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Using Teaching Cases for Achieving Bloom's High-Order Cognitive Levels: An Application in Technically-Oriented Information Systems Course

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USING TEACHING CASES FOR ACHIEVING BLOOM'S HIGH-ORDER COGNITIVE LEVELS: AN APPLICATION IN TECHNICALLY-ORIENTED INFORMATION SYSTEMS COURSE

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Abstract:

Case-teaching has been an attractive pedagogy method for bringing in real-world examples into the classroom. However, it is challenging to introduce cases to address high-order cognitive skills such as analyzing and creating new IT solutions in technically-oriented computing course. In this research, we present our experience in introducing three types of case studies -- Story-Telling case, Design-and-Problem-Solving case, and Create-Design-Implement case to a course in an undergraduate Information Systems programme. For each case study, we plan and map the learning objectives to address various cognitive levels in the revised Bloom's Taxonomy. Using surveys conducted over two academic years, we show with empirical data, that the case studies are effective in helping students achieve the higher order cognitive levels such as "evaluating" and "creating" (includes design and implement) complex enterprise web solutions.

Keywords: case-teaching, information systems education, applied Bloom's Taxonomy

I. INTRODUCTION

Case-teaching method has been widely studied in many pedagogy research. Case studies in Science subjects were found to increase students' critical thinking and problem-solving skills [Dochy et al., 2003], higher-order thinking skills [Dori, Tal, and Tsaushu, 2003], and improve their motivation to learn [Yadav et al., 2007]. Case-teaching in Information Systems (IS) education has been recognized by many IS educators as a valuable pedagogical tool, especially in the recent two decades. In the computing field, Hackney et al. provided examples of case studies bringing in real-world examples into the classroom and to develop high-order reasoning skills among students [Hackney et al.,2003].

However, most case studies found in computing and science fields are "*story-telling cases*" where problems and solutions (or options) are described within the case and do not involve technical tasks. It is challenging to applying case-teaching to technically-oriented IS courses because of software designs involve complex considerations to design, implementation and delivery. User requirements, design, development tools and implementation details are either not easily described or difficult to be assigned as tasks in cases. As a result, limited technical case studies with technical depth and details for design and implementation of a software application or enterprise application[1] are available in IS field. Story-telling cases also tend to look at each issue in isolation but not as a set of cohesive interconnected solutions across business processes. We recognize that in an information systems undergraduate programme the ability to provide a sound system design and to be able to implement the suggested solutions for real-world scenarios are two key learning outcomes. Often, such learning outcomes cannot be achieved through the story-telling case studies.

Going beyond story-telling case teaching was introduced to design and deliver technology-centered computing courses at Singapore Management University, School of Information Systems [Baumgartner, 2013]. Baumgartner used a teaching case to bring the students through the implementation scenario of an enterprise-wide portal solution in a course titled

[1] Enterprise software is a computer software that caters to the needs of an organization rather than an individual. It is usually contain modular features, complex and large.

"Enterprise Web Solution". This course has been offered in the university's undergraduate programme in Information Systems. A key purpose was to provide students with career-ready skills that apply concepts to real-world scenarios.

The "Enterprise Web Solution" course has gone through cycles of revision and alignment with overall learning outcomes and industry needs. The course addresses use of enterprise web, to develop skills for building enterprise applications through understanding of process integration, middleware services to aggregate people, information and processes at aggregation (or portal) layer. Some topics covered in the course include information architecture, content management, collaboration, streamline business processes, enterprise search, putting information together in a useful manner through data analytics and extending the functionality of a commercial-off-the-shelf-products. The various topics must be well-integrated to form a cohesive enterprise solution for an organization.

In this research, we build on the concept of using cases to bring students through end-to-end application lifecycle, from scenario (problem statement) to system design and to system implementation. We questioned ourselves how we could use case-teaching to develop and achieve the full range of cognitive skills. With this in mind, we applied the revised Bloom's taxonomy [Bloom et al., 1956]. We have also introduced new cases to the course to cover each cognitive skills in the Bloom's taxonomy, namely remembering, understanding, applying (concepts), analyzing (problem and solution domains), evaluating (solutions) and creating (new solutions).

In the rest of this paper, we show how we applied three types of case studies in this technically-oriented course. Each case study is selected or designed to address a number of cognitive levels. The impact of the types of cases on the students' cognitive skills is evaluated based on a survey conducted at the end of the semesters, over two academic years. The course enrols about 120 to 160 students per semester.

The three types of case-studies are:

a) Type 1 Case: We used a **story-telling** case where students read the case and discuss the content. The case presents the problem domain and provided suggested solutions. Although conflict is presented in the case, so are the final decisions and solutions. Students evaluate the pros and cons of the solutions provided in the case. Type 1 Case aims at addressing lower cognitive levels of remembering, understanding and applying.

b) Type 2 Case: A **design and problem-solving** case where students read one or more scenarios in a case and design system-related features to address the issues given in the scenario(s). Design options and dilemma can be found in the cases. Students work on parts of the case over multiple lessons and topics to form a cohesive and integrated enterprise solution based on a set of guided hands-on exercises as scaffolding activities.

c) Type 3 Case: **Create, design and implement** case-study. The students study existing real-world cases to create a new scenario, design system-related features to address the issues depicted in the case, and implement (also mean configuring the features of packaged software, and customizing it by developing and using extensions) the features to validate the design.

Through our research study, we provide empirical evidences that the case studies are helpful in achieving the various cognitive levels. Case-studies allow students to put the solutions into perspective, consider the implications of their solutions and even experience the actual impact of their design decisions in the implementation phase. We hope, through the cases, our students are better prepared to be career-ready – to take on tasks in the industry to design and implement applications that solve real-world problems.

The contributions in this paper are in two folds. Firstly, we provided a systematic evaluation to the use of case studies, showing their impacts on the cognitive domain based on the revised Bloom's taxonomy. Secondly, we showed how case studies can be used across multiple weeks to effectively address the higher-order cognitive level such as "creating" in a technically-oriented course which requires design and implementation of a complex enterprise solution.

In the rest of the paper, we will discuss related literature in Section II; share details about the methodology of our research in Section III. In Section IV, we show the empirical results of the survey and analysis and finally concluding this paper in Section V.

II. LITERATURE

Bloom's taxonomy was first modeled for the cognitive domain in 1956 [Bloom et al., 1956]. The model was revisited in 2001 which changes were made to the terminology and structure of the taxonomy [Anderson et al. 2001]. The aim of the taxonomy was to develop a system of categories of learning behaviour to assist in the design and assessment of educational learning. The revised taxonomy provides 6 cognitive levels from a lower form of thinking to a higher form of thinking. The 6 levels (starting from a lower level) are "remembering", "understanding", "applying", "analyzing", "evaluating" and "creating".

Bloom's taxonomy has been applied to the education domain of technical subjects such as in computer science for course design and evaluation [Scott 2003], evaluating assessments [Thompson et al. 2008], and evaluating the final examination questions in Engineering [Swart, 2010].

Literature review for case studies used in computing or information systems subjects has been covered in the Introduction Section. Case studies are also used in engineering education as early as in the 1960s [Raju and Sankar, 1999]. Engineering cases are also technical by nature, exposing students to open ended problems whose solution often depends on making assessments, judgments, and decisions about the technical competencies of the organization [Richards et al., 1995], hence engineering cases are not widely available. According to Prince and Felder, empirical research on the effectiveness of case studies is limited too [Prince and Felder, 2006].

In this research, we used the revised Bloom's taxonomy, as a systematic framework, to better understand how students develop (in terms of attaining the cognitive skills) from the selected teaching cases.

III. METHODOLOGY

Participants

Teaching cases were used in a core undergraduate course to build a portal-based web solution. In Academic Years 2015/16 and 2016/17, about 115 to 120 students took the course in Semester 1 (August to December) under the same Instructor. The same module runs in Semester 2 (January to April) under two other instructors who used the same materials. This course is designed to provide an understanding and experience in design and development of a prototype of an end-to-end enterprise web portal. The students were enrolled in an Information Systems programme.

Case Studies' Mapping to Bloom's Taxonomy

The three types of case studies are selected to address different cognitive levels in the course. Each type of case study is aimed to address the different cognitive levels of learning in the Bloom's taxonomy as depicted in Figure 1. The Type 1 Case, being the story-telling case study, addresses the lower cognitive levels such as remembering, understanding and applying. Type 2 Case was designed by instructor, based on scenarios that mimic the real-life industry situation. Type 2 Case allows students to identify the challenges, rationale various design considerations and challenge their thinking when applying the concepts to resolve the challenges. Hands-on activities were also designed to illustrate how challenges can be addressed and solutions can be implemented. The Type 2 Case aims to address the first four cognitive levels including analysing. Type 3 Case includes putting together ideas from a few story-telling case studies and students were to create a new scenario that mimics the real-life,

provide solutions to address a number of selected challenges. Eventually, students must implement their design, hence validating and iteratively improving the solutions. All solutions must be well integrated into a single cohesive enterprise solution that supports the needs of the organization in the case. The Type 3 Case addresses the high cognitive levels such as applying, analysing, evaluating and creating, with remembering and understanding as implicit pre-requisites.

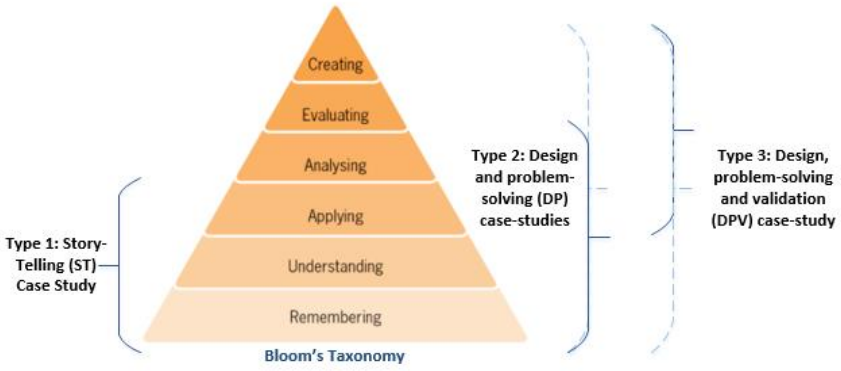


Figure 1: Mapping to Bloom's taxonomy

Type 1: Story-telling case-study (ST)

The Type 1 Story-Telling case study used in the course is a paper in Harvard Business Review. This case study examined the time budgets of large corporations and explained key reasons for time being squandered: E-mail, meeting time, lack of collaboration is, dysfunctional meeting behaviour and lack of formal controls. Students recognize the need for an enterprise-wide collaborative environment that connects people to organizational data and processes. With this case, instructor helps students identify the enterprise web features required to help organization address the challenges described in the case. This case does not present design dilemma or conflict in the resolution. The case presents in factual form, the challenges and associated resolutions. The instructor can hold discussions and revisit concepts that were taught earlier in the course content.

Type 2: Design-and-Problem-Solving case-study (DP)

The Type 2 Design-and-Problem-solving case study presents specific scenarios of challenges faced by selected organization(s) in the real world. It provides dilemmas or conflict situations and require students to either select a solution or provide a solution design to address the challenges in the case. The Type 2 case study focuses mainly on the first 4 levels (i.e., from remembering to analysing) and to some extent, can be extended to achieving the two higher level ones i.e., evaluating and creating new scenarios and solutions.

In the course, the Type 2 Case presents a narrative scenario of the organization's structure, departments and their challenges to manage the content of the company; promote collaboration within the company; streamline the work processes in the company; improve information retrieval and comprehension capabilities. This case was designed to provide incremental scenarios to students to apply the various concepts in the class across multiple weeks. The case breaks the whole solution into bite-size to form the bigger enterprise web solution. Students were expected to provide designs to address the challenges in the case. However, in terms of implementation, hands-on exercises were provided by instructors implementing one of the possible solutions. Students do not implement their designs hence not having the opportunities to evaluate their designs or make comparisons. Through this

incremental case, a real-world complex case is broken down into manageable bite-size such that students can handle the design and gain implementation skills through hands-on exercises. The students could also appreciate how various concepts are linked together to provide a coherent solution for the case company.

Type 3: Create-Design-Implement (CDI) case-study

The Type 3 Case is a Create-Design-Implement Case Study. The case study focused on developing higher cognitive levels and implicitly assume students to have attained the lower cognitive levels. Based on scaffolding guidance across weeks of lessons, students create a new scenario after learning from a number of other real-world scenarios that is suitable for an enterprise-wide portal solution. Students would then asked to provide designs of their solution based on the problem domain selected by the students. Finally, in the project, students verify their design through implementation using the software tools such as an enterprise portal, data analytics visualization tool, workflow designer and other tools such as external plug-in components. The outcome of the case-study is an implementation of the system along with a business process relevant to the scenario and domain selected by the student.

Survey

To evaluate the effectiveness of using these cases in helping students to learn. We designed a survey that maps the learning objectives of each case to the cognitive levels of revised Bloom's Taxonomy. The survey collects information about students' perception on how they learn using the three types of cases.

The surveys have been carried out in Term 1 of academic years (AY) 2015/16 and 2016/17 with more than 100 students enrolled in each term. The data from Term 2 was not collected because the course was taught by different faculty members. With different styles and slight differences in the class delivery, the comparisons will not be meaningful and hence was excluded as part of this research. The survey was conducted at the end of the term. The participation in the survey is voluntary and responses are anonymous. We collected no personal information in the survey. The survey does not affect students' performance in any assessment and students can choose to opt out of the survey with no risk involved. Students participated in the survey independently either at the same time in AY2015/16 or within the same week in AY2016/17. We obtained a total of 207 responses with 113 and 94 responses from each academic year. For each question in the survey, the students were given four options to indicate if the case study has helped them to achieve the cognitive levels. The four options are "Strongly Disagree", "Disagree", "Agree", "Strongly Agree" with given weight 1 to 4.

IV. DATA ANALYSIS

Hypothesis

In our analysis, we have two objectives. Firstly, we want to understand if each case consistently achieved the cognitive levels set out at the start of semester across the academic years. Secondly, we also investigate if there are evidences showing students attaining a cognitive level more than another.

Using the data collected over two years, we set up a common hypothesis for these purposes. The hypothesis:

Null Hypothesis H_0	Distributions of D_1 and D_2 are equal.
Alternative Hypothesis H_1	Distributions D_1 and D_2 are not equal.

With relatively small sample sizes (113 in 2015 and 94 in 2016) from each AY, we cannot ascertain if the results are normally distributed and hence we adopt the non-parametric tests, i.e., Wilcoxon Rank-Sum test and Tukey-Kramer. These tests statistically compare between two sets of data, if they are significantly different. We make comparisons either across the years of the same question or across different questions with two years of data. For example, suppose data column D_2 indicates the data collected for achieving "understanding" for Type 1 Case and data column D_1 indicates the data collected for "remembering", we say that there is an evidence that Type 1 Case achieved "understanding" more than "remembering" if the Wilcoxon Rank-Sum test has a p-value of less than 0.05, i.e., reject H_0. We also use Tukey-Kramer as the post hoc to test for differences among the means.

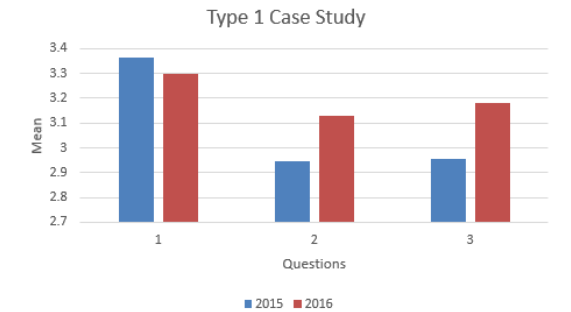
Survey Results and Analysis

Type 1 Case Analysis

We present the results of the survey for Type 1 Case in Table 1 and Figure 2. Overall, the results showed that the students agreed that the cases have helped them to achieve the various cognitive levels in the revised Bloom's taxonomy with mean scores near or higher than 3 (Agree). There were in fact, improvement in remembering and applying key features in 2016.

Table 1: Survey Results of Type 1 Case from students across two AYs

Type 1 Case:	2015		2016		Wilcoxon RS (p-value)	Tukey-Kramer	Interpretations
	Mean	SE	Mean	SE			
Qn 1	3.36	0.047	3.30	0.054	0.411	insignificant	H0 holds. No difference over the years
Qn 2	2.95	0.062	3.13	0.068	0.046	significant	Reject H0. Significantly higher in 2016
Qn 3	2.96	0.062	3.18	0.068	0.017	significant	Reject H0. Significantly higher in 2016



1	Helped me **understand** the need for an enterprise web and its role in enhancing collaboration, information sharing and avoiding time wastage.
2	Helped me **remember** the key features of an enterprise web
3	Helped me **apply** key features of an enterprise web to real-world context

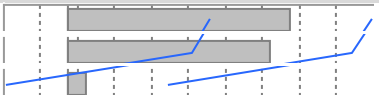
Figure 2: Histogram plotted based on the mean for each question in the survey for Type 1 Case Study across both AYs

We ran statistical tests using Wilcoxon rank-sum test and post hoc test using Tukey-Kramer (see Table 1), the responses from students were consistent across both academic years about helping them to understand the need for enterprise web. The cohort in AY2016/17 felt more strongly about the case was useful in terms of helping them to remember and apply the key features. From Table 2, when we compare the differences in means, we can see that students

found the story-telling case is more useful for their understanding than to remember and to apply the concepts.

Table 2: Comparison of all pairs using Tukey-Kramer HSD (combined over 2 years)

Level	- Level	Difference	Std Err Dif	p-Value
1	3	0.4009662	0.0617804	<.0001*
1	2	0.3671498	0.0617804	<.0001*
2	3	0.0338164	0.0617804	0.8479



Type 2 Case Analysis

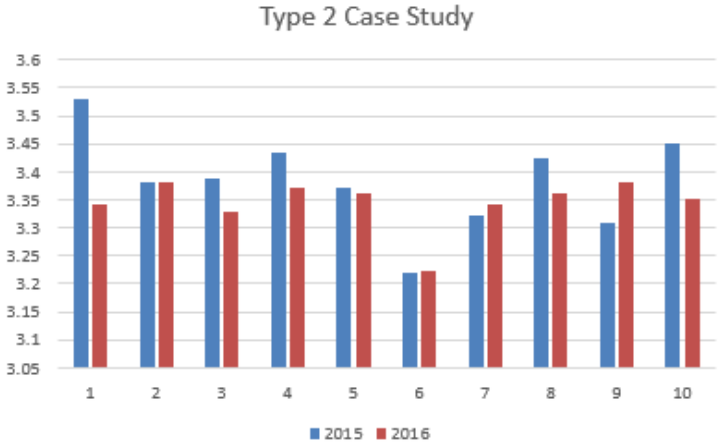
Similar tests were carried out for survey results for Type 2 Case. We use the term "design" in the survey to imply "applying appropriate knowledge". Some of the questions (shown in Figure 3) may refer to particular terminologies and topics in the course.

Table 3: Survey Results of Type 2 Case from students across two AYs

Type 2 Case:	2015		2016		Wilcoxon RS (p-value)	Tukey-Kramer	Interpretations
	Mean	SE	Mean	SE			
Qn 1	3.53	0.047	3.34	0.052	0.0081	significant	Reject H0. Significantly lower in 2016
Qn 2	3.38	0.050	3.38	0.056	0.8866	Insignificant	H0 holds. No difference over the years
Qn 3	3.39	0.056	3.33	0.061	0.6082	Insignificant	H0 holds. No difference over the years
Qn 4	3.43	0.051	3.37	0.056	0.4431	Insignificant	H0 holds. No difference over the years
Qn 5	3.37	0.053	3.36	0.058	0.9224	Insignificant	H0 holds. No difference over the years
Qn 6	3.22	0.059	3.22	0.064	0.9748	Insignificant	H0 holds. No difference over the years
Qn 7	3.32	0.062	3.34	0.068	0.6800	Insignificant	H0 holds. No difference over the years
Qn 8	3.42	0.057	3.36	0.063	0.4182	Insignificant	H0 holds. No difference over the years
Qn 9	3.31	0.054	3.38	0.060	0.3286	Insignificant	H0 holds. No difference over the years
Qn 10	3.45	0.057	3.35	0.063	0.1569	Insignificant	H0 holds. No difference over the years

Based on the survey results, it was consistent across both academic years that the Type 2 Case was helpful in "applying" concepts and "analysing" scenarios and design. All the questions received responses greater than 3 (Agree). The result for Question 6 was lower could be because the topic of dashboard was not quite evident in the case and we were using an external software tool to build the dashboard. To our pleasant surprise, the Type 2 Case, although not designed specifically to address "evaluating" and "creating", results from both

years showed consistent feedback from students that the case was useful for the two higher cognitive levels (i.e., evaluating and creating). This was beyond our expectations. The case has helped students compare their solution with their peers' (Question 8) and has helped students to evaluate (Question 9) the solution designs and create (Question 10) their own solution. We also ran Tukey-Kramer test to evaluate if there are significant differences between Questions 2 (Applying), 7 (Analysing), 9 (Evaluating) and 10 (Creating). There are no significant differences among the results showing that students felt they have achieved each of the levels equally.



1	Helped me **understand** the various features an enterprise web and their role in enhancing collaboration and access to information
2	Helped me **apply** various features to an enterprise web
3	Helped me get hands-on experience in **designing** an enterprise web topology
4	Helped me **apply** appropriate enterprise content management tools for the problems faced by various departments in Company A
5	Helped me select and **apply** collaboration tools (including workflow) for the problems faced in Company A
6	Helped me **understand** the need of dashboard
7	Helped me to better **analyze** a business scenario
8	The sharing session with other classmates and class room discussion sessions helped me **compare** my solution with others
9	Helped me to better appreciate and **evaluate** the different design options
10	It was effective as an example to better **create** my own business scenario for assignment 1 and project

Figure 3: Histogram plotted based on the mean for each question in the survey for Type 2 Case across both AYs

Type 3 Case Analysis

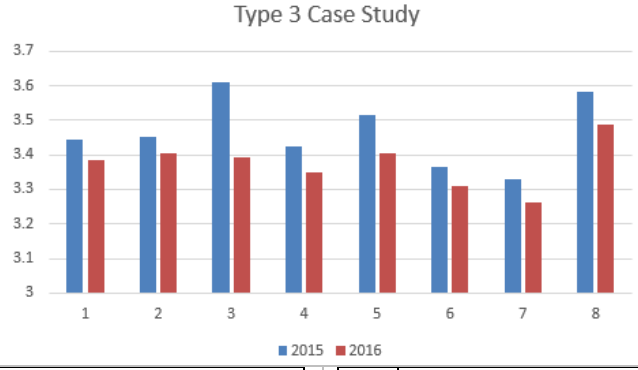
Similarly, tests were carried out for survey results for Type 3 Case using responses from both academic years. The questions were different from those of Type 2 case study and also mixed up the question in terms of sequencing so as to keep the responses independent. The results are shown in Table 4 and Figure 4.

Table 4: Survey Results of Type 3 Case from students across two AYs

Type 3 Case:	2015		2016		Wilcoxon RS (p-value)	Tukey-Kramer	Interpretations
	Mean	SE	Mean	SE			

Qn 1	3.44	0.052	3.38	0.057	0.5031	Insignificant	H0 holds. No difference over the years
Qn 2	3.45	0.050	3.40	0.055	0.5270	Insignificant	H0 holds. No difference over the years
Qn 3	3.61	0.049	3.39	0.054	0.0032	Significant	Reject H0. Significantly lower in 2016
Qn 4	3.42	0.056	3.35	0.062	0.3107	Insignificant	H0 holds. No difference over the years
Qn 5	3.51	0.050	3.40	0.054	0.0894	Insignificant	H0 holds. No difference over the years
Qn 6	3.36	0.053	3.31	0.058	0.3240	Insignificant	H0 holds. No difference over the years
Qn 7	3.33	0.060	3.26	0.066	0.3361	Insignificant	H0 holds. No difference over the years
Qn 8	3.58	0.051	3.49	0.056	0.1301	Insignificant	H0 holds. No difference over the years

It was consistent with no significant differences across both academic years that the Type 3 Case has been helpful for applying concepts, analysing and evaluating solution options. The responses for creating solution was somewhat lower among the students in AY2016/17. However, it has also attained a score more than 3 (Agree). All the questions in the case received responses greater than 3.



1	Helped me gain experience in planning a portal project
2	Helped me gain experience in **designing** a portal site
3	Helped me get a hands-on experience with using the commercial portal solution in **creating** the key features of a portal-based enterprise web
4	Helped me **integrate** (apply) all the different concepts I learnt in the course

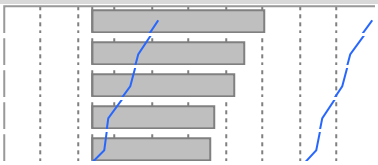
5	Helped me test my **understanding** of the concepts by implementing them in the commercial portal software
6	I am confident of **applying** what I learnt from this project to another scenario
7	Helped me **critique** our project when compared with other team's project
8	By doing the project, I **remember** the features of enterprise web taught in class.

Figure 4: Histogram plotted based on the mean for each question in the survey for Type 3 Case Study across both AYs

We did a comparison between the questions. From Table 5, a key observation is that students felt stronger that they could remember and create a solution by implementing the features. This is in-line with the objectives of using the case studies and emphasize the importance of hands-on experience along with a business scenario for a technically-oriented course.

Table 5: Comparison of all pairs using Tukey-Kramer HSD based on different questions

Level	- Level	Difference	Std Err Dif	p-Value
Qn8	Qn7	0.2439614	0.0552065	0.0001*
Qn3	Qn7	0.2149758	0.0552065	0.0010*
Qn8	Qn6	0.2028986	0.0552065	0.0023*
Qn3	Qn6	0.1739130	0.0552065	0.0145*
Qn5	Qn7	0.1666667	0.0552065	0.0218*



Final thoughts

From the analysis of the survey data, we have large extent of consistency across two AY. Type 1 Case was effective in achieving the lower cognitive levels remembering, understanding and applying, with stronger evidence that students find the case helpful to their understanding. Interestingly, Type 2 Case, although aimed at the lower to mid cognitive levels, results showed that they are surprisingly effective in achieving the higher cognitive levels, i.e., analyzing, evaluating and creating solutions. The Type 3 Case, targeted at applying, evaluating and creating, was also found to be effective in achieving the low to mid cognitive levels such as remembering and understanding.

We recognize the limitation in this work that we could not provide a control environment to evaluate students' learning without the use of cases. However, this work provides opportunities for other future work. Next step, we could map the learning objectives of the cases to the results of the related assessments of the course. We could then evaluate the learning outcomes based on both the survey results (students' self-evaluation) and with the quantitative analysis of their assessment results.

VI. CONCLUSION

In this paper, we presented a systematic approach to evaluating the cognitive levels achieved by the students from using case studies in a technically-oriented course in an Information Systems undergraduate programme. Three types of case studies were used in the course, namely Story-Telling, Design-and-Problem-Solving, and Create-Design-Implement case studies. With the three types of cases, we found that they are effective in developing the various cognitive skills in the revised Bloom's Taxonomy.

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