Analysis of Student Course Evaluation Data for an IT Subject: Implications for Improving STEM Education

William W. Guo, Wei Li, Yucang Wang, and Jun Shen

***Abstract*—This paper reports data analysis of students' satisfaction on a graduate course in information technology for 11 consecutive semesters over six years at an Australian university. We find a negative trend between course satisfaction and class size and a positive trend between teaching and course satisfactions, consistent with what reported in literature from other disciplines. This study also reveals that teaching satisfaction rate has a negative association with neutral rate but surprisingly no association with course dissatisfaction rate. This implies that improvement on student course satisfaction through good teaching may mainly be resulted from converting those undecided students from neutrality to satisfaction. Results of this data analysis support a parallel flow model between course satisfaction and both neutrality and dissatisfaction, which leads to a new strategy for achieving a high level of course satisfaction for other domain-complexity courses in science, technology, engineering and mathematics (STEM) education. Strategically, innovative and engaged teaching is still the key to achieve a high course satisfaction. Tactically, guided by existing and emerging teaching and learning theories, a number of specified measures are worth of consideration in course design and delivery for similar highly technical courses for achieving a high level of course satisfaction in future.**

***Index Terms*—Course improvement, course satisfaction, student course evaluation, STEM education, teaching satisfaction.**

I. Introduction

Students' opinions on good tertiary education may be affected by many factors, but their satisfaction on individual courses completed should be very influential on the formation of their perceptions. This is because course satisfaction on individual courses studied is the foundation of students' overall satisfaction on a program undertaken. In most Australian institutions, centrally organized student course evaluations for all courses offered in a semester are conducted near the end of a semester. Students enrolled to a course are required to participate in the evaluation for assessing a number of aspects associated with course design and delivery. Results of these surveys have been used for three major purposes: gathering student's feedback on the current configuration of a course, identifying areas where further improvement could be made to a course, and assessing instructor's performance of course delivery which is normally linked to the promotion of the involved faculty.

There have been strong arguments surrounding the centralized student course evaluation since students' responses depend on many unquantified factors. For example, Hager & Butler [1] compared two different educational assessment models for assessing workplace performance and found each model was appropriate for some specific circumstances. This implies that there might be no universal model for evaluating a variety of courses in difference fields at any comprehensive institution. Husbands [2] reported that class size and sharing teaching duty among multiple instructors for one course had significant influence on the outcome of student course evaluation. Student emotional state at the end of a semester, driven by a bad incident or fear of failing the course, also affected the evaluation outcomes [3], [4]. Cohen [5] found that students evaluated their teachers and courses differently. Based on the fact that student course approval strongly correlated to student's grade expectations, Kidd & Latif [6] questioned the usefulness of student course evaluations. Menachemi [7] found that the Web-based student survey may yield biased responses.

These findings indicate the possible existence of some uncertainties associated with student course evaluations. However, in the meantime, many studies have also shown that data of student course evaluation should contain useful information about course design, delivery, and improvement from student' point of view [8]-[13]. Some useful facts may be hidden in the course evaluation data, in addition to the standard statistical presentation of the data released to the involved faculty and management team. Therefore, this study focuses on firstly identifying potential facts that are most likely to affect students' satisfaction on a course studied, and secondly using this acquired knowledge to define strategies of course design and delivery for improving student satisfaction in the future.

In this paper, the student survey results from past 11 consecutive semesters over six years on a graduate course, *Distributed Systems*, are analyzed in order to find the hidden facts that may have affected the satisfaction rating for this course from student's point of view. We firstly provide an outline of this course and the selected aspects of the student survey. The historic data of student survey on this course are then analyzed using statistical analysis to reveal any hidden facts contained in the data. These findings are discussed incorporating the teaching practices in this course. Conclusions are finally drawn in terms of defining new strategies for improving student course satisfaction in the future. These findings will be useful in guiding course design and delivery of other highly technical courses in STEM.

Manuscript received May 19, 2016; revised July 20, 2016.

William Guo, Wei Li, and Yucang Wang are with School of Engineering and Technology, Central Queensland University, Rockhampton 4702, Australia (e-mail: w.guo@cqu.edu.au).

Jun Shen is with School of Information Systems and Technology, University of Wollongong, Wollongong, NSW 2522, Australia.

doi: 10.18178/ijiet.2017.7.9.945

II. Course Structure

Distributed Systems had been a compulsory course in Master of Information Technology and an elective to other graduate programs for more than two decades at this university. This course provided students with an opportunity to integrate knowledge and skills learnt from previous courses on data communication, programming, networking, operating systems, network management, and computer security into critical analysis and strategic design for real-world distributed systems.

This one-semester course was introduced in the middle 1990s with a series of independent seminars compiled from conference and journal articles, reports, books, and case studies, and coordinated by several instructors in different semesters. Students constantly demanded a systematic change to the course so that its contents could be serialized according to the logical connections among topics. To address student's concerns, redevelopment of this course was made in an effort to include recent development in and serialize the relevant topics on distributed systems.

The redevelopment also led to the structural changes in teaching settings of this course. It had three hours of face-to-face teaching each week consisting of two periods of 45-minute formal lecture presented by the instructor and two sections of 30-minute informal seminar given by students. Informal seminars were scheduled from the fourth to the eleventh weeks as a complement to the formal lectures that focused on theoretical framework and strategic analysis. The informal seminar was counted for 15% of the total mark; another major assignment was worth 25% of the total mark; the final examination, which students must obtain at least half or more to pass this course, contributed to the remaining 60%.

This general structure had been kept for 11 semesters after its inaugural offering although minor changes were brought into this course in each offering. The reason that this course was not undergone any major redevelopment for six years was the student evaluations on this course during this period were mostly highly satisfactory. This course was developed and directly coordinated and delivered by the same person during this period of 11 consecutive semesters, which was very rare in any other courses. This is actually the fundamental reason for this course to be chosen for this study because of its high consistence in course delivery over the period.

In its 12th offering, this course became an elective for all relevant graduate programs and thus be offered only once per year. This course was redeveloped by a different developer. Details of student course evaluation on the redeveloped course were not available due to confidentiality, but the overall course satisfaction was going downwards, which also motivated this study on using the historic data of this course for investigating useful ways to bring back the high course satisfaction achieved in the past and to make further improvement on this course and similar highly technical courses in STEM in the future.

III. Course Evaluation Data

In the last two weeks of a semester, the university centrally organizes student course evaluations for all courses offered in that semester. Students enrolled to a course are required to participate in this survey for assessing the design and delivery of that course. There are multiple questions in the evaluation covering a number of different aspects, and the final question asks students to assess their overall satisfaction on the enrolled course. Student' responses fall into one of the three broad categories: dissatisfaction (DIS), neutrality (NEU), and satisfaction (SAT). The evaluation results on overall course and teaching satisfaction for *Distributed Systems* for 11 semesters are summarized in Table I, which also includes the number of students enrolled to the course or class size (CLS) in each semester.

TABLE I: Course and Teaching Satisfaction Rates for *Distributed Systems*

Year	1		2		3		4		5		6	Mean	SD
Semester	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	N=11	-
CLS (%)	16	14	34	11	37	30	39	29	15	11	21	23	11
TCS (%)	86	81	83	100	80	71	89	81	100	92	86	86	9
SAT (%)	88	86	67	91	79	74	76	82	100	91	92	84	10
NEU (%)	0	14	22	0	14	13	10	18	0	9	8	10	7
DIS (%)	12	0	11	9	7	13	14	0	0	0	0	6	6

CLS: class size; TCS: teaching satisfaction; SAT: satisfaction; NEU: neutrality; DIS: dissatisfaction

The class size varied from 11 to 39 over the period with an average of 23 students per semester. In fact, the course configuration was originally based on a desired class size of 15 to 20 students. The overall course satisfaction varied from 67% to 100% with an average of 84% over 11 semesters. In the six semesters when the class size was smaller than the average of 23, the course satisfaction was higher than the average of 84%. On the contrary, in other five semesters when the class size was close to 30 or more, the course satisfaction was below the average. The worst case occurred in the 3rd offering when the first time 34 students were enrolled to the course, doubled its historic average enrolment. The 30-minute informal seminar given by students had to be shortened to 15 minutes each and four such seminars had to be facilitated each week from the fourth week onwards in the semester. In the end, a course satisfaction of 67% was marked by students, implying one out of three students was either unsatisfied with or kept neutral on the delivery of this course. The surprising outcome from this survey was that the course dissatisfaction was not abnormally increased for this occasion; rather a record high neutral rate of 22% was banked.

Instructor's teaching satisfaction (TCS) judged by students varied from 71% to 100% over the same period with an average of 86%, slightly better than the average of course satisfaction. However, the negative correlation between teaching satisfaction and class size was not as close as that between course satisfaction and class size. For example, the largest class of 39 students in the 7th offering had a teaching satisfaction of 89%, 3% above the average; a smaller class of 14 students in the 2nd offering had a teaching satisfaction of 81%, 5% below the average.

On average, the course dissatisfaction is about 6% with zero disapproval for the last four consecutive offerings. The average neutral rate is about 10%, almost doubled the average of dissatisfaction rate with a standard deviation of 7%.

Since student enrolment to this course varied from semester to semester, no systematic changes were made to the configuration of the course delivery. However, some adjustments, such as allowing paired team to present the informal seminar and redefining the requirements for the major assignment, were made to improve course delivery for large classes. These efforts brought considerable improvement on student course satisfaction from that worst point of 67%, but the course satisfaction of small classes was still superior to that of large classes.

IV. Data Analysis

Over the 11 semesters, despite some variations, the course satisfaction exhibited a gradual improvement as a result of an overall decrease in dissatisfaction rate, to which a slight improvement on teaching satisfaction over the same period might have had a positive contribution (Table II). However, these are only trends over the period because no significant temporal correlation has been confirmed by statistical analysis [14]-[16]. The temporal correlation coefficient for SAT, DIS, and TCS is 0.3709, -0.5197, and 0.2289 respectively, their absolute values being smaller than the critical value of 0.602 for 11 datasets at 95% confident level. The neutral rate does not show any sign of temporal correlation over the time.

Table II also shows associations between class size and course satisfaction rates. A strong negative trend between CLS and SAT indicates that the larger the class; the lower the course satisfaction (Fig. 1). This is not incidental. With more students in a class, the share of instructor's time of assistance to individuals and of the discussion time for each informal seminar given by a student was dramatically reduced. In fact, the small classes in the last three semesters all resulted in a course satisfaction over 90%.

TABLE II: Correlation Analysis of Satisfaction Rates

	Correlation coefficient			
	SAT	NEU	DIS	TCS
Temporal correlation	0.3709	-0.056	-0.519	0.2289
CLS	-0.805	0.4932	0.6384	-0.550
TCS	0.6841	-0.696	-0.228	1

The logical inference of a positive association between class size and dissatisfaction is also confirmed in this case, indicated by a correlation coefficient of 0.6384. As we can see in Table I, the four lowest satisfactions (below 80%) were all associated with a class size of 30 or more. This is a complement to the negative correlation between class size and course satisfaction. There is a positive trend between class size and the neutral rate but it is not as significant as the other two trends. It is a reasonable inference that in most cases there were (and will be) a few students who could not make a definite decision at the time of course evaluation, no matter how many students were (and will be) enrolled to a course.

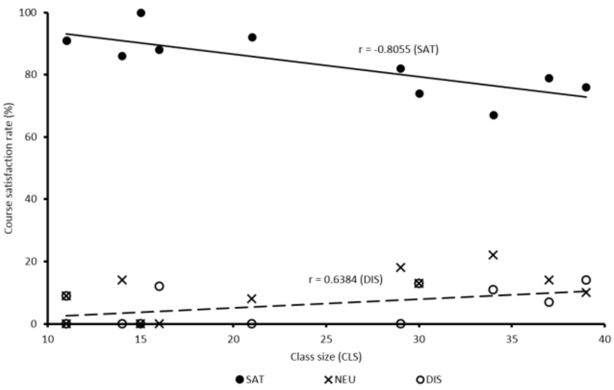

Fig. 1. Correlations between class size and course satisfaction rates.

Although a correlation coefficient of -0.5509 does not support the existence of a significant association between teaching satisfaction and class size (Table II), it does indicate that a larger class would be susceptible to a lower course satisfaction, given the fact that the teaching satisfaction had been maintained steady or improved slightly over the 11 semesters for *Distributed Systems*. This may imply, compared to the significant correlation between class size and course satisfaction, that student' perception on course satisfaction is different from that on teaching satisfaction, which seems consistent with the observation in [5].

Teaching satisfaction is expected to have a strong positive correlation with course satisfaction (Table II), this being echoed by a strong negative association with the neutral rate (Fig. 2). Surprisingly, course dissatisfaction rate has no significant association with teaching satisfaction statistically. This may imply, no matter how high the teaching satisfaction was (or will be), in many cases there were (or will be) a few students never satisfied with any course, which may be related to student irresponsibility, one of the five conceptions of unsuccessful teaching in information technology education [17].

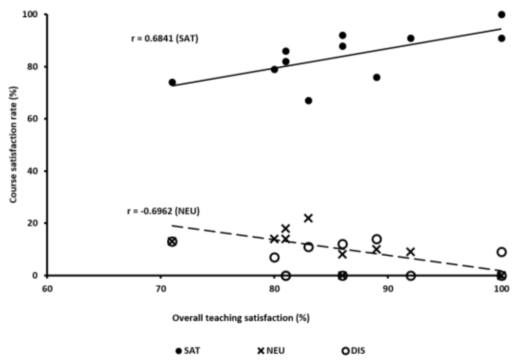

Fig. 2. Correlations between teaching and course satisfaction rates.

It is easy to understand the negative correlation between

SAT and NEU or DIS because these three factors are dependent constrained by SAT+NEU+DIS = 100% (Table III). The higher the SAT is; the lower both the NEU and DIS are. However, the most interesting fact revealed by this analysis is that no any relation can be drawn between dissatisfaction and neutrality. These facts shown in Table III have profound implications in defining new strategies for improving student course satisfactions in the future.

TABLE III: CORRELATION ANALYSIS OF COURSE SATISFACTION RATES

	Correlation coefficient		
	SAT	NEU	DIS
SAT	1	-0.7773	-0.6309
NEU	-0.7773	1	0.0022

V. DISCUSSION

The strong negative association between class size and course satisfaction implies that the class size must be confined to a certain number for achieving a certain level of course satisfaction. For *Distributed Systems*, this number is between 15 and 20. A significant increase in class size may lead to a lower course satisfaction, which has also been reported in other studies [2], [17], [18]. However, a class with fewer than 15 students may not necessarily result in a high course satisfaction. This is because often there may be one or a few students who remain undecided on or unsatisfied with a course at the time of course evaluation taking place no matter what the class size is. In fact, this random factor will have a more negative impact on course satisfaction to a small class than that to a large class because in a small class each response is weighted relatively higher. This is demonstrated by the results of the 4th and 10th offerings when one out of eleven students was undecided on or unsatisfied with the course, and each reduced the course satisfaction by 9% alone. In general, restricting class size to a certain number may reduce the dissatisfaction rate, but this may have a limited impact on improving the course satisfaction because the average dissatisfaction is only about 6% in this course.

Reducing class size seems a logical way to improve course satisfaction, but many institutions are reluctant to do so due to the lack of resources [19]. Hence, other strategies are needed to achieve an acceptable course satisfaction for large classes. The strong negative association between SAT and NEU or DIS shows that course satisfaction should move up if either or both NEU and DIS can be reduced, no matter how large the class size is. On the other hand, correlation analysis also shows that no relation exists between NEU and DIS (Table III), which implies that there is no mutual flow between DIS and NEU statistically. These two facts indicate that a parallel flow model likely exists between SAT and both NEU and DIS (Fig. 3), rather than a sequential progressive model transferring students from dissatisfaction to neutrality then to satisfaction.

This parallel flow model provides new ideas for improving student course satisfaction for large classes. Firstly, for those students who are not satisfied with the course, it is useless in making effort to change their decision from dissatisfaction to neutrality so as to minimize the negative impact to the overall course satisfaction. Although there is a portion of such students who may be genuinely dissatisfied with a course, the fact is that there are often a few students who are never satisfied with any course in any circumstances, a case of student irresponsibility described in [17]. It will be an enormous challenge to make such students become satisfactory. Fortunately, on average such students constituted only 6% of the enrolled students for this course.

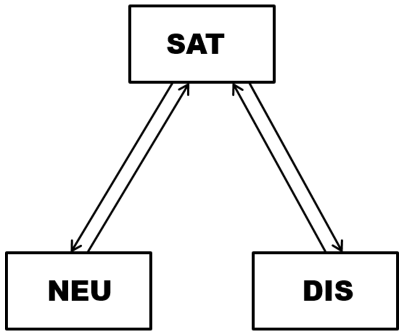

Fig. 3. Parallel flow model among course satisfaction rates.

Secondly, for those students who are unsure whether they are satisfied with a course, great efforts should be made in converting these students onto the positive end. This is because such students constituted about 10% of the total on average with a potential up to more than 20% for large classes according to this course. This is significantly higher than the percentage of unsatisfied students. Most of these undecided students would expect frequent contact with the instructor for discussing concerns in their study during the course. For *Distributed Systems*, an effective way to achieve frequent contact is to change the one lot of 3-hour face-to-face teaching per week to two lots of 2-hour face-to-face teaching per week for large classes. By adding one more hour to the course delivery, informal seminars given by up to 40 students can be accommodated with the original schedule of 30 minutes per session without reduction of the class size. The two face-to-face teaching periods per week create two opportunities of direct contact between students and the instructor in a week and hence provide students with more opportunities for discussing their concerns on the course with the instructor. Frequent contact with students does have positive impact on the outcome of student evaluations, which was reported in [11]. This change may also turn a couple of unsatisfied students to satisfaction, rather than to neutrality (Fig. 3).

Quality teaching is still the fundamental means to improve course satisfaction regardless of class sizes. Improvement on course satisfaction brought by good teaching seems mainly achieved by converting those undecided students to satisfaction, which is evidenced by the strong negative trend between TCS and NEU (Fig. 2). This observation is also based on the fact that teaching satisfaction is almost unrelated to course dissatisfaction (Table II). *Distributed Systems* is a course that requires students to have a high level of pre-knowledge in information and communication technology in order to make smooth progress during the course. This domain complexity [17] may make those students without good preparation feel unconfident in fully understanding some elements of and hence passing this course. Some new tactics could be useful in easing the concerns of these undecided students.

Creating an engaged learning environment for students is likely to switch students from passive receivers to active contributors. This can be realized by adopting diverse activities driven by different learning theories. For *Distributed Systems*, the formal lectures and student informal seminars can still follow the current format as cognitive and constructive activities because the highly technical nature of this course requires a logical path for knowledge accumulation. This is driven by both cognitivism [20] and constructivism [21], [22], two most commonly adopted learning theories in education today. It can go further to have a constructive evaluation [23] as a new set of student-contributed assessment at the partial expense of exanimation. This new activity requires students to author a question that assesses one or more of the learning outcomes of the course and to prepare a solution to the question. These questions, anonymously stored in the assessment bank, become available for other students to answer. In this way, students can see how other students have answered the question and can reflect on their own responses.

This can move forward even further by modifying the major assignment to be a group project that can be carried out by 4-5 students using social construction approaches [24], such as action learning [25], [26], to deal with a highly technical task collectively. To effectively facilitate these diverse engagements in teaching and learning, an online community can also be created for all students and the instructor to interact without temporal and spatial constraints. This is driven by connectivism which believes that learning is learner-motivated and collaborative and rests in diversity of sources and opinions [27]. All these new measures would be able to shift students from being passive receivers of knowledge to active participants in and contributors to a community of engaged learning and knowledge sharing. Consequently, a sustainable high course satisfaction could be achieved for courses with similar domain complexity in STEM.

VI. Conclusion

Analysis of student course evaluation data for *Distributed Systems* over past 11 consecutive semesters reaffirms the existence of both a negative association between course satisfaction and class size and a positive association between teaching and course satisfactions, which have been reported in previous literature in other disciplines. In addition, this study also revealed that improvement on course satisfaction brought by good teaching is mainly from converting those undecided students from neutrality to satisfaction. Results of this analysis support a parallel flow model among course satisfaction rates, which in turn results in a new strategy in achieving and maintaining a high level of course satisfaction for similar domain-complexity courses in STEM. This is to focus on making effort on converting most undecided and perhaps a few unsatisfied students directly to satisfaction, rather than converting those unsatisfied students to neutrality.

How to achieve a sustainable high level of course satisfaction is a challenge to all educators and administrators. Strategically, innovative and quality teaching is the key to approach and maintain a high course satisfaction rate. Guided by existing and emerging teaching and learning theories, a number of tactical measures, for example, adjusting the difficulty of course contents to an proper level acceptable by majority of the students enrolled, boosting student' confidence in succeeding their study through inspirational and engaging teaching, promptly providing feedback on assignments to students [28], keeping class to a reasonable size, are worth of consideration in course design and delivery for achieving this goal.

Although there have been arguments on the effectiveness and fairness of student course evaluations probably since their first introduction, this study demonstrates that some useful information is indeed hidden in the student evaluation data. Organizational intelligence is the collective assemblage of value-added benefits derived from the organization's intangible assets and built on a hierarchy of components consisting of, from bottom to top, Data, Information, Knowledge, Expertise, Wisdom [29]. Information is patterns and/or indicators revealed from discerned data elements. Information plus insights and experience becomes knowledge. Knowledge in a specialized area becomes expertise. Expertise evolves to wisdom after many years of experience and lessons learned. This study spans only the first three levels of the intelligence hierarchy for the specified course at one university. If similar research can be done for many other courses in different fields at various universities over the world, we should have expertise in effectively dealing with student satisfaction on teaching, courses, programs, and even entire tertiary education in the future.

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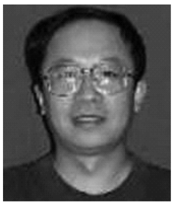
William W. Guo is a professor in applied computation and mathematics at Central Queensland University Australia. He received a PhD from the University of Western Australia. His research interests include computational intelligence, data and image processing, modelling and simulation, and geophysics. He has published over 100 papers in international journals, conference proceedings, and edited books, and co-edited two special issues in international journal "Mathematical Problem in Engineering". He has supervised multiple PhD students and served as a keynote speaker at many international conferences and regional events. He has abundant experience in leadership and academic governance through his services as Dean/Deputy Dean of School, and Members of University Academic Board, Education Committee, and Academic Promotion Committee. He is a member of IEEE, ACM, ACS, and Australian Mathematics Society (AUSTMS).



Wei Li received the BS, MS and PhD degrees all in computer science from Harbin University of Science & Technology, China, Harbin Institute of Technology, China, and the Institute of Computing Technology of Chinese Academy of Sciences, China in 1986, 1989, and 1998 respectively. He is currently a senior lecturer in information technology with School of Engineering and Technology, Central Queensland University, Australia. He has been a peer reviewer of a number of international journals and a program committee member of 30 international conferences in his research domain. His research interests include dynamic software architecture, P2P volunteer computing and multi-agent systems.

Yucang Wang now works at Central Queensland University, Rockhampton, Australia. He obtained a bachelor of physics (1987), and a master's degree (1992) and PhD degree (1998) in geophysics. He had a post-doc experience (1998-2000) in Institute of Mechanics, Chinese Academy of Sciences. From 2001-2008, he worked in Earth System Science Computational Centre (ESSCC), the University of Queensland, Australia. He was the major physical developer of Esys-Particle code, an open source code developed there. From 2009 to May 2014, he worked in Earth Science and Resource Engineering, Commonwealth Science and Industry Research Organization (CSIRO), Australia. He has been developing and using the Discrete Element Model (DEM) in the past 20 years. Currently he is interested in coupling of DEM with other physics and application of DEM in simulating coal and gas outburst, geothermal energy extraction.

Jun Shen was awarded the PhD in 2001 at Southeast University, China. He held positions at Swinburne University of Technology in Melbourne and University of South Australia in Adelaide before 2006. He is an associate professor in School of Computing and Information Technology at University of Wollongong in Wollongong, NSW of Australia. He is a Senior Member of three institutions: IEEE, ACM and ACS. He has published more than 120 papers in prestigious journals (including IEEE Transactions) and conferences (for example, IEEE Big Data) in CS/IT areas, in particular on computational intelligence topics. His expertise includes Web services, Cloud computing and learning technologies including MOOC. He has been Editor, PC Chair, Guest Editor, PC Member for numerous journals and conferences published by IEEE, ACM, Elsevier and Springer. A/Prof Shen is also a current member of ACM/AIS Task Force on Curriculum MSIS 2016.