feasibility of including student self-assessment among more time-consuming direct measures for assessment for Information Systems programs, using an introductory Information Systems course as a test case.

II. ASSESSMENT

Palomba and Banta [1999] define assessment as the "systematic collection, review, and use of information about educational programs undertaken for the purpose of improving student learning and development." It is inextricably linked to the intended learning outcomes of a course or program [Marriott and Lau, 2008] and may be gathered using a wide variety of both quantitative and qualitative methods, depending on the outcomes being measured [ABET, 2009]. For assessment purposes, the desired learning outcomes must be broken down into specific characteristics or traits that can be measured [Pringle and Michel, 2007]. Harper and Harder [2009] maintain that outcomes for information sciences and other technical programs fall into four categories: technical, analytical, communication, and managerial. Regardless of the category of the outcomes of interest, assessment concerns the effectiveness of the course, sequence of courses, or program. How successful is it at enabling students to learn and to do what the course or program aims to teach? Because it focuses on the achievement of the student in the course or program, assessment is distinct from the evaluation of student performance for the purpose of assigning grades for the students in a particular course.

Programs can employ direct and indirect assessment methods. Direct measures involve a systematic and objective examination of actual student products to determine the extent to which the students are able to do what the program's student-learning outcomes state they should be able to do. Indirect assessment measures perceptions of students' abilities. AACSB and ABET permit both direct and indirect measures, but state that indirect measures alone are not sufficient. Multiple methods and multi-source approaches—including direct assessment—reduce bias and increase the validity of data. Many colleges and universities have found that in order to measure the skills and competencies they value, they need to use multiple methods and triangulate the assessment data that they produce [Lopez, 2002].

Both direct and indirect assessments may be conducted in a variety of ways. The alternatives are associated with different kinds of information that faculty may gather and different amounts of time invested in acquiring the information.

Direct Assessment

The student products used for direct assessment can vary widely, including (but not limited to) multiple-choice tests, short-answer tests, essay tests, term papers, presentations, prototypes students have created, databases they have designed, and reports in which they advise imaginary or real decision-makers about the best courses of action to take.

When choosing the products to be assessed, programs need to consider the likely validity of the results they will obtain and, for very practical reasons, the amount of faculty time and effort the assessment will require. Because success in business and industry depends on clarity, Calfee [2000] argues that student learning is better assessed through writing. Essay exams are often favored on the grounds that they are best at testing deep understanding, especially of conceptual material. When taking essay exams, students have to take the business context into account, integrate material, and communicate cogent arguments. In an Information Systems context, for example, essay exams could be more effective than multiple-choice questions at ascertaining students' mastery of concepts such as the strategic use of Information Systems or the underlying assumptions of alternative architectures for Information Systems.

A drawback of using essay questions, of course, is the time it takes a faculty member to evaluate them. In addition, to be truly useful for assessment, more than one faculty member needs to examine the essay question. Further, whenever more than one person evaluates essays, the role that subjectivity plays in evaluation is highlighted. To achieve acceptable inter-rater reliability, an additional step—calibration of the evaluators' judgments—must be added to the process.

In contrast, multiple-choice exams have the inherent benefit of being graded easily, quickly, and consistently while demanding very little faculty time. A common use of multiple-choice questions in Information System courses is to test whether the student understands a definition or technical term. Textbooks for introductory courses often provide test-bank questions of this type.

Controversy exists over whether multiple-choice tests are equally capable of evaluating higher-order thinking. Based on a review of the relevant literature, Street [1990] concludes that objective testing methods are not likely to evaluate higher-order learning. A study by Kuechler and Simkin [2004] in the accounting and Information Systems domain found only moderate relationships between the constructed responses and the multiple-choice portion of an exam. Martinez [1999] maintains that even when a relationship is established, different kinds of thinking and reasoning may be involved. Ruiz-Primo et al. [2001] found that students reasoned differently on highly structured and loosely structured assignments. In highly structured problems, students strategized as to which alternative is best, while for loosely structured assignments they reasoned through the problem.

On the other hand, some of the literature from educational psychology and assessment suggests that it is possible for multiple-choice questions to be developed that measure some of the same cognitive abilities as essay questions [Martinez, 1999; Keuchler and Simkin, 2004]. Wainier and Thissen [2003] argue that anything measurable with essay questions can be measured by constructing objective questions.

Indirect Assessment

In contrast to direct assessment's use of actual student products to gauge students' abilities, indirect assessments ascertain people's perceptions of students' abilities. Programs may gather these perceptions from the students themselves, employers, alumni/ae or others deemed capable of judging. Perceptions may be gathered via externally administered surveys such as the National Survey of Student Engagement, locally devised surveys, focus groups, and interviews, among other means.

Much evidence suggests that self-assessment can be both helpful and useful. For course and program assessment, self-assessment by students has the advantage of being easier and less time consuming than direct assessment. For gathering information from students, it requires even less than multiple-choice tests because construction of the exam questions takes time and thought. Self-assessment is also a trusted mainstay of education in some fields, such as the medical professions, where it is presumed to be directly linked to the quality of patient care [Westberg and Jason, 1994; Davis et al., 2006; AMA, 2009]. The American Board of Medical Specialties [AMA, 2009] includes self-assessment among the four elements in its Maintenance of Certification program.

Use of self-assessment in Information Systems can help students develop important skills they will need as professionals and life-long learners [Sluijsmans et al., 1999]. Larres et al. [2003] argue that self-assessment is an important factor in career development because it stimulates reflection about one's competencies, something professionals must continuously think about if they are to stay current in their chosen careers.

Student self-assessment also provides valuable insights for faculty because it offers a different perspective than does direct assessment [Merhout et al., 2008]. For upper-level electrical and computer engineering courses, Rover and Fisher [1998] discuss the use of a variety of self-assessment tools, such as surveys, to determine if student background and preparation is sufficient and whether learning objectives are achieved.

However, the literature on self-assessment raises concerns about its validity. Comparisons of self-assessment and instructor assessments yield mixed results [Chen, 2008]. Rogers [2006] suggests indirect methods are not as strong as direct measures. Students exhibit overconfidence and tend to rate their abilities higher than they actually are [Price and Randall, 2008]. In the field of computer literacy, Larres et al. [2003], and Ballantine et al. [2007] report significant differences in the students' perceived and actual computer literacy with the vast majority over-estimating their computer knowledge.

Other research indicates that self-assessment is more accurate in some circumstances than others. For example, students with greater computer skills and ability were more accurate in their self-assessments. Self-assessment measures depend on their specificity and correspondence to actual performance tasks [Zimmerman,1995]. Clear criteria, feedback, and practice improve the accuracy and quality of student self-assessments [AlFallay, 2004]. Also, students may be able to assess some kinds of knowledge, skills, and abilities better than others. Falchikov and Boud [1989] report better agreements between student and faculty assessments in science subjects than in social science subjects. Similarly, Brewster et al. [2008] found that residents' self-assessment of their surgical abilities agreed with the assessments of trained faculty in medical school, but their self-assessments of their skills in dealing with patients before and after surgery did not.

In the current assessment context, however, the salient question for Information Systems faculty is not whether the students' self-assessment scores of their abilities match direct assessment scores of those abilities. The goal is not to ascertain an absolute "score" to determine whether a course or program is "good enough." Rather, assessment is aimed at identifying ways to make even the most successful course or program even better. For this purpose, the salient question is whether students' self-assessment scores correlate with direct assessment scores. Faculty need to identify a course's or program's relative success at achieving each of its learning outcomes. The learning outcomes for which the results are weakest are the ones on which faculty can concentrate their efforts at revising their curricula or teaching strategies. After improvements in teaching these outcomes produces better results, future assessment will show that some other outcomes now present the best target for attention. Thus, student self-assessment would offer a timesaving way of achieving the continuous improvement accrediting agencies are demanding and academic programs desire if student self-assessment scores were to correlate with direct-assessment scores.

III. RESEARCH QUESTIONS

Given the time and effort that could be saved by using student self-assessment in Information Systems program assessment and given the uncertainty about the validity of student self-assessment, we decided to address two research questions.

1. Do students' self-assessment of their abilities correlate with direct assessment of their abilities?

2. If so, do students' self-assessment correlate with direct assessments of their abilities for some types of learning outcomes but not others?

IV. METHOD

To address these questions, we conducted two studies. In both, we worked with an introductory, sophomore-level Information Systems course that enrolls approximately 550 students per term. The course is taught in sections of approximately forty students but has a common final exam taken by all students. The course's nineteen learning outcomes are included in the syllabus for all sections.

Selection of Outcomes

To address our research questions, we focused on five learning outcomes. To select these outcomes, we first asked four IS faculty members independently to rank the nineteen outcomes in order of importance. Because of the research suggesting that self-assessments of some kinds of knowledge agree with direct assessment more than self-assessments of other kinds of knowledge [Falchikov and Boud, 1989; Brewster et al., 2008], we also wanted the five outcomes to include a variety of kinds of learning. Consequently, we chose the three most highly ranked managerial/conceptual outcomes and the two most highly ranked technical outcomes.

All of the course's learning outcomes, including the five we selected, were phrased to complete a sentence that begins, "When they complete this course, students should be able to…."

The managerial/conceptual outcomes were:

1. Explain how Information Systems influence organizational competitiveness.

2. Describe how organizations develop, acquire, and implement Information Systems and the role that users play in this process.

3. Explain how Information Systems enable organizational processes and process change.

The two technical outcomes were:

4. Choose when spreadsheet and database technologies are applicable to solve various business problems.

5. Access information in a relational database using Structured Query Language.

Direct Assessment

For direct assessment, we employed students' answers to selected sets of multiple-choice questions on the common final exam. For each outcome, we used a set of four to six questions. Traditionally, the faculty teaching the course collaboratively create the questions on the final exam. For outcomes 4 and 5, this group created the questions we used. For each of the other three outcomes, three faculty independently drafted several questions. From this pool, the group selected and refined four questions for each outcome.

Indirect Assessment

To elicit students' assessment of their own abilities, we created a student survey based on all the learning outcomes specified for the course and included in the syllabus for all sections. For example, one desired outcome was that students should be able to "Explain the role of information technology including: How Information Systems influence organizational competitiveness." This outcome was translated into a survey question that asked students to agree or disagree with the statement "I can explain how an Information System could give a company competitive advantage." Each learning outcome for the course was similarly translated to a self-report survey question. All questions used a five-point scale that varied from strongly disagree to strongly agree, with three being neutral.

Data Collection

We collected two sets of data, in Spring 2009 and Fall 2009, in order to assure that whatever results we found would hold up for different groups of students.

The self-assessment survey was administered in the individual sections during the last two weeks of each semester. Participation was optional but made available to all students. The surveys were distributed and collected in class by neutral third party while the instructor was outside of the classroom. Students could return the survey form without filling it out, if they wished. On the form, students could provide their university identification numbers (ids) for the purpose of participating in the research comparing self-assessment with direct assessment. The ids enabled us to link a student's survey with his or her final exam. Data was recorded and verified manually into an Excel spreadsheet.

Data for the direct assessment was collected via the common final, for which students responded to the multiple-choice questions on scantron sheets. Electronic files of student responses identified by user ids were obtained and merged with the self-assessment responses of students who provided their ids. Usable self-assessment responses that could be merged with direct data were received from 280 students in Spring 2009 and 460 in Fall 2009.

V. RESULTS

To test the level of agreement across the two types of assessment measures, the single-item self-assessment measure for each learning objective was correlated with a factor score for the direct measures for each learning outcome. Factor scores were calculated by summing the number of correct responses for each objective. Table 1 lists descriptive statistics for the data from both semesters of data collection.

Table 2 provides the correlation of the direct to self-assessment measures for both semesters. The direct and self-assessment measures for the most technical of the learning outcomes was the only one that significantly correlated both semesters. Two of the more conceptual outcomes significantly correlated in the Spring data only.

Table 1: Descriptive Statistics for Self-Assessment and Direct Assessment in Spring and Fall Semesters 2009				
	Spring (N = 280)		Fall (N = 460)	
Learning objective (Number of Direct Questions)	SA Mean (StDev)	DA Mean (StDev)	SA Mean (StDev)	DA Mean (StDev)
1. Explain how Information Systems influence organizational competitiveness. (4)	4.4 (0.6)	2.3 (1.0)	4.3 (0.6)	2.3 (1.0)
2. Describe how organizations develop, acquire, and implement Information Systems and the role that users play in this process. (4)	4.0 (0.7)	2.4 (0.9)	4.0 (0.7)	2.6 (0.9)
3. Explain how Information Systems enable organizational processes and process change. (4)	4.2 (0.7)	3.2 (0.9)	4.2 (0.6)	2.8 (1.0)
4. Choose when spreadsheet and database technologies are applicable to solve various business problems. (5)	3.9 (0.8)	4.2 (0.9)	4.1 (0.7)	4.3 (1.0)
5. Access information in a relational database using Structured Query Language. (6)	4.0 (0.7)	4.6 (1.3)	4.0 (1.0)	4.8 (1.3)

Table 2: Pearson Correlation Coefficients for Self-Assessment and Direct Assessment for Spring and Fall Semesters 2009		
Learning Objective	Spring 2009 Pearson Coefficients and Significance	Fall 2009 Pearson Coefficients and Significance
1. Explain how Information Systems influence organizational competitiveness.	0.061 p = 0.309	-0.061 p = 0.193
2. Describe how organizations develop, acquire, and implement Information Systems and the role that users play in this process.	0.040 p = 0.501	0.018 p = 0.695
3. Explain how Information Systems enable organizational processes and process change.	0.151 p = 0.012*	0.053 p = 0.257
4. Choose when spreadsheet and database technologies are applicable to solve various business problems.	0.135 p = 0.023 *	0.022 p = 0.638
5. Access information in a relational database using Structured Query Language	0.197 p < 0.001**	0.238 p < 0.001**

* significant at 0.05, ** significant at .001

Discussion of Self-Assessment Versus Score on Multiple-Choice Exams

The results suggest that the five learning outcomes we selected represented a range of mental abilities rather than two distinct categories, the conceptual/managerial and the technical. They also suggest that as the objectives become less technical and more conceptual, there is a diminishing likelihood that self-assessment and direct assessment will correlate. This pattern is consistent with Brewster et al. [2008], who interpret surgical skill as a technical skill when speculating on the reasons that medical residents' self-assessment of their surgical skill correlates with trained medical teachers but their clinical patient relations skills do not. Falchikov and Boud's [1989] finding that students' self-assessment of their abilities in science are more accurate than in social science might reflect the tendency of science education to focus on correct answers while the social sciences require more conceptual understanding and application.

In our study, the most technical learning outcome concerned students' ability to access information in a relational database using structured query language (Outcome 5). The multiple-choice (direct-assessment) questions associated with this objective required some conceptual thinking. Students had to understand the managerial question being asked, the data model provided, as well as SQL syntax in order to recognize the correct query from the alternatives provided. Nevertheless, the multiple-choice questions ultimately tested their ability with SQL. Students accurately perceived their relative ability for this outcome. In both semesters, the self-assessment and direct assessments for this highly technical learning objective were strongly correlated (p < 0.001).

The two most conceptual outcomes involved explaining how Information Systems influence organizational competitiveness (Outcome 1) and describing how organizations develop, acquire and implement Information Systems and the role that users play in this process (Outcome 2). Neither the textbook treatment nor class presentations related to these outcomes included the specific, detailed, invariant procedures of the kind that are involved in Outcome 5, for which students use a specific language to access particular pieces of information in a certain kind of database. Results for these two conceptual outcomes (1 and 2) show no correlation in either semester between the students' self-assessment and the direct assessment of their knowledge.

In this interpretation, the other two outcomes (3 and 4) would be somewhere in between completely conceptual and completely technical. Outcome 4, choosing when spreadsheet and database technologies are applicable to solve various business problems, fits this characterization. When this topic was discussed in class, students had hands-on experience with both technologies, and examples involved the specific spreadsheet and database programs and procedures the students had used. The self-assessment and direct assessment results for Outcome 4 correlated significantly one semester ($p < 0.05$) but not the other.

Results for Outcome 3 also showed correlation in one semester but not the other. However, it is less clear why Outcome 3 could be seen as partly conceptual and partly technical. Neither the presentation in the textbook nor discussions in class referred to specific technologies nor detailed step-by-step procedures involved with using Information Systems to enable organizational processes and process change. It is possible that the discussions referred to the technologies used, at least in a general sense, so that students had reference points that seemed concrete.

In sum, the most striking result is the correlation between self-assessment and direct assessment results for the most technical outcome. The absence of correlation for two of the outcomes and the difference for two other outcomes in the two semesters may have many causes. These include ambiguity in the students' minds about the meaning of the outcome statements; difficulty of creating valid multiple-choice questions for assessing conceptual outcomes that renders direct assessment inadequate; and students' general tendency to overestimate their abilities [Falchikov and Boud, 1989], at least when they don't receive direct feedback on their performance.

Analysis of Self-Assessment Versus Scores on Essay Exam Questions

Further analysis was done to address one of the questions raised in the discussion above: Are multiple-choice questions weak direct measures of student performance with regard to conceptual learning outcomes? In Fall 2009, essay exam questions from several sections of the course tested students' achievements with respect to learning outcomes 3 and 4. We performed an additional direct assessment using these written responses to determine whether students' self-assessment correlates with direct assessment based on their writing in these questions. We first created a rubric to assess the student performance for these essay exams. Three faculty then independently assessed both the essay exams for all students. Using a sample of the student essays, the faculty calibrated themselves before independently assessing both the essay exams. We then compared the assessment scores with the students' self-assessments from Fall 2009 and also the direct assessment using the multiple-choice questions. To test the level of agreement across the different types of assessment measures, the essay exam direct measure was correlated with both the single item self-assessment measure and the multiple choice direct measure for the two learning objectives.

Table 3 provides the results of the additional assessment. Students' indirect self-assessments do not correlate with direct assessments of their essay exam questions (just as their self-assessments do not correlate with direct assessment of their multiple-choice responses). Direct assessment of students' essay exam questions correlates (but weakly in one case) with direct assessment based on their responses to multiple-choice questions. It appears that it may be equally efficacious to use multiple choice questions as essay or written questions to assess student outcomes and that multiple choice questions are a reasonable surrogate for essay questions in the Information Systems discipline. This result agrees with Wainier and Thissen [1993] arguments that anything measurable with essay questions can be measured by constructing objective questions.

VI. IMPLICATIONS

This study suggests that for outcomes associated with a student's technical abilities, of which there are plenty in Information Systems, self-assessment may serve as a valid proxy for direct assessment. The correlation of factor scores based on the multiple-choice exam and students' appraisal of their own abilities indicate that they are equally effective at determining how well students have mastered technical learning outcomes. As learning outcomes become more conceptual, correlation between self-assessment and direct assessment is reduced. This lack of correlation may be attributed to a lack of validity of the direct assessment, the indirect assessment, or both.

Table 3: Pearson Correlation Coefficients for Self-Assessment and Direct Assessment (Essay and Multiple Choice) for Fall Semester 2009			
Learning Objective	Multiple Choice vs. Self-Assessment Fall 2009 Pearson Coefficients and Significance	Essay vs. Self-Assessment Fall 2009 Pearson Coefficients and Significance	Essay vs. Multiple Choice Fall 2009 Pearson Coefficients and Significance
1.Explain how Information Systems enable organizational processes and process change.	0.053 p = 0.257	0.070 p = 0.658	0.345 p = 0.023*
2.Choose when spreadsheet and database technologies are applicable to solve various business problems.	0.022 p = 0.638	0.127 p = 0.290	0.228 P = 0.056

* significant at .05

However, the correlation between the two direct-assessment ratings (essay and multiple-choice; Table 3) seems to provide evidence of the validity of the two types of direct assessment. The lack of validity appears to arise in the students' self-assessment. The question is … Why?

Many studies suggest that students overestimate their abilities so that they believe, for instance, that they have earned higher scores on examinations than faculty give them. However, overestimation was not a factor in our study. Because our direct assessment and indirect assessment scores are on different scales, our analysis does not test the likelihood that students' self-assessment scores match their direct assessment scores. Rather, it indicates the likelihood that students who achieve a higher score on the direct assessment will also indicate a higher rating for their abilities in the self-assessment survey.

Perhaps the difference arises in the ways students learn the technical and conceptual knowledge and abilities. What all the learning outcomes in this study share is that they are contextually defined. What constitutes an ability to construct successful SQL queries differs between an introductory course and an advanced one. Just as one would expect a college senior or graduate student to provide a more detailed and sophisticated explanation of the ways that Information Systems enable organizational processes and process change, so too would one expect a more advanced student to be able to successfully construct much more complex SQL queries than a student in an introductory course.

In the course we studied, students received a detailed understanding of the instructors' contextual definition of the technical learning outcomes. The assignments and exercises they were given indicated the level of performance they were expected to achieve. The practice they received and the feedback provided through that practice—whether in the form of instructor comments or their own degree of success at completing assignments successfully in a reasonable time—provided each student with a solid indication of how well he or she was doing with respect to the desired learning outcome.

For conceptual outcomes, however, the students had less practice and less individual feedback. Conceptual topics were presented in the textbook and discussed in class, but each student came to the exam without sufficient practice at answering in either written or spoken form the direct questions that were asked. Without having the practice and associated feedback that would have helped them develop a sense of the instructors' expectations and their own level of achieving those expectations as defined for this course, the students perhaps lacked a firm understanding of where to rate their mastery of these conceptual abilities in the self-assessment.

It is notable that feedback based on practice is widely understood to be an important component of learning [Martin et al., 2007]. Thus, altering the pedagogy of the course in ways that provide this sort of practice might increase not only the validity of student self-assessment as a proxy for direct assessment but also increase student mastery of the learning outcomes themselves. One method might be an active learning approach where instead of simply discussing the material that the students were asked to prepare, students in small groups work on context-based problems such as case studies that apply the material [Lage et al., 2000]. Students get immediate feedback about where they stand relative to others in their groups in the mastery of the material. Faculty can also provide immediate feedback to the entire class by evaluating the solutions proposed by some of the groups or by having the student

groups evaluate one another's solutions. Future research should explore the applicability of indirect measures to more conceptual outcomes when different pedagogies are used to deliver and help students learn the material.

VII. CONCLUSION

From a resource requirements standpoint, indirect assessment is preferable to direct. The results of this study support the use of student self-assessment for certain types of learning outcomes such as the assessment of students' technical abilities. Perhaps pedagogical changes as suggested in the implications sections above could allow for the application of indirect measures to other, more conceptual types of learning outcomes. For example, if practice indeed makes perfect, then more active-learning approaches might provide the necessary practice and feedback that students need to more accurately self-assess their ability relative to conceptual knowledge.

There is more work to do in this area, but because of the ease of use of indirect when compared to direct assessment, this study lends hope to reducing the perceived burden of assessment for faculty. As educators continue to wrestle with balancing the requirements for and benefits of assessment with the resources required to implement continuous-improvement efforts, the validation of indirect measures could contribute in significant ways to truly achieving the closed-loop, continuous improvement that will truly benefit our programs.

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