A CONFIRMATORY FACTOR ANALYSIS OF PEER ASSESSMENT SCALE

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ABSTRACT

Both the information technology (IT) industry and the Accreditation Board for Engineering and Technology (ABET) demand soft-skill training in higher education and require IT graduates to demonstrate competence in interpersonal communication, teamwork, and conflict management. Group projects provide teamwork environment for soft-skill training, but their practical success is difficult to assess. Group activities often take place outside of the classroom, and instructors are kept out of communication and interaction loops. Free-rider problems arise when some students are awarded the same grades as others who contribute more than their fair share of the work. Many studies have suggested that, for group projects, peer evaluation is more effective than instructor evaluation. However, most peer assessment scales are ad hoc, neither standardized nor well-structured. This study designed a scale for group peer evaluations, and used a factor analysis to validate the underlying dimensions of the scale. The study will be valuable for educators seeking to use peer evaluations to enhance soft-skill training.

INTRODUCTION

Group projects have become increasingly important due to two driving forces. First, the Information Technology (IT) industry and Accreditation Board for Engineering and Technology (ABET) require college graduates to attain skills in interpersonal communication, teamwork, and conflict management (Aasheim, Li, & Williams, 2009). Second, colleges and universities are shifting their pedagogical approaches from passive to active learning, from class lecture ("sage on the stage") to cooperative learning ("guide on the side"; Tagg, 2003). However, for group projects to be successful, a validated peer assessment tool is essential. This study aimed to promote group learning by designing and validating a peer assessment scale. This paper describes challenges and demands, reviews literature, and reports the design and the factor analysis.

CHALLENGES AND DEMANDS

Demand for Soft Skills

In a recent survey, 348 IT managers were asked to rate the importance of various skills (Aasheim, Li, & Williams, 2009). Soft skills were rated high (see Table 1), while hard skills related to knowledge of operating systems, hardware, databases, security, web development languages, telecommunications, and networking were rated much lower.

ABET specified two program outcomes in its Criteria for Accrediting Computing Programs, "ability to function effectively on teams to accomplish a common goal" and "ability to communicate effectively with a range of audiences" (2010, p. 3). The concept of soft skills is not new to higher education. Accrediting agencies have recommended them for over half a century (American Society for Engineering Education, 1950). However, soft-skill training is still particularly weak in science and engineering programs (Schulz, 2008), and this deficit hampers the career progression of today's IT graduates (Williams, 2011). Like engineering programs, IT curricula are loaded with hard-skill courses, and adding a soft-skills course is almost impossible. To meet the demand for soft-skill competence, this study provides a tool for implementing and assessing soft-skill training in a hard-skills course.

Table1: Top 17 Skills Ranked by 348 IT Managers

Skills and Traits	Scale of 1 to 5
1. Honesty/integrity	4.62
2. Communication skills	4.54
3. Analytical skills	4.51
4. Ability to work in teams	4.49
5. Interpersonal skills	4.37
6. Motivation	4.37
7. Flexibility/adaptability	4.33
8. Creative thinking	4.18
9. Organizational skills	4.13
10. Relevant work experience	4.06
11. Awareness of IT technology trends	4.04
12. Operating systems	3.99
13. Hardware concepts	3.92
14. Database	3.92
15. Security	3.91
16. Telecommunications/Networking	3.90
17. Web development languages	3.85

Note: Original table lists 32 skills and traits. Source: Aasheim, Li, & Williams (2009, p. 353).

Demand for Active and Deep Learning

Pedagogical approaches can be classified as passive or active. In passive learning, students merely receive; the instructor designs the learning program, determines assessment criteria, delivers lectures, and evaluates student performance (Falchikov, 1986). In active learning, students participate or take full responsibility for learning.

Learning can also be categorized as surface or deep (Tagg, 2003). Surface learning focuses on information and emphasizes repetition and memorization techniques. According to Tagg (p. 70), "Deep learning is learning that takes root in our apparatus of understanding, in the embedded meanings that define us and that we use to define the world." Students engaged in deep learning have higher levels of intellectual development and satisfaction with college (Laird, Shoup, & Kuh, 2005).

To achieve deep learning, group projects are more effective than such methods as essay tests or multiple choice tests (Figure 1). Numerous studies support the advantages of group projects, such as poster presentations on the use of the biosciences to solve industrial problems (Butcher & Stefani, 1995), group presentations in pharmacology (Hughes & Large,1993), case studies in production management (Kaimann, 1974), simulated training for groups in hotel management and tourism (Kwan & Leung, 1996), team presentations in American history and literature (Oitzinger & Kallgren, 2004), and team learning in business and organizational communication (Roebuck, 1998).

Compared with other fields, engineering programs are less likely to use deep learning approaches (Laird, Shoup, & Kuh, 2005). Figure 2 compares disciplines in terms of their use of deep learning approaches.

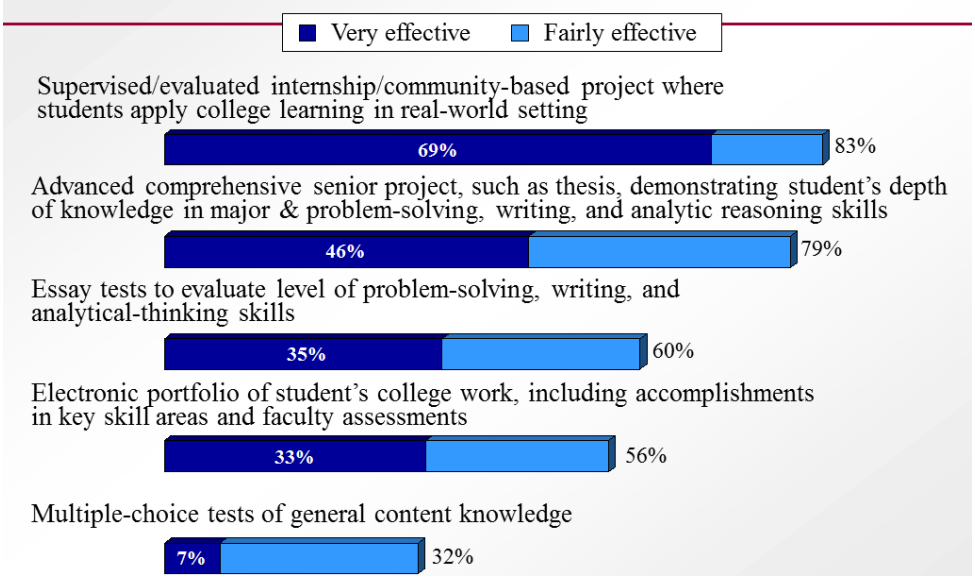

Figure 1: Effectiveness of Deep Learning through Group Projects
Source: Association of American Colleges and Universities, www.aacu.org/meetings/effective_educational_practices/documents/CS6.ppt.

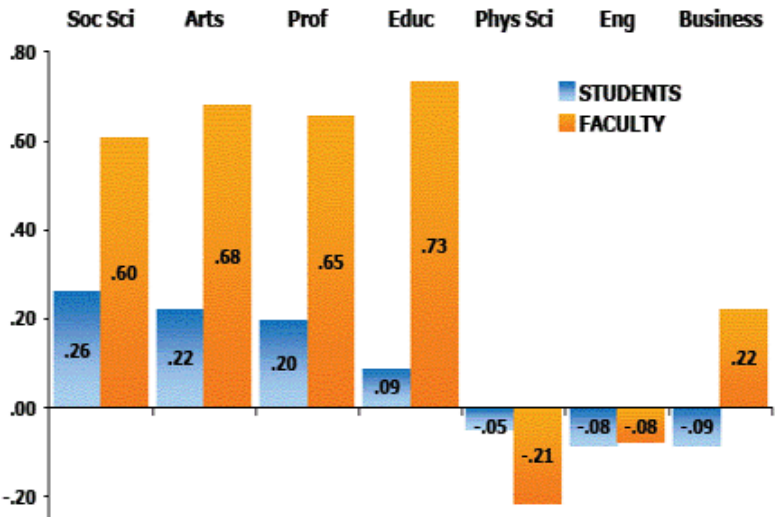

Figure 2: Disciplinary Comparisons of Standardized Means of Deep Learning Approaches Source: Kuh, Laird, & Kinzie (2006).

Challenges in Assessing Soft Skills

In traditional pedagogy, quizzes, exams, and assignments are used to assess individual performance. Students have little input on the assessment criteria and process (Falchikov, 1986). Quizzes or exams cannot accurately measure interpersonal and leadership skills. While group projects provide excellent opportunities for soft-skill training, but individual performance of group members is difficult to assess. Group activities often take place outside of the classroom, and instructors are kept out of communication

and interaction loops. Free-rider problems arise when some students are awarded the same grades as others who contribute more than their fair share of the work.

Tremendous effort has been invested in specifying protocols and designing standardized assessment scales to measure the interpersonal communication skills of doctors, counselors, and nurses (Accreditation Council for Graduate Medical Education, 2005). The importance of this training for doctor and patient interaction during the diagnostic process or surgical team communication during an operation is easy to appreciate. Less effort has been invested in developing assessment scales to measure the soft skills of future IT professionals, who nonetheless must optimize teamwork and communicate effectively with a range of audiences. This study aims to improve IT education by designing and validating an assessment scale.

LITERATURE REVIEW

Definition and Importance of Assessment

Assessment is defined as the activities and processes involved in judging performance. In peer assessment, students are involved in assessing the work of others (Reese-Durham, 2005).

Since Skinner's study of human behavior (1953), hundreds of studies have established that human behavior is shaped by intrinsic motivation and extrinsic rewards, and that extrinsic rewards positively influence intrinsic motivation (Deci, Koestner, & Ryan, 1999). The performance assessment is an extrinsic reward that has tremendous influence over what and how students learn (Gibbs & Haveshaw, 1989). It fosters learning habits and inevitably shapes the learning that takes place (Biggs, 1989).

Positive Results of Peer Evaluation

Many studies confirmed validity and value of peer evaluation. Peer evaluation was shown to be more effective in predicting the success of first-year graduate study than GRE results, biographical and demographic surveys, and the Opinion, Attitude, and Interest Survey (Wiggins & Blackburn, 1969). It is highly correlated with instructor evaluations and produces a typical grade distribution and high degree of internal consistency (Hughes & Large, 1993; Burke, 1969; Pease, 1959; Morton & Macbeth, 1977; Kaimann, 1974). Orpen (1982) showed that there was no difference between peer and instructor evaluations in terms of absolute scores, average scores, variation of scores, and association of scores with final course grades. Kane and Lawler (1978) concluded that peer evaluations provide a unique way to assess students' behaviors and that peers can accurately perceive and interpret each others' behavior and performance.

Peer evaluation also provides a learning opportunity for students to develop the ability to realistically judge the performance of others as well as their own. Boud & Lublin (1983) considered peer assessment one of the most important teaching methodologies in undergraduate education. In a computer sciences course, 84 percent of students believed that evaluating their peers' work enhanced the educational process and reinforced what they had leaned (Rushton, Ramsey, & Rada, 1993). Natriello (1987) reported that peer assessment had a profound effect on student learning. Fry (1990, p.181) validated five advantages of peer evaluation:

1. Students are encouraged to tackle problems outside the tutorial session.
2. In grading others' work, students appreciate and reinforce the correct solutions;
3. Students become aware of the grading scheme and appreciate the reasoning behind points awarded or deducted.
4. In grading others' work, students realize the importance of clearly presenting the solution.
5. The instructor can act as a facilitator rather than an assessor.

Controversial Results of Peer Evaluation

Not all findings are consistent with this positive view. Some studies reported that peer evaluations were significantly higher than those of either instructor or self (Mowl & Pain, 1995; Fuqua, et al., 1986; Friesen & Dunning, 1973), while others found peer evaluations more stringent (Kwan & Leung, 1996; Stefani, 1994). Rushton, Ramsey, and Rada (1993, p. 76) raised the following concerns:

1. Students may not have the same level of understanding of the subject matter as instructors;
2. Instructors are more likely to provide useful feedback;
3. Students may have to be told what points to look for when assessing others' work;
4. Students may be inclined to show bias toward their friends;
5. Students may be reluctant to award poor work low marks for fear of offending peers;
6. Students may not devote sufficient time and attention to this demanding task;
7. Students may be tempted to "borrow" ideas from other students for use in their own work.

THEORETICAL FOUNDATION

Regardless of whether peer assessment is superior to other assessment methods, the objective of this study is to move forward, and to contribute to the body of research by designing and validating the scale to enable students to evaluate the soft-skill competence of their peers in group projects.

Johnson and Johnson's teamwork model (1997) proposes that group members perform two basic functions: the task and social activities (Levi & Cadiz, 1998). The theoretical framework of this study maps hard-skill training with task activities, such as attending meetings, preparing and delivering quality work, and providing ideas and initiatives. At the same time, it maps soft-skill training with social activities related to cooperation and communication, conflict resolution, trust building, and leadership.

Human behavior theory holds that human behavior is shaped by intrinsic motivation and extrinsic rewards. Merely providing soft- and hard-skills training is not sufficient to induce learning. Providing accurate assessment as an extrinsic reward fosters and shapes the learning that takes place (Biggs, 1989; Skinner 1953; Gibbs & Haveshaw, 1989). Figure 3 shows the theoretical framework of this study. Opportunities for training are independent variables; accurate assessments are moderator variables; and learning is the dependent variable. The model emphasizes both soft- and hard-skills training and the role of assessment in the learning process. The objective of this study is not to prove the proposed theory, but to develop an accurate assessment tool that would provide the needed extrinsic reinforcement.

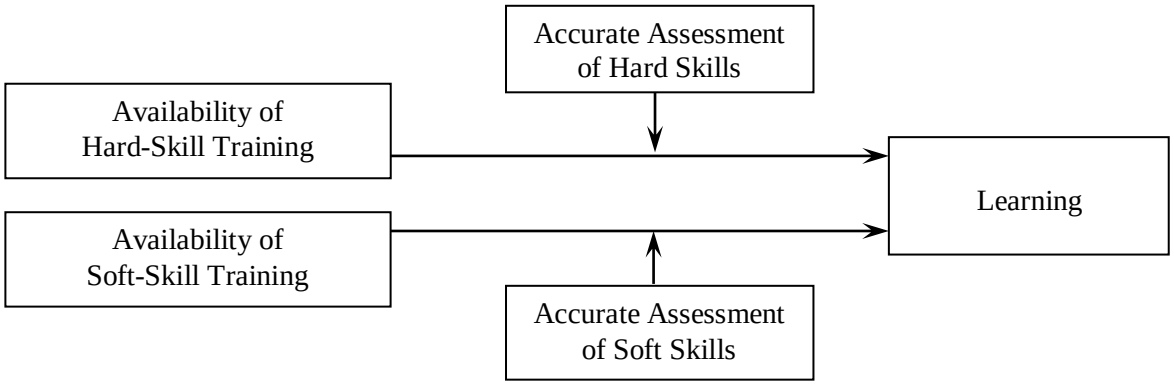

Figure 3. Factors and Moderator for Learning

DESIGN OF THE ASSESSMENT SCALE

To design the assessment scale, I reviewed the existing tools. Levi and Cadiz (1998) designed a peer assessment scale in which four items measure task activities, and four items measure social activities. Gueldenzoph and May (2002) reviewed several peer evaluation studies and designed a scale for evaluating group presentations in a business communication course. It has 11 items. Table 2 shows the design of the assessment scale for this study and source reference for each item. Items 1 through 8 are designed to measure hard skills; items 9 through 16, soft skills; item 17 is the overall grade, and item 18, the discriminate score. All items except 18 used a 5-point Likert scale.

Table 2: Scale Items and Source References

Items	Source References
1. Attends meetings	Chalupa, Chen, & Sormunen-Jones, 2000; Johnson, 1993; Gueldenzoph & May, 2002
2. Comes to meetings prepared	Odom, Glenn, & Sanner, 2009
3. Does quality work	Chalupa, Chen, & Sormunen-Jones, 2000; Levi & Cadiz, 1998; Johnson, 1993
4. Proposes quality ideas and initiatives	Chalupa, Chen, & Sormunen-Jones, 2000; Johnson, 1993
5. Does more than fair share of work	Chalupa, Chen, & Sormunen-Jones, 2000; Levi & Cadiz, 1998; Odom, Glenn, & Sanner, 2009
6. Devotes time and effort to the project	Johnson, 1993
7. Completes work on time	Chalupa, Chen, & Sormunen-Jones, 2000; Levi & Cadiz, 1998; Johnson, 1993; Gueldenzoph & May, 2002
8. Understands concepts and has knowledge of the project	Goldfinch, 1994
9. Dependable and responsible	Chalupa, Chen, & Sormunen-Jones, 2000; Johnson, 1993
10. Communicates with group members	Johnson, 1993; Odom, Glenn, & Sanner, 2009
11. Cooperates with and supports group members (shares resource, ideas, encouragement, constructive feedback)	Chalupa, Chen, & Sormunen-Jones, 2000; Levi & Cadiz, 1998; Johnson, 1993; Gueldenzoph & May, 2002
12. Works through conflicts and handles conflicts in a constructive manner	Chalupa, Chen, & Sormunen-Jones, 2000; Levi & Cadiz, 1998; Gueldenzoph & May, 2002
13. Respectful of others' ideas and stays positive and open-minded	Levi & Cadiz, 1998; Odom, Glenn, & Sanner, 2009
14. Commits to group goal	Chalupa, Chen, & Sormunen-Jones, 2000; Levi & Cadiz, 1998
15. Takes a leadership role	Odom, Glenn, & Sanner, 2009; Gueldenzoph & May, 2002
16. Organizes the group and helps it to function as a team	Goldfinch, 1994
17. At this point, what grade would you give this group member for the project? A___ B___ C___ D___ F___	Johnson, 1993

18. Distribute a total of 100 points among your group members, including yourself. Member 1__ Member 2__ Member 3__ Member 4__ Member 5__	Johnson, 1993

ASSESSMENT ADMINISTRATION AND DATA COLLECTION

Course Background and Setting

The senior-level IT course involved in this study met 3.5 hours per week for a 16-week semester (see Table 3 for schedule). Prerequisites of the course included HTML, CSS, JavaScript, Java, database management, and server configuration. The class had 24 students, 5 women, 19 men, ranging in age from 20 to 31, majoring in IT or pre-IT. Their total credit hours earned ranged from 43 to 168. Students were randomly assigned to 5 groups: PHP, Ajax, XML, HTML5, or RSS.

The first 3.5 weeks of the semester were a facilitating phase during which the instructor taught JSP, which has characteristics similar to those of PHP. This phase lowered the learning curve for PHP and other topics and established a teaching example for students to follow. During the next 2.5 weeks, each group learned one of the 5 topics: PHP, Ajax, XML, HTML5, or RSS. For each, the instructor provided a set of written program codes and a brief assignment instruction. Each group was responsible for figuring out the codes, learning and preparing to teach the topic to the rest of the class. After the 2.5 weeks of preparation, each group had 1.5 weeks to present a topic, run the labs, tutor students, and grade assignments and tests.

Table 3: Class Schedule

<table>
<tr><th>Date</th><th>Topic</th><th>Activities</th></tr>
<tr><td>3.5 week</td><td>JSP</td><td>Instructor teaches JSP with individual assignments</td></tr>
<tr><td>2.5 week</td><td>Group learning</td><td>• Textbook (Sebesta, 2010)
• Instructor provides each group with a set of program codes and a brief assignment instruction
• Group prepares PPT presentation, assignment instructions, test questions, and suggested reading materials
• Collect first-round peer evaluations within all groups</td></tr>
<tr><td>1.5 week</td><td>PHP</td><td rowspan="5">5 Groups Teach 5 Topics
• Each group gives lectures and tours labs
• The class is given a project assignment, a written test, and an online quiz for each topic
• The class evaluates each group.
• The instructor collects the second round of peer evaluations.</td></tr>
<tr><td>1.5 week</td><td>Ajax</td></tr>
<tr><td>1.5 week</td><td>XML</td></tr>
<tr><td>1.5 week</td><td>HTML5</td></tr>
<tr><td>1.5 week</td><td>RSS</td></tr>
<tr><td>Final</td><td></td><td>Term Paper on Group Teaching</td></tr>
</table>

Data Collection

The assessment scale was presented to the class at the beginning of the semester, so students would have a clear understanding of the evaluation criteria and who would evaluate them. This preparation motivated students to improve their skills when interacting with peers.

Within the groups, each member evaluated the others and him or herself twice during the semester. The first round was administered at the end of group learning; the second, at the end of group teaching (see Table 3 for the data collection schedule). I created the assessment scale using tools at surveymonkey.com. A hyperlink was provided on the Blackboard Learning System, where other course materials were posted. The data were automatically collected at surveymonkey.com.

FACTOR ANALYSIS

Item 18 was a discriminate measurement, not designed for measuring soft or hard skills, so it was eliminated from the factor analysis. Table 4 lists the number of items, number of measurements, and methods used in factor analysis.

Table 4: Factor Analysis

Number of measurements	228
Number of items	17
Extraction Method	Alpha Factoring
Rotation Method	Varimax with Kaiser Normalization

Table 5: Kaiser-Meyer-Olkin (KMO) and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.948
Bartlett's Test of Sphericity	Approx. Chi-Square	3623.616
	df	136
	Sig.	0.000

Table 6: Total Variance Explained

Total			% of Variance		
Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
10.553	62.075	62.075	5.810	34.175	34.175
0.838	4.930	67.005	5.581	32.830	67.005

Table 7: Rotated Factor Matrix

	Factor	
	1	2
Item 1		0.575
Item 2		0.777
Item 3		0.867
Item 4		0.698
Item 5		0.759
Item 6	0.539	0.697
Item 7		0.607
Item 8		0.506
Item 9	0.694	0.508

Table 8: Reliability Analysis

	Cronbach's α
Item 1	0.938
Item 2	0.930
Item 3	0.930
Item 4	0.930
Item 5	0.930
Item 6	0.928
Item 7	0.934
Item 8	0.940
Item 9	0.923
Item 10	0.924

Item 10	0.737	
Item 11	0.753	
Item 12	0.712	
Item 13	0.757	
Item 14	0.718	
Item 15	0.656	
Item 16	0.679	
Item 17	0.514	0.621

Item 11	0.922
Item 12	0.926
Item 13	0.931
Item 14	0.928
Item 15	0.929
Item 16	0.927
Item 17	0.935

To measure sampling adequacy, the Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were conducted. The recommended minimum value of KMO is 0.50 (Pett, Lackey, & Sullivan, 2003). The assessment's KMO score of 0.948 was greater than 0.5 (see Table 5), indicating adequate sampling. Bartlett's test examined the null hypothesis of the correlation matrix being an identity matrix. With a degree of freedom of 136 and *p* value of 0.000, the null hypothesis was rejected.

Table 6 shows that two factors captured 67 percent of variance. Table 7 contains the rotated factor loadings. The option blank was set at 0.5, so SPSS printed blanks for any correlations of 0.5 or less.

Reliability was analyzed by examining Cronbach's α values (1951). A Cronbach α value of 0.70 or higher is sufficient for social studies. All items passed with Cronbach's α values greater than 0.70 (see Table 8).

CONCLUSION

According to the Robbins-Gioia Survey, 51 percent of companies that implemented Enterprise Resource Planning (ERP) considered the implementation unsuccessful ("Failure Rate", 2001). User resistance to change during the deployment stage is a bigger hurdle than designing a system. Conflicts are inevitable when a computer system like ERP must be integrated across functions or divisions. IT education must prepare future IT professionals with hard and soft skills to communicate with end users, to resolve conflicts, and to bring different functions together to work toward the common goal. The study should prove valuable for educators to promote soft-skill training and to use peer evaluations to achieve success in IT education.

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