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EMPIRICS OF AN ONLINE ASSESSMENT SYSTEM FOR INDIVIDUAL SCORES (OASIS)

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ABSTRACT

Thanks to their well-documented benefits, team projects are increasingly popular as a valuable learning/teaching tool in higher education. Fully realizing such benefits, however, is predicted on the presumption of no free riding. Hence, a suitably designed assessment method for team projects should *ex ante* discourage free riding before project commencement and *ex post* punish free riders when such behavior is found to exist upon project completion. This paper documents the empirics of a newly developed **O**nline **A**ssessment **S**ystem for **I**ndividual **S**cores (OASIS) implemented by teachers of nine courses across five universities in the U.S., Hong Kong and India. Its key findings are as follows. First, OASIS encourages student participation in a team project through its contractual commitment and contribution-score relationship. Second, OASIS identifies and quantifies the extent of free ridership via negotiation in an end-of-project meeting among team members, thereby generating mutually agreed peer assessment data for individual scoring. Third, OASIS uses the peer assessment data to determine a team member's relative contribution based on median estimation, which is less susceptible to gaming and outlier biases than the alternative of mean estimation. Finally, OASIS automatically assigns individual scores to members of a project team based on their estimated relative contributions and the project's overall score set by a teacher, yielding individual scores that obey the principles of fairness and due diligence in academic assessment. Lending support to these findings is the continued interest in using OASIS of ***all*** participating teachers for their future courses. Further, student surveys indicate that OASIS can improve student perception on the educational value of team projects. Hence, OASIS deserves serious consideration by teachers worldwide who are already or consider using team projects in their teaching courses in different disciplines.

Keywords: Empirics; Online Assessment; Individual Scores; OASIS.

INTRODUCTION

Team projects offer well-documented benefits in student learning (Cheng and Warren, 2000; Hall and Buzwell, 2012). With a valid purpose and proper use of rubrics and marking guidelines, they enable students to learn about each other (Webb, 1997; Aggarwal and O'Brien, 2008) and experience situations that can enhance their communication, teamwork and leadership skills (McCorkle et al., 1999).

Rising popularity of team projects triggers several substantive questions in academic assessment:

- How may an assessment method induce student participation? Based on the theory of incentive, the method should embody a clearly defined relationship between a student's project contribution and academic score (McMillan, 1992; Laffont and Martimort, 2002). By giving higher scores to members who have contributed more to a team project, it induces student participation, which in turn improves the team's overall performance.
- Can the method detect a free rider? A student may become a free rider for various reasons, including his/her sense of futility in active engagement (Webb, 1997), dislike of exploitation by other team members (Wagner, 1995), and possible gain with impunity (Dommeyer, 2007). Irrespective of the underlying reason, however, identifying a free rider is a critical first step in a fair assessment of individual contributions in a team project (Cohen and Lotan, 2014).[1]
- How may the method grade a free rider? When using team projects as a learning tool, a teacher desires all members in a team project making approximately equal contributions (Pfaff and Huddleston, 2003). As free riding may range from zero to less-than-equal contribution, a free rider's individual score should match his/her relative contribution, a direct consequence of the method's contribution-score relationship.
- Is the method easy to implement, timely yielding individual scores that can withstand independent review and verification? If it is hard to implement, it likely attracts few users. As reasoned in Section 2 below, easy implementation should not compromise the resulting scores' transparency and reasonableness. Further, individual scores based on an opaque and subjective method are hard to defend when responding to student complaints of unfair grading.

This paper documents the empirics of a newly developed **O**nline **A**ssessment **S**ystem for **I**ndividual **S**cores (OASIS) implemented by teachers of nine courses across five universities in the U.S., Hong Kong and India. It answers the questions posted above by demonstrating that:

- OASIS encourages student participation through its contractual commitment and contribution-score relationship.
- OASIS identifies and quantifies the extent of free ridership via negotiation in an end-of-project meeting among team members, thereby generating mutually agreed peer assessment data for individual scoring.
- OASIS uses the peer assessment data to determine a team member's relative contribution based on median estimation, which is less susceptible to gaming and outlier biases than the alternative of mean estimation.
- OASIS automatically assigns individual scores to members of a project team based on their estimated relative contributions and the project's overall score set by a teacher, yielding individual scores that obey the principles of fairness and due diligence in academic assessment.

Lending support to the above findings is the continued interest in using OASIS of ***all*** participating teachers for their future courses. Further, student surveys indicate that OASIS can improve student perception on the educational value of team projects. Hence, we conclude that OASIS is a useful peer assessment method for scoring individual contributions to a team project's quality and completion.

This paper makes three contributions to the literature of academic assessment. First, it introduces OASIS, a newly developed peer assessment method to fairly score individual

[1] Our focus of contributions reflects the outcome-based assessment approach adopted by many universities, including those employing the authors.

contributions. Second, its empirics document the practical merits of OASIS, including its ease of implementation, time-efficient determination of individual scores, and applicability to diverse courses across disciplines and regions. Finally, it shows how OASIS can effectively mitigate free riding, generate meaningful peer assessment data via a negotiation process, estimate relative contributions by team members in the presence of gaming and outliers, and reduce student complaints of unfair grading. To the best of our knowledge, these contributions are new, chiefly because OASIS is a new peer assessment tool with empirics unseen in the extant literature.

The paper proceeds as follows. Section 2 summarizes the pedagogical benefits of team projects, discusses the problem of free riding in a team project, reviews three common peer assessment methods, details OASIS, and explains how it differs from the other peer assessment methods. Section 3 reports the results from the first year of OASIS implementation. Section 4 is a discussion of the benefits of OASIS. Section 5 concludes.

LITERATURE AND METHODS

Pedagogical benefits of team projects

To provide a contextual background for this paper, this section briefly reviews the main pedagogical benefits of team projects (Cohen and Lotan, 2014):

- Increased learning. Team projects help co-construct knowledge, as dialogue and interactions produce new understandings among participants (Vygotsky, 1978, 1981). Moreover, they help build soft skills in communication, presentation, problem-solving, leadership, and project management (Hall and Buzwell, 2012).
- Increased motivation. Team projects promote learning through team discussions and debates (Boud et al., 2001). Students learn how to justify ideas, resolve disagreements and understand new perspectives.
- Improved relationships. Team projects facilitate team learning and cooperation, interpersonal relationship development and management, and acceptance of individual responsibilities and accountabilities (Smith, 1996).
- Decreased isolation. Team projects facilitate student interactions in the pursuit of a common goal, thus reducing their sense of isolation (Aggarwal and O'Brien, 2008; Webb, 1997).

To realize the above benefits requires active participation and meaningful contribution by a team project's members. Unfortunately, some members may free ride, as reflected by their inactive participation and/or subpar contribution. As a result, discouraging free riding is critical in helping students to achieve their education goals.

Free riding in a team project

In an ideal world, all members would contribute equally to a team project. In reality, however, some members might exploit the group work setting, making a minimal or even zero contribution. Free riding frustrates team members and teachers (Webb, 1995, pp.245-246). Worse still, a free rider demotivates contributions by other team members (Lee and Lim, 2012; Mulvey and Klein, 1998), thus lowering overall team performance (Aggarwal and O'Brien, 2008; Brooks and Ammons, 2003; Lee and Lim, 2012).

Free riding can cause three types of student complaints. First, it may cause complaints of unsatisfactory group-work experiences (Mello, 1993; Strong and Anderson, 1990; Williams et l., 1991). Second, it may cause complaints of unfair grading by students who have made relatively more contribution and yet received the same score as those who have made relatively less contribution (Healey, 1993). Finally, a free rider may complain about his/her lower score understating his/her relative contribution (Davies, 2009; Joyce, 1999; Maranto and Gresham, 1998).

Addressing the above complaints requires answers to the following questions: (1) can an assessment method mitigate free riding? (2) can the method identify and quantify individual contributions when free riding may have occurred? and (3) can the method yield scores commensurate with team members' individual contributions?

As will be shown below, our answer to the first question is "OASIS" and the next two questions a resounding "yes". To be fair, there are peer assessment methods with goals similar to those of OASIS. The remainder of this paper, however, will demonstrate that OASIS has theoretical and practical merits not shared by these methods, making OASIS a reasonable alternative for consideration by teachers who wish to individually score a team project's members.

Assessment methods for team projects

There are two assessment methods for grading team projects: (a) group assessment which awards the same score to all members of a project team, regardless of individual contributions; and (b) individual assessment of each team member based on his/her individual contribution (Conway et al., 1993; Goldfinch and Raeside, 1990). Identical scoring is unfair for three reasons: (1) it benefits free riders who did little or no work; (2) it benefits team members who delivered low quality work products; and (3) it harms team members who made relatively more contributions (Cheng and Warren, 2000).

Mitigating free riding and determining individual scores predicate on knowing individual contributions by members of a project team (Davies, 2009). A teacher's measurement of a member's contribution, however, can be labor intensive and time consuming (Black et al., 2003). For example, investigation of a team's activities, possibly augmented by interviews with member students, entails substantial amounts of time and effort. Moreover, a fair and consistent outcome may not occur, possibly due to inadequate evidences (Gibbs and Simpson, 2005) and the rater effect (leniency/severity) in large courses involving multiple instructors (Izzo et al., 1999).

Peer assessment by team members is a useful alternative to teacher assessment of individual contributions (Topping, 1998; Cheng and Warren, 2000; Aggarwal and O'Brien, 2008). It involves members who likely know more about "who did what?" in a team than a teacher. Further, it removes the rater effect by precluding the teacher from the contribution data's generation process. Hence, the remainder of this paper will focus on peer assessment of individual contributions to a team project's completion.

What is OASIS?

OASIS is a peer assessment method to transparently produce individual scores for a team project's members. Its implementation entails the steps detailed below.

The first step is team formation and submission of member-specific statement of contribution (SC). Before project commencement, students form teams, which can be voluntarily done by students or through random assignment by a teacher. Each team member must sign a SC, reflecting the course's expectation of equal contribution and high cooperation. Each team then submits the SCs of all members as part of its mandatory declaration of membership. The

SCs commit members to their chosen responsibilities and promised diligence and cooperation, thereby mitigating free riding that may occur after project commencement (Pinto and Slevin 1987; Hoegl et al., 2004). Available online at http://www.eduhk.hk/oasis, Appendix 1 is an example of a SC for a hypothetical team project. Each team's SCs serve as useful inputs in the next step designed to generate meaningful peer assessment data.

The second step is an end-of-project team meeting to produce a team-specific statement of output (SO). After project completion, each team holds a meeting to reflect on their experiences, a common practice already adopted in courses with team projects as part of their learning and teaching. Supported by SCs and documented evidence of deliverables, each member announces his/her initial assessment of self and peer contributions. Members can then openly discuss and revise their assessments before submitting the team's SO to a teacher.[2] Their revised assessments are aided by an online spreadsheet that automatically calculates individual scores based on an assumed overall project score.[3] Available on line at http://www.eduhk.hk/oasis, Appendix 2 is an example of a SO submitted by a hypothetical team.

A team's opportunity to discuss and revise members' assessment data enables a bargaining process that has two major advantages (Muthoo, 1999). The first advantage is that it discourages members from making unsubstantiated claims. To see this point, consider the following cases in which each member's self and peer assessment data for relative contributions must sum to 100%. The first case is a free rider who inflates his/her contribution and therefore understates other members'. The second case is collusive gaming by two or more members who overstate their contributions at the expense of the remaining members. The last case is interpersonal dislike that causes a downward bias in a member's assessment of another member's contribution.

The second advantage is discovery of evidentiary information to be commonly shared by all members, thus facilitating a negotiated settlement through such questions as "who did what?" and "how well did a member fulfill his/her individual responsibilities stated in his/her SC?" The settlement outcome is the team's submitted SO, the basis for estimating member-specific relative contributions in the next step. Because of the settlement nature of the submitted SO, the estimated contributions and their associated individual scores are less prone to student complaints of unfair grading. Section 3 below contains examples of final assessments that differ from initial assessments made by members of a given team.

The third and final step is an automatic calculation of individual scores. Based on a team's submitted SO, OASIS uses median estimation to determine each member's relative contribution to a team project. To illustrate, consider an example of a team of five members: A, …, E. A's contribution estimate is C_A, the median of peer assessments made by the other four members: B, …, E. As A's own assessment does not enter into the median estimation, it cannot influence C_A. Further, an outlier assessment by a given member (e.g., B) is unlikely to have a material effect on the median estimation's result.[4]

[2] If the team fails to reach a settlement, teacher mediation is required.
[3] This meeting may be replaced by an alternative that does not involve open discussion and announcement of member-specific contributions. If that is the case, each member instead of each team submits his/her own SO.
[4] A good analogy here is the scoring system used in Olympic diving competition whereby the highest two and lowest two scores made by a panel of seven judges are discarded in the final score computation of a given dive made by a diver.

OASIS benchmarks C_A against F, a fraction implied by equal contribution (= 0.2 for the 5-member team), yielding a benchmarking value of $D_A = C_A / F$. The benchmarking values of $D_B, \ldots, D_E$ for other members are similarly calculated. As the benchmarking values may not sum to 1.0, OASIS sets A's relative contribution at $R_A = D_A / (D_A + \ldots + D_E)$. OASIS then determines A's individual score as:

$$G_A = \min(R_A G, \alpha G, 100), \quad (1)$$

where G is the team project's overall score based on a 100-point scale given by a teacher and α is a multiple (e.g., 1.5) preset by the same teacher. Equation (1) caps Member A's individual score G_A at the lesser of α G and 100, so as to preclude the potentially odd outcome of excessively high individual scores that may exceed 100 points.

Individual scoring by OASIS embodies a clearly defined contribution-score relationship. If all members have contributed equally, they receive the same score. A member with below (above) equal-share contribution leads to an individual score below (above) the team project's overall score. Finally, a complete free rider with zero contribution gets a zero score. Section 3 below contains examples of individual scores based on a sample of SOs submitted by some project teams.

OASIS vs. three commonly used peer assessment systems

This section begins by describing three popular peer assessment systems. The Comprehensive Assessment of Team Member Effectiveness (CATME) is a web-based tool for individual scores.[5] With self and peer assessment based on five dimensions (contributing to the team's work, having relevant knowledge, skills and abilities, expecting quality, keeping the team on track, and interacting with teammates), CATME allows team member to see his/her assessment by the peers and the average score of the team. However, its complicated algorithm for individual scores and user fee burden the course instructors and the students.

WebPA is an online automated system for assessing team project.[6] It asks each team member to assess his/her own performance and those of team members. WebPA uses equally-weighted mean estimation to generate individual scores and therefore has limited effectiveness on mitigating the strategic behavior of potential free riders. For example, a free rider may overstate his/her performance, thereby raising the mean-based estimate of his/her relative contribution.

iPeer is a web-based platform to develop peer assessment.[7] It combines self/peer assessment and weighted mean estimation which moderately deters potential free riders. However, egoistic bias (Musch et al., 2012) and strategic behavior could still exist because of the inherent weakness of mean estimation.

As shown in Table 1, the aforementioned peer assessment systems can be time consuming, opaque, subjective and hence arbitrary. If individual members are solely responsible for a specific portion of a team project, these methods cannot provide a clear link to the final output that drives a project's overall score, let alone individual scores that truly reflect individual contributions.

[5] http://info.catme.org/
[6] http://webpaproject.lboro.ac.uk/
[7] http://ipeer.ctlt.ubc.ca/

OASIS differs from CATME, WebPA, and iPeer in three important ways. First, it uses SC and SO in the peer assessment data's generating process. The "mere exposure" to peer assessment of contributions helps reduce the possibility of free riding as the anticipation of receiving low assessment contributions would urge the student to modify his/her behavior (Brooks and Ammons, 2003). Free riding is further discouraged by student awareness of the evidence-based negotiation process in the end-of-project meeting that allows a team's members to openly discuss and revise their peer assessment data. In summary, a member cannot easily make unsubstantiated claims in front of his/her fellow members. Second, it uses median estimation to mitigate the possible distortion caused by outliers in the peer assessment data. Finally, OASIS is relatively easy to implement, without requiring its users to decide the criteria or weighting, unlike other peer assessment methods such as WebPA and CATME.

RESULTS

After a one-year implementation since May 2017, we obtain survey data and completed SOs for nine courses taught at five universities in the U.S., Hong Kong and India. Available on line at http://www.eduhk.hk/oasis, Appendix 3 details these courses, all of which have team work as one of their assessment components. The courses are diverse, differentiated by location, class size, student mix, discipline (e.g., engineering vs. business), and level (e.g., first year undergrad vs. graduate), thus attesting the general applicability of OASIS.

We asked each teacher to distribute survey questionnaires to his/her students at course commencement and course end.[8] We use the student survey data to assess student perceptions of team projects, free riding and grading. We also asked each teacher to complete a survey questionnaire designed to elicit his/her views of OASIS. We use the teacher survey data to gauge teacher views on OASIS.

Results from student surveys

The student survey data reveal a relationship between (a) a student's perception of the educational value of team projects based on his/her opinion (1 = strongly disagree, …, 6 = strongly agree) on the statement: "Team projects are useful for achieving my education goals"; and (b) the student's past experience based on his/her opinions (1 = strongly disagree, …, 6 = strongly agree) on the statement: "In my past team projects, members contributed equally".

Let Y_{jk} = opinion of student j in course k on the value of team projects and Z_{jk} = opinion of the same student on his/her past experience of equally contributing members. Table 2 reports the mostly positive course-specific correlations between value perceptions and past experiences, suggesting that high value perceptions tend to associate with positive past experiences.

While informative, the correlations in Table 2 do not quantify the effect of a student's past experience on value perception. To see this point, consider the following OLS regression with intercept β (Wooldridge, 2001):

$$Y_{jk} = \beta + \beta_Z Z_{jk} + \Sigma_k \phi_k C_k + \varepsilon_{jk}. \qquad (2)$$

In equation (2), coefficient β_Z is the marginal effect of Z_{jk} on Y_{jk}. The binary indicators $\{C_k\}$ with coefficients $\{\phi_k\}$ capture the course-specific fixed effects. Finally, the heteroskedastic random error ε_{jk} is assumed to have zero mean and finite variance.

[8] All survey questionnaires are available from the corresponding author upon request.

Since student perceptions may change during a course semester, we first use the survey data collected at course commencement to estimate equation (2). We then repeat the estimation using the survey data collected at course end.

While useful for an initial exploration, the OLS regression given by equation (2) may have estimation bias because Y_{jk} is a qualitative variable (Maddala, 1983). Hence, we also estimate equation (2) as an ordered logit regression (Greene and Hensher, 2010).

Table 3 reports our regression results. For the OLS regression, the estimates for β_Z are 0.1273 and 0.1491 at course commencement and course end respectively. For the ordered logit regression, the corresponding estimates are 0.2424 and 0.3006. As all four β_Z estimates are significantly positive at the 1% level, we infer that a student's positive experience of equally contributing members tends to enhance his/her value perception of team projects. Since OASIS is designed to encourage student participation and mitigate free riding, an implication of our inference is that implementing OASIS likely improves student perception on the education value of team projects.

Results from teacher surveys

Panels A and B of Table 4 show the positive responses from teachers, demonstrating that OASIS has delivered its promised benefits. In particular, almost all teachers agree or strongly agree with all stated benefits of OASIS, with the exception of three expressing neutral opinions. All teachers indicate that they will continue to use OASIS in their future teaching. As shown in Panel B, two teachers are second time users for three different subjects.

Table 5 summarizes the teachers' open-ended responses on OASIS implementation, which include comments on operation and administration and suggestions for improvement. The teachers also mention specific aspects of OASIS that interest them, including: (a) OASIS' ability to evaluate member's specific contribution and its automatic generation of individual scores; and (b) OASIS' helpful features of student commitment declaration, peer evaluation, and end-of-project negotiation.

Other findings of interest

Many teams with unequal contributing team members

Table 6 shows the percentage of teams with unequal contributing team members by course. All courses have such teams, best exemplified by the CBS course's 95% (= 40 out of 42 teams). This suggests the need to score unequal contributions by team members, chiefly because some team members would have been graded unfairly *sans* individual assessment.

Allegedly complete free riders and their self-assessment data

We define a student as an allegedly complete free rider (ACFR) when he/she receives a peer assessment of zero contribution by at least one other team member in a team's submitted SO. Table 6 shows the percentage of teams with ACFRs.

Based on all SOs received, we identify eleven ACFRs in two of the nine courses: CBS and EIE2282. Of the nine ACFRs in the CBS course, five rated themselves as more-than- equal contributors, two equal contributors, and two less-than-equal contributors. In contrast, two students in EIE2282 admitted their zero contributions, as confirmed by all other team members.

While five ACFRs in the CBS course reported more-than-equal contributions, OASIS's median-based calculation removes their self-assessment data from the relative contribution determination, leading to individual scores that are, in the absence of student complaints, deemed reasonable. Had the mean-based calculations of WebPA and iPeer been used, these ACFRs could have received higher individual scores.

Revised assessments of team members

The last column of Table 6 reports each course's share of teams that have revised assessments in their submitted SOs. All courses have teams with initial assessments that differ from final assessments. Further, EIE2282, ECO395K and EIE3115 are the three courses that have 58.3%, 50% and 37.5% of their project teams reporting revised assessments. Thus, negotiation among members during an end-of-project meeting helps settle a team's final SO.

DISCUSSION

This section discusses the benefits of OASIS from three perspectives: students, teachers, and university management, thereby helping a teacher to decide if OASIS is a useful assessment tool for his/her course that uses team projects for student learning.

Student perspective

Based on the survey data and SO submissions, OASIS offers the following student benefits. First, it increases students' ownership of learning and assessment process through self-directed work allocation among team members and open discussion of team members' contributions and individual scores.

Second, it allows students to learn conflict resolution skills and decision-making strategies through team meeting, reflection and peer assessment.

Third, it reduces student concerns with free riders, as its individual scoring calculation ostensibly rewards students with relatively high contributions and punishes those with relatively low contributions.

Fourth, it prevents free riders from benefitting through inflated self-ratings by precluding such ratings in its median estimation. It also mitigates scoring biases that may arise from collusion and interpersonal dislike.

Finally and most importantly, it enhances students' value of team projects and encourages them to contribute.

Teacher perspective

The teacher survey data indicate the teachers' positive responses and continued use of OASIS. Summarized below are the teacher benefits. First, OASIS saves efforts in monitoring the progress of team work in large courses.

Second, it saves time in grading, particularly for courses with large number of students due to its automatic generation of individual scores.

Third, it documents the extent of free riding based on a team's SO submission. As such, it discourages free riding. When free riding does occur, it reduces a free rider's individual score below the team project's overall score.

Fourth, its fair grading process yields consistent individual scoring of member-specific contributions across classes in a given course. In particular, it preempts inaccurate grading caused by inflated self-ratings by free riders.

Fifth, it monitors grading severity and consistency of individual instructors. This is useful for courses with large number of students that involve multiple instructors for teaching and grading.

Sixth, it transparently generates individual scores that obey a clearly defined contribution-score relationship that is fully explained to students at course commencement. This feature is particularly attractive when unequal contributions are likely in a large class of many students of differing abilities who do not know each other well.

Finally, it fully documents a student's relative contribution to a team project based on the student's own SC and the team's SO. This documentation serves to reduce and, if necessary, address potential student complaints of unfair grading.

Management perspective

For an education institution's senior management, OASIS offers the following benefits based on the authors' communications with the members of the teaching and learning committees of their respective universities. First, OASIS complies with the requirement of outcome-based assessment. Second, it remedies the lack of a clearly defined process to prevent and handle free riding cases. Third, it promotes improvement in academic assessment, offering a new way to identify and tackle free riding and various gaming behaviors due to collusion and interpersonal dislike. Fourth, OASIS is general, applicable to courses in different disciplines, ranging from engineering to business. Finally and most importantly, it minimizes student complaints of free riding. Supporting the last benefit is our evidence of ***no*** student complaints in all nine courses, notwithstanding that the ACFRs received individual scores that are far below their team projects' overall scores.

CONCLUSION

This paper introduces OASIS and documents empirics that support its benefits for students, teachers and senior management. As a peer assessment method for generating fair individual scores, OASIS remedies the common problems of free riding and gaming behaviors in project teams.

Our empirical analysis of OASIS deployment in nine courses across five universities affirms that (1) OASIS encourages student participation in team projects; (2) it can detect free riding in a team project; (3) it fairly scores individual contributions by members of a team project; (4) it is user friendly; and (5) it benefits students, teachers and university management. Based on these findings, we conclude that OASIS is a useful peer assessment method that deserves teachers' attention, as evidenced by Appendix 4 available at http://www.eduhk.hk/oasisthat lists the confirmed users in the coming year.

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TABLES AND FIGURES

Table 1. Attribute comparison of four peer assessment methods

Attribute	CATME	WebPA	iPeer	OASIS
Platform	Web-based	Web-based	Web-based	Web-based and Excel worksheet
Basis for determining individual scores	Survey data analysis	Self and peer assessment	Self and peer assessment	Peer assessment
Calculation of individual scoring	Statistical method	Mean estimation	Weighted mean estimation	Median estimation
Cost of implementation	A minimum license fee of 25 unique students or $50.00 to single instructors; $2.00 per year per unique student who used CATME in the previous academic year	Free program ownership and license conditions	Free program downloads and installment	Free
Ease of use	Low	High	High	Medium
Ease of understanding final scores	Medium	Medium	Low	Medium

Table 2. Course-specific correlations of student opinions between education value of team projects and past experiences of equally contributing members

Course ID: title	Department	Institute	Location	Correlation based on survey data collected at course commencement	Correlation based on survey data collected at course end
EIE2282: Information Technology	Electronic and Information Engineering	Hong Kong Polytechnic University	Hong Kong	0.37	0.37
CBS: Capstone Business Strategy Simulation	Business	Goa Institute of Management	India	0.21	0.20
ECO395K: Markets for Electricity	Economics and Public Affairs (cross-listed)	University of Texas at Austin	U.S.	-0.16	-*
EIE3115: Airport Information Systems	Electronic and Information Engineering	Hong Kong Polytechnic University	Hong Kong	0.45	0.12
AF3625: Engineering Economics	Accounting and Finance	Hong Kong Polytechnic University	Hong Kong	0.02	0.18
ECON7450: Energy Economics	Economics	Hong Kong Baptist University	Hong Kong	-0.04	0.24
POS2002: China's Rise and Globalized World	Asian and Policy Studies	Education University of Hong Kong	Hong Kong	0.19	0.07
AAE2002: Aviation Information Systems	Electronic and Information Engineering	Hong Kong Polytechnic University	Hong Kong	0.21	0.10
EIE3360: Integrated Project	Electronic and Information Engineering	Hong Kong Polytechnic University	Hong Kong	-0.03	0.70

* No data is provided for calculation as the teacher did not distribute the survey questionnaire at course end.

Table 3. Summary of OLS and ordered logit regression results, where dependent variable Y_{jk} = opinion of student *j* in course *k* on the value of team projects

Panel A: Results based on survey data collected at course commencement; sample size = 634 observations

Variable: definition	OLS			Ordered logit		
	Estimate	Standard error	*p*-value	Estimate	Standard error	*p*-value
Goodness of fit statistic defined in note (2) below	0.1193	--	--	0.0568	--	--
Z_{jk}: Student opinion (1 = strongly disagree, …, 6 = strongly agree) on the statement: In my past team projects, members contribute equally (β_Z)	0.1273	0.0373	0.0007	0.2424	0.0566	<.0001

Panel B: Results based on survey data collected at course end; sample size = 630 observations

Variable: definition	OLS			Ordered logit		
	Estimate	Standard error	*p*-value	Estimate	Standard error	*p*-value
Goodness of fit statistic defined in note (2) below	0.1396	--	--	0.0720	--	--
Z_{jk}: Student opinion (1 = strongly disagree, …, 6 = strongly agree) on the statement: In my past team projects, members contribute equally (β_Z)	0.1491	0.0374	<.0001	0.3006	0.0646	<.0001

Notes: (1) The standard errors are heteroscedasticity-consistent (Wooldridge, 2001).

(2) For the OLS regression estimated using PROC REG in SAS, the statistic is the adjusted R^2. For the ordered logit regression estimated using PROC LOGISTIC in SAS, it is McFadden's pseudo R^2 = 1 – (log-likelihood at convergence / log-likelihood with intercept only) (Greene and Hensher, 2010).

(3) For brevity, both tables exclude the coefficient estimates for the intercept β and course-specific binary indicators $\{C_k\}$.

Table 4. Teachers' survey responses on OASIS implementation

Panel A: Initial users in semester 1 of the academic year 2017-2018

Questions	EIE2282		CBS	
	Dr. Pauli Lai	Dr. Doris Lin	Dr. Hemant K. Padhiari	Dr. R Rathish Bhatt
1. The process has advanced a team project's learning goals.	▽	○	○	○
2. The process has discouraged free riding behavior.	●	○	○	○
3. The process is easy to implement *sans* costly monitoring and evaluation.	○	○	○	○
4. The process is fair, yielding individual scores that reflect member-specific contributions.	●	▽	○	●
5. The process is transparent and objective.	●	○	○	●
6. I will continue to use the process in my future teaching.	●	○	○	○

Panel B: Second-round users in semester 2 of the academic year 2017-2018

<table>
<tr><td rowspan="2">Questions</td><td>ECO395K</td><td>EIE3115</td><td colspan="2">AF3625</td><td>ECON7450</td><td>POS2002</td><td>AAE2002</td><td>EIE3360</td></tr>
<tr><td>Dr. Jay Zarnikau</td><td>Dr. Pauli Lai</td><td>Dr. Tak Wai Chau</td><td>Dr. Tina Wong</td><td>Dr. Ray Li</td><td>Dr. Lee Siu Yau</td><td colspan="2">Dr. Doris Lin</td></tr>
<tr><td>1. The OASIS process advanced each team project’s learning goals.</td><td>○</td><td>○</td><td>○</td><td>○</td><td>○</td><td>●</td><td colspan="2">○</td></tr>
<tr><td>2. The OASIS process discouraged free riding.</td><td>○</td><td>○</td><td>○</td><td>●</td><td>○</td><td>●</td><td colspan="2">●</td></tr>
<tr><td>3. The OASIS process is easy to implement.</td><td>○</td><td>○</td><td>○</td><td>●</td><td>▽</td><td>○</td><td colspan="2">●</td></tr>
<tr><td>4. The OASIS process is fair.</td><td>○</td><td>○</td><td>○</td><td>●</td><td>○</td><td>○</td><td colspan="2">○</td></tr>
<tr><td>5. The OASIS process is transparent.</td><td>●</td><td>●</td><td>○</td><td>●</td><td>○</td><td>○</td><td colspan="2">●</td></tr>
<tr><td>6. The OASIS process is objective.</td><td>●</td><td>○</td><td>○</td><td>○</td><td>○</td><td>●</td><td colspan="2">○</td></tr>
<tr><td>7. I will use the OASIS process in my future teaching.</td><td>○</td><td>●</td><td>○</td><td>●</td><td>○</td><td>●</td><td colspan="2">●</td></tr>
</table>

Notes: ● = ‘Strongly agree’, ○ = ‘Agree’ and ▽ = ‘Neutral’.

Table 5. Teachers' open-ended responses on OASIS implementation

Question	Responses
Which aspect(s) of OASIS interests you the most?	• The ability to help identifying free riders in team projects • The ability to evaluate each member's specific contribution • The fair grading of individual scores • The simple input requirement from students and teachers • The easy understanding and implementation of Excel scoring spreadsheet • The automatic generation of individual project scores • The objective verification of students' work utilizing SC and negotiation process • The transparency and well-articulated process
What aspect(s) of OASIS need(s) improvement and what changes would you suggest?	• Use sealed submission to avoid direct conflict • Develop a mobile version of OASIS with push notifications • Use google form for students' and teachers' evaluation to facilitate data collection • Improve the report generator
Which parts of the OASIS process did you find helpful? How so?	• Peer evaluation of contribution • Students' commitment declaration • Contributions identification at end-of-project meeting
Any additional comments on the implementation, operation and administration of OASIS?	• Set alert messaging function for invalid inputs of information • Need a more systematic written guidelines on various components of OASIS • Simplify the areas of commitment declaration • Re-design the Statement of Output so that the components can be put vertically
Any problems encountered/issues concerned in the implementation?	• Some students did not treat the SC earnestly and fulfil their declared responsibilities • Some students might not put down true assessments on teammates' contributions so as to eschew hurting team amity • Some students did not fill in the required information in SO properly, causing more follow-up work for teachers

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Table 6. Summary of course-specific statements of output

Course	Semester number in 2017-2018	Total number of students	Total number of teams	Percentage of teams with equally contributing team members in *final* assessment of contributions[#]	Percentage of teams with unequal contributing team members in *final* assessment of contributions[#]	Percentage of teams with allegedly complete free riders in *final* assessment of contributions	Percentage of teams with revised assessments of contributions
EIE2282	1	70	12	41.67	58.33	16.67	58.33
CBS	1	261	42	4.76	95.24	19.05	2.38
ECO395K	1	14	4	50	50	0	50.00
EIE3115	2	35	8	75	25	0	37.50
AF3625	2	273	78	79.49	16.67	0	7.59
ECON7450	2	28	9	77.78	22.22	0	22.22
POS2002	2	59	19	42.11	10.53	0	10.53
AAE2002	2	51	10	90	10	0	10.00
EIE3360	2	32	16	68.75	12.50	0	6.25

[#] Since some teams did not submit their final assessment of contributions, these two percentages may not sum up to 100%.

APPENDICES

Appendix 1. An example of statement of commitment for a hypothetical team project

As a valuable member of this 5-person team, I commit to actively cooperate and diligently contribute 20% (= 1/5) of this team project's final output. To ensure the project's timely completion and high quality, my primary areas of responsibility are marked by "×" below:

□ Topic selection □ Research plan: what and when to do?
□ Literature review □ Experiment / survey design
□ Data collection and analysis □ Graphics, tables and charts
□ Discussion of key findings □ Implications and recommendations
□ Presentation preparation □ Final report preparation
□ Editing and proofreading □ Project management and coordination
□ Fund raising □ Dissemination of research findings
□ Other: ____

Name: ______________________
Student ID: ______________________
Signature: ______________________
Date: ______________________

Appendix 2. An example of statement of output spreadsheet for a hypothetical team project

Team input: expected project score	100	Project Name	Project A	Clean up all entries
		Team Name	Yellow Submarine	
Teacher input: adjustment	1.5			Read Initial Assessment
		Number of Students	5	
Teacher input: actual project score	90			Read Final Assessment

Part A

Team's membership declaraion

Part B

Team's commitment declaration

Member ID	Student name	Student ID	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9	Area 10	Area 11	Area 12	Area 13	Area 14	Area 15
1	Adam	1707XXXXD	✓	✓		✓	✓			✓			✓	✓	✓		✓
2	Bobby	1708XXXXD	✓	✓		✓	✓		✓	✓	✓		✓	✓	✓		✓
3	Jenny	1706XXXXD	✓	✓	✓		✓	✓	✓		✓	✓	✓		✓	✓	
4	Zoe	1707XXXXD	✓		✓			✓	✓		✓	✓				✓	
5	Peter	1708XXXXD	✓		✓	✓		✓	✓	✓	✓	✓		✓		✓	✓
6																	
7																	
8																	
9																	
10																	

Part C

Team's initial assessment of contributions

Part D

Individual scores based on expected project score

Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7	Member 8	Member 9	Member 10	Reasons	Part D
0.3	0.2	0.2	0.2	0.1							100
0.2	0.3	0.2	0.1	0.2							100
0.2	0.2	0.2	0.2	0.2							100
0.3	0.2	0.2	0.2	0.1							100
0.3	0.2	0.2	0.2	0.1							75

Part E

Team's final assessment of contributions

Part F

Individual scores based on expected project score

Part G

Individual scores based on actual project score

Member 1	Member 2	Member 3	Member 4	Member 5	Member 6	Member 7	Member 8	Member 9	Member 10	Reasons	Part F	Part G
0.2	0.3	0.2	0.2	0.1							100	100
0.3	0.3	0.2	0.1	0.1							100	100
0.1	0.3	0.2	0.2	0.2							95	86
0.3	0.2	0.2	0.2	0.1							95	86
0.3	0.2	0.2	0.2	0.1							48	43

Appendix 3. Description of courses that used OASIS in the 2017-2018 academic year

Course code	Course title	Level of subject	Department	Institute	Location	Content	Assessment method
EIE2282	Information Technology	Undergraduate	Electronic and Information Engineering	Hong Kong Polytechnic University	Hong Kong	● Professional/academic knowledge and skills in information technology ● Attributes for all-roundedness	● **Case study project (20%)** ● Laboratory sessions (30%) ● Online tests (30%) ● Written test (20%)
CBS	CBS Capstone Business Strategy Simulation	Postgraduate	Business	Goa Institute of Management	India	● Business knowledge in decision makings and skills in forming business strategies ● Learning through experience and learning by doing	● **Group simulation game (50%)** ● Quiz (10%) ● Presentation (10%) ● Individual end-term project (30%)
ECO395K	Markets for Electricity	Postgraduate	Economics and Public Affairs (cross-listed)	University of Texas at Austin	U.S.	● Energy economics topics	● **Two homework sets (30%)** ● Term paper (and associated in-class presentation) (40%) ● Mid-term exam (30%)
EIE3115	Airport Information Systems	Undergraduate	Electronic and Information Engineering	Hong Kong Polytechnic University	Hong Kong	● Knowledge and skills in information systems in aviation industry ● Hand-on experience to operate and maintain existing airport information systems ● Analyze and develop new subsystems for desired needs ● Extend knowledge of airport information systems to different situations of engineering context and professional practice	● Homework assignment (10%) ● Quizzes (20%) ● **Case study report and presentation (20%)** ● Examination (50%)
AF3625	Engineering Economics	Undergraduate	Accounting and Finance	Hong Kong Polytechnic University	Hong Kong	● Knowledge on how relevant economic factors shape the environment within which an engineering company operates ● Evaluate financial condition of a company based on financial	● **Group presentation (10%)** ● Individual written assignment (15%) ● Tutorial attendance and participation (5%)

						statements ● Apply basic cost accounting techniques in planning and control of engineering and production activities	● Mid-term test (20%) ● Final Examination (50%)
ECON7450	Energy Economics	Postgraduate	Economics	Hong Kong Baptist University	Hong Kong	● Knowledge on role of energy in economic growth and environmental sustainability ● Knowledge on key issues of energy sector ● Evaluate impacts of energy policies of the government ● Provide policy recommendations	● **Class Participation/Discussion (15%)** ● Assignment(s) (25%) ● Test(s) (20%) ● Examination (40%)
POS2002	China's Rise and Globalized World	Undergraduate	Asian and Policy Studies	Education University of Hong Kong	Hong Kong	● Knowledge on China's changing role in world affairs ● Knowledge on forces of globalization shaping China's domestic developments and foreign relations ● Analyze China's role in stabilizing global order ● Understand the principle antagonisms and dynamics of relationship between China, major global actors and globalized world ● Use knowledge of past and present conditions to make predictions about China's future role in world affairs	● **Group tutorial presentation and discussion (30%)** ● **Group presentation report (20%)** ● Examination (50%)

AAE2002	Aviation Information Systems	Undergraduate	Electronic and Information Engineering	Hong Kong Polytechnic University	Hong Kong	● Possess essential knowledge and skills in the area of aviation information systems ● Apply their knowledge, skills and hand-on experience to maintain and perform ● diagnosis on existing aviation information systems ● Extend knowledge to analyze and develop new modules and components in aviation information systems for desired needs	● Labs (20%) ● Online Test (10%) ● **Case study project (report + presentation) (20%)** ● Written final test (10%) ● Exam: (40%)
EIE3360	Integrated Project	Undergraduate	Electronic and Information Engineering	Hong Kong Polytechnic University	Hong Kong	● Professional/academic knowledge and skills ■ Design effective and reliable software programs to achieve the objectives of a project ■ Critically evaluate the different alternatives and strategies when implementing a project ■ Locate and resolve problems in a multimedia system and the related software ● Attributes for all-roundedness ■ Search, self-learn and try untaught solutions ■ Effectively use the limited resource and exercise discipline and time-planning to meet deadlines ■ Present ideas and findings effectively ■ Work as a team and collaborate effectively with others	● Tutorial exercises (10%) ● Lab exercise (10%) ● Logbook, proposal, final report, and presentation (22%) ● **Preliminary project demo (15%)** ● **Final project demo (30%)** ● **Project management, Online discussion forum, team assessment (13%)**

Appendix 4. Confirmed OASIS users in 2018-2019 academic year

OASIS Users	Position	School/Department	Institution	Course name	Subject area	Number of students
Dr. Lam Kim Hung	Teaching Fellow	Department of Applied Biology and Chemical Technology	The Hong Kong Polytechnic University	ABCT1D09 Greenhouse gases and life	Food Analysis	100+
Dr. Alice Shiu	Associate Professor	School of Accounting and Finance	The Hong Kong Polytechnic University	AF3625 Engineering Economics	Economics	150+
Dr. Wong Sau Ngai Kate	Teaching Fellow	Department of Chinese Culture	The Hong Kong Polytechnic University	CC312P Women in China	History	38
Prof. Jinping Tong	Associate Dean	Business School	Changzhou University	School team member selection for the "Challenge Cup (挑戰杯)" Competition	Logistics and student affairs	~20
Mr. Craig Nicholson	Vice President	School of Business	Guizhou Forerunner College	Evaluation of the teaching crew for the courses of: Beer Brewing, Dessert, and Chinese Tea-making	Cooking	~10
Dr. Angelia Wang Dr. Sandy Sabapathy	Instructor Teaching Fellow	School of Accounting and Finance	The Hong Kong Polytechnic University	AF3507 Company Law	Law	120
Dr. Anson Wong	Teaching Fellow	School of Accounting and Finance	The Hong Kong Polytechnic University	AF5326 Managerial Finance	Finance	100
Dr. Lolita Edralin	Professor of Practice	School of Accounting and Finance	The Hong Kong Polytechnic University	AF5203 Contemporary Issues in Accounting Information System	Accounting	50
				AF5204 Contemporary Issues in Information Systems Controls and Audit	Accounting	20+
Dr. Andy Chui Dr. Alice Shiu	Associate Professor Associate Professor	School of Accounting and Finance	The Hong Kong Polytechnic University	AF4912 Capstone Project	Accounting and Finance	6 6
Miss Doris Lin	Instructor	Department of Electronic and Information	The Hong Kong Polytechnic	EIE3120 Network Technologies	Information technology	~40

		Engineering	University	and Security		
Dr. Hemant Kumar Padhiari	Associate Professor		Goa Institute of Management	Awaiting information	Awaiting information	Awaiting information
Mr. Daniel Chi Shing Yeung	Lecturer	Department of Health and Physical Education	The Education University of Hong Kong	PES4208 Principles and Practice of Health Promotion	Health and physical education	57
				PES1195 Growth, Development and Ageing	Health and physical education	46
Dr. Jay Zarnikau	Adjunct Professor of Public Affairs	Economics and Public Affairs (cross-listed)	University of Texas at Austin	ECO386K Markets for Electricity	Economics of electricity	~12-13