12-2019

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***Abstract*—The experiential learning method aligns well for a design thinking course. While many studies advocate the benefits of how experience influences the learning process, there are also critiques that argue the complexity of experiences with uncontrolled environment. In a course design with experiential learning, the learning activities have to be designed to maximize learning effectiveness of the participants. One design challenge is the duration of these learning activities for experiential learning. These learning activities take up time and effort for teachers to design and student to perform. Proper design of the number and type of activities based on their effectiveness in achieving their learning outcome is required. Another design challenge is the minimum instructional guidance of these learning activities which potentially impact the learning effectiveness of novice students. In this paper, we describe our experiences and findings of applying experiential learning method in a design thinking course with a list of learning activities performed iteratively. Each of the learning activity varies in their duration required and level of instructional guidance. Our survey seeks to find out which of the learning activities are effective for the students to achieve their learning outcomes and how does the level of instructional guidance and duration required in these learning activities affect them. The survey involves 104 undergraduate Information Systems students who have performed these learning activities. Our survey results show that there is only weak correlation between the level of instructional guidance or the activity duration to their learning effectiveness. However, the results show the students prefer certain learning activities, fewer iterations and more time to focus on the learning activities within each iteration. We will also discuss other factors that impact their learning effectiveness such as the complexity of these learning activities and the instructor's teaching style. We hope that these insights can help course designers to better design the learning activities in their design thinking courses.**

Keywords*— experiential learning, design thinking, learning activity duration, instructional guidance

I. Research Questions

Design thinking is a collaborative process that utilizes critical thinking to build new knowledge and solve problems. Our design thinking course adopts the experiential learning method through learning activities. The learning activities allow the learner to practice empathy by observing a situation, to define and synthesize their understanding by analysis the data collected from observation, to ideate and prototype, and to test the prototypes using studies and experiments.

In this paper, we describe our experiences to design the learning activities for experiential learning in a design thinking course. We seek to evaluate the effectiveness of these learning activities for the students to achieve the learning outcomes and how the varying level of instructional guidance and activity duration in each learning activity impact the learning effectiveness. This evaluation involves surveying 104 Information Systems students.

The main research question is "Are the learning activities effective for the student to achieve their learning outcomes?" To address the main research question, we investigate the following sub-questions.

RQ1 (Achieve Learning Outcomes) To what degree does the student achieve the learning outcomes of each activity?

This is measured by the student's level of understanding of the purpose of each activity.

RQ2 (Student's Learning Effectiveness) Do the factors (time spent, number of iterations, design and test activities) of each activity affect the student's learning effectiveness?

We seek to correlate these results to their level of understanding of the activity in **RQ1** to explore these questions - "Does more time spent co-relate to a better understanding?", "Should the number of iterations be increased or decreased?", "Does the student agree that coding of their design can improve student learning outcome?", "Does student's opinion on coding to improve learning influenced by the total amount of time spent?", "Which of the test activities does the student prefer to remove?" and "Is this choice influenced by students learning effectiveness?"

RQ3 (Level of Guidance and Complexity) Do the level of guidance and level of complexity of each activity affect the student's learning effectiveness?

We seek to correlate these results to their level of understanding of the activity in **RQ1** to explore these questions - "Does more guided instructions co-relate to a better understanding?" and "Does the level of complexity in each activity impact the student's learning effectiveness?"

To the best of the authors' knowledge, this paper explores a novel area of designing and evaluating experiential learning activities designed for learning effectiveness of the students in a design thinking course.

The rest of the paper is organized as follows: We present the background and related work in Section II and subsequently describe our course design and learning activities in Section III. We explain our conduct of the survey and analyse the survey results to address the research questions in Section IV. We summarise the survey findings and give our recommendations in Section V. A discussion on the threats to the validity of our results is given in Section VI and we conclude our paper and future works in Section VII.

II. BACKGROUND AND RELATED WORK

A. Design Thinking

Design thinking dates back to 1987 in a book by Peter Rowe [1] but it is arguably made popular by David Kelley from IDEO and d.school at Stanford. "Design thinking is a human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success." by Tim Brown, CEO of IDEO [2]. The d.school design thinking iterative process can be identified as five "modes" described below [3]-[4].

1. Empathize - To build empathy for your users by learning their values.
2. Define - To unpack your empathy findings into needs and scope a meaningful challenge.
3. Ideate - To generate radical design alternatives.
4. Prototype - To get ideas out of your head and into the world.
5. Test - To gather feedback, refine solutions, and continue to learn about your users.

This human-centred approach is hugely popular in multiple disciplines such as management, engineering and computer science. Dym, Agogino, Eris, Frey and Leifer [5] explain why design is hard to learn and harder still to teach. They outline the research available on how well design thinking skills are learned. They explore the pedagogical model for teaching design based on project-based learning (PBL) with available assessment data on its success. Zaqoot and Oh [6] explore the use of online whiteboarding as a new learning platform to handle the challenging task of teaching design thinking. Their findings suggest that learners with growth creative mindsets report a higher level of perceived usefulness of whiteboarding as compared to fixed creative mindsets.

In the design thinking process, two key learning activities are design and test activities. Students gain experiences working in design activities by prototyping using low fidelity paper, high-fidelity prototyping tools (e.g. Axure, Adobe XD, Figma or Justinmind) or code their design using software integrated development environment (e.g. Visual Studio, Eclipse, NetBeans, XCode or Android Studio). Developing a prototype requires less time than coding their design. However, prototyping lacks the discovery of implementation issues in coding. On the other hand, test activities can be heuristic evaluation, laboratory studies or web experiments. Students can understand their design better with multiple test activities but it will take a longer duration. These decisions on design and test activities have to be made during the design of the learning activities.

B. Experiential Learning and Design Education

Existing studies reported their experiences in applying the experiential learning method in the design thinking process. While many of these studies focus on the process and high-level models that adopt experiential learning method in design thinking, this paper focuses on the experiential design of the learning activities for effective learning.

Experiential learning is about the nature of experience and how it influences the process of learning from it [7]-[9]. Kolb in his work [10] goes into how different educators define these experiences as an educational technique. His focus is on a process of learning that questions preconceptions of direct experience; tempers the vividness and emotion of experience with critical reflection; and extracts the correct lessons from the consequences of the action. Instead of passive learning that just reads about, hears about, talks about, or writes about the realities being studied but never comes into contact with them as part of the learning process, experiential learning is from life experience. On the other hand, critiques argue that experiences are complex with uncontrolled variables such as environment and participants, and noisy with errors in observation or interpretations. March [11] argues that experience is an "imperfect teacher" but acknowledges organizational performance improving with experience. Mayer [12] argues that the constructivist view of learning may be best supported by methods of instruction that involve cognitive activity rather than behavioural activity, instructional guidance rather than pure discovery, and curricular focus rather than unstructured exploration. Kirschner, Sweller and Clark [13] further argue that so far the evidence from controlled studies, it almost uniformly supports direct, strong instructional guidance rather than constructivist-based minimal guidance during the instruction of novice to intermediate learners. We seek to further understand the impact of the level of instructional guidance to the learning effectiveness in a design thinking course.

Experience, crafted carefully as described in Kolb's Experiential Learning Theory (ELT), can be a powerful learning process. Bates in his work [14] feels that most university and college courses are overstuffed with content and not enough consideration is given to what students need to do to absorb, apply and evaluate such content. He has a very rough rule of thumb that students should spend no more than half their time reading content and attending lectures, the rest being spent on interpreting, analyzing, or applying that content through learning activities. In particular, they will need some way of getting feedback or comments on their activities, either from the instructor or from other students. The design of the activity duration will have to take account of the students' workload. Both the number of iterations of learning activities and the duration required of each learning activity have to be designed with the aim to increase the learning effectiveness of the students.

The Experiential Learning Theory (ELT) divides the process of learning into four phases in an iterative process as shown in Fig 1: Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE). These cycle of gaining experiences (CE and AC) and transforming experiences (RO and AE) allows us to classify four learning styles: Accommodating, Diverging, Assimilating and Converging. Accommodating style learners prefer hands-on, action-oriented doing. Diverging style learners synthesize observation to generate ideas. Assimilating style learners take information and logically orders them through thoughts. Converging style learners prefer to experiment with new ideas, simulations and practical applications. A learner would move through all phases of the learning cycle iteratively.

The experiential learning approach is widely discussed together with design thinking concepts. We begin with how design thinking address innovation using experiential learning, followed by work on experiential learning in design

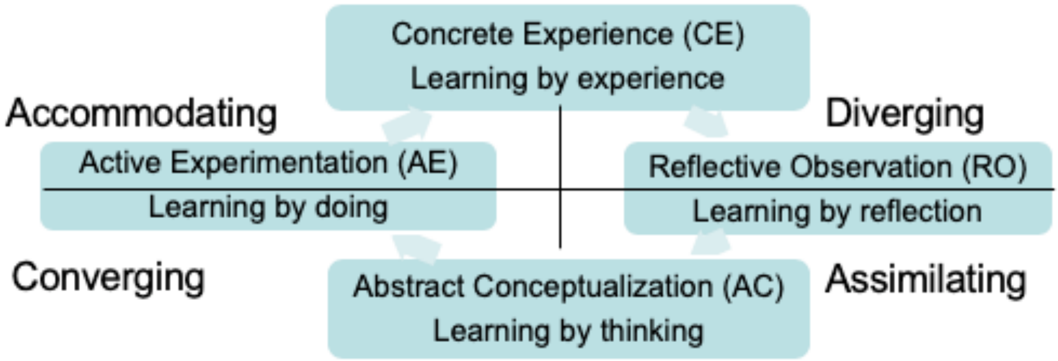

Figure I. Learning Styles from Experiential Learning Theory (ELT) from (Kolb 2014)

education of various disciplines. Beckman developed a generic innovation process based on Kolb's experiential learning theory (ELT) and design thinking process that can be applied in many sectors [15]. Stock, Bucar and Vokoun [16] integrate both experiential learning and design thinking concepts in management teaching to address the "innovation gap". Their modified use of the assignment shows that when you ask students to be more creative in their responses that they are "more creative than the control group" .

Design education is the base of knowledge about design creativity. Understanding the ways design creativity is taught will lead to a better understanding of the human capability of solving complex problems. Parisi, Rognoli and Sonneveld [17] adopted the experiential learning approach to a product design education on materials tinkering. They argue that this approach may be helpful to foster students' creativity and to educate them in understanding, evaluating, and designing the experiential, expressive, and sensorial characteristics of materials. Ouh and Irawan [18] proposed a model incorporating experiential learning and risk management process to design an undergraduate software architecture design course. Their findings show that the students preferred this model consistently when compared each stage of the model against the traditional lecture-based lesson. Dym [1] focus on design education for engineers, specifically project-based learning, and an experiential learning method. Based on the experiential learning theory, Demirbas and Demirkan [19] explore the effects of learning styles and gender on the performance scores of freshman design students in three successive academic years. Findings indicate that the distribution of design students through learning style type preference was more concentrated in assimilating and converging groups. In design education, there are many variants of learning activities for experiential learning including laboratory, problem-based learning, case-based learning, project-based learning and inquiry-based learning [14].

III. COURSE BACKGROUND

In this section, we explain how we design our learning activities based on the d.school design thinking process. The key learning outcomes of our course are for students to be able to empathize with users; design high-quality user interfaces; build prototypes; test designs through inspection, laboratory studies, web-based surveys; and be able to present their work. We seek to investigate which of the learning activities are effective to improve our student's learning experience.

A. Design Education Course

Our design thinking course is conducted over a thirteen weeks period and the course design has evolved for over eight years. In the early years, we provided extensive learning activities with three iterations from low fidelity prototyping to the coding of the prototypes. The course requires a software engineering prerequisite, only third-year IS students are able to take the course.

The workload was extensive and students complaints about it every year in our student feedback. To cut the workload, we reduce documentations, remove the poster session with external judges for their final product, focus on design by removing the coding activity, and we move to 2.5 iterations. It is a 2.5 by combining iterations 2 and 3. Students are not required to present their 2nd iteration results. With the focus on design, there is no longer a coding requirement, allowing us to remove the software engineering prerequisite. This means students from the end of year one can take this course. Currently, this is a core course for our entire cohort of students.

B. Learning Activities

In our design thinking course, we design three process "modes" which are mapped to the d.school design thinking process as follows:

- (OA) Observe Activity: Maps to Empathize and Define
- (DA) Design Activity: Maps to Ideate and Prototype
- (TA) Test Activity: Maps to Test

These three process "modes" are iterated over 2.5 iterations. The learning activity in each iteration differs slightly. The learning activities in these iterations are as follows:

Iteration 1

- (Iter1.OA) Observe, Interview or Immerse as the user. Derive the persona and scenarios.
- (Iter1.DA) Design a low-fidelity paper prototype
- (Iter1.TA) Test another team using Jakob Nelson's Heuristic Evaluation. Present.

Iteration 2

- (Iter2.OA) Observe as necessary. Define laboratory goals and scenarios.
- (Iter2.DA) Design a high-fidelity prototype using prototyping tools such as Axure
- (Iter2.TA) Test by real users in a laboratory study

Iteration 2.5

- (Iter2.5.OA) Observe as necessary. Define the A/B cases.
- (Iter2.5.DA) Update high-fidelity prototype
- (Iter2.5.TA) Test by real users in an A/B experiment using the web survey. Present.

In the thirteen weeks duration, students proposed and pitched their projects during weeks one and two. From weeks three to six, they complete iteration 1 and present their results. Iteration 2 continues from weeks seven to ten, with a break on week eight. Students do not have to present their work at the end of week ten. Iteration 2.5 continues till week thirteen with a final presentation in week thirteen. The class is scheduled for a three-hour class time each week and the students are expected to work outside class for nine hours a week. There are no other non-project related assignments for the course. The project accounts for 50-55% of the course grades with the rest for class participation and the final exam.

Instructional guidance is in the forms of classroom presentation and feedback, mentor sessions outside class and a google site for collaboration. Each iteration is described in a document on google site explaining what is expected from each step of the iteration, sample deliverables, suggested schedule of work completion and the grading rubric. Since we have different instructors and mentors, we conduct regular meetings and a WhatsApp group to reduce inconsistencies in our guidance for the project. The course slides are from a master copy distributed on our learning management system.

We follow as closely to Kolb's ELT with multiple stages for each learning activities. For example, during the high-fidelity prototyping learning activity, students do the prototype (CE concrete experience), present their preliminary work in class as well as sharing them on the class Google site for peer and teacher feedback (RO reflective observation), review other team's prototype to understand what constitutes good design (AC abstract conceptualization) and regularly meet with a mentor to learn if their revised prototype works (AE active experimentation).

IV. Survey

A. How was the survey conducted?

The survey was carried out after the last presentation for the project. There were three sections/classes for a total of 104 students involved in this survey. Students in these three sections were asked to fill in a survey outside the classroom where the faculty is not present. The survey, approved by Institutional Review Board (IRB) with informed consent, has questions for each learning activity and for the overall set of learning activities. These questions are derived from our research question which helps us understand how the students feel about the workload and the type of activities in relation to their learning outcome. The survey was expected to take about 20 minutes. Below are the survey questions (SQ).

SQ1 Estimate the duration you spent in each project activity (hours). Please include all planning, designing, executing or implementing and reflecting that you personally put in.

SQ2 Rate the instructions given in terms of A, B, C or D below

A. Instructions are not enough and should give more specific instructions

B. Instructions are just right

C. Instructions can be less guided, leaving us more freedom to design

D. Instructions should not be guided at all

SQ3 Rate the complexity of each activity given in terms of A, B, C or D below

A. Activities are easy to do without any prior understanding or skills

B. Activities are doable with few complex understanding or skills

C. Activities are difficult to do, needing prior knowledge or complex understanding

D. Activities are very complex and most of us do not have prior knowledge or skills

SQ4 Explain the purpose of the activity. We graded their explanation in a scale of 1-5, where 1 is no relevance to 5 for a detail correct explanation of the activities.

SQ5 Do you think we should (choose one) reduce to 2 iterations or expand to 3 iterations (from 2.5 iterations)? Explain.

SQ6 Coding of the design can improve your learning outcome. What do you think of this statement? Strongly disagree, disagree, neutral, agree or strongly agree. Explain.

SQ7 If we need to remove one of the test activities, which one would you choose? (Heuristic Evaluation, Lab Study or Quantitative Analysis in Web Experiment). Explain.

SQ1 – SQ4 are questions for each individual learning activity and SQ5 – SQ7 are questions for the overall design of the learning activities.

B. Individual Activity Survey Result

Our survey results for each learning activity are shown in Table I. The duration is the average number of hours each student estimated they spent in the activity, followed by the instruction and complexity rating counts. The knowledge score is the average score of the level of understanding based on the explanation given by the students. We graded the response to SQ4 to match the expected learning outcome of each learning activity. They get a knowledge score of 1 for a totally irrelevant response, 2 for a little mention of the activity purpose, 3 for a general statement of the activity, 4 for a good understanding of the activity and 5 for a detailed breakdown of the activity.

The top 3 learning activities in terms of duration involves the prototypes. This result is expected as it typically takes a longer time to do design prototypes. The learning activity that

TABLE I. SURVEY RESULTS FOR EACH LEARNING ACTIVITY

SQ1-SQ4 Learning Activity	**Duration (hours)**	**Instruction (count)**				**Complexity (count)**				**Knowledge score**
		A	**B**	**C**	**D**	**A**	**B**	**C**	**D**	
Iter1.OA Observation	5.1	7	**94**	3	0	**50**	54	0	0	3.85
Iter1.DA Low-Fidelity Prototype	**10.2**	18	82	4	0	39	57	7	0	**4.05**
Iter1.TA Heuristic Evaluation	4.3	13	**88**	4	0	27	68	9	0	3.82
Iter2.OA Observation	**3.1**	14	82	4	0	**40**	59	1	0	3.86
Iter2.DA High-Fidelity Prototype	**20.3**	16	79	8	1	8	52	**31**	**12**	3.94
Iter2.TA Lab study	6.9	**22**	76	6	0	14	65	23	0	3.89
Iter2.5.OA Observation	4.3	7	44	3	0	20	32	2	0	3.78
Iter2.5.DA High-Fidelity Prototype	**7.2**	7	50	4	1	4	34	16	5	3.83
Iter2.5.TA Web Experiment	6.4	**23**	66	4	0	8	47	**32**	4	**3.79**

took up the most time is Iter2.DA activity with an average of 20.3 hours. The Iter1.DA activity took an average of 10.2 hours and the Iter2.5.DA activity took an average of 7.2 hours. The learning activity that took the least time is the observation activity Iter2.OA. The second observation is optional, and some students did not do this activity.

For the instructions given or the level of guidance, the largest group of students are those with ratings “B”. They feel that instructions given are just right especially for the activities: Iter1.OA and Iter1.TA with a count of 94 and 88 respectively. The second-largest group of students are those with ratings “A”. They feel instructions are not enough and should give more specific instructions, especially for the test activities, TA: Iter2.TA and Iter2.5.TA with a count of 22 and 23 respectively.

For the level of complexity of the learning activities, the largest group of students are those with ratings “B”. They feel the complexity are doable with few complexities. The early activities (Iter1.OA, Iter1.DA, Iter1.TA and Iter2.OA) are easier without any prior understanding or skills especially for observation activities, OA: Iter1.OA and Iter2.OA with a count of 50 and 40 respectively for ratings “A”. However, the later activities (Iter2.DA, Iter2.TA, Iter2.5.DA, Iter1.5.TA) are more complex and needed prior knowledge or complex understanding especially for activities: Iter2.DA and Iter2.5.TA with a count of 31 and 32 counts respectively for ratings “C”. The highest count for very complex and most of the students feeling they have no prior knowledge is for the Iter2.DA with a count of 12 for ratings “D”.

The knowledge score helps us answer our research question **RQ1** (Achieve Learning Outcomes). In a scale of 1 to 5, 5 being the highest score on explaining the purpose of the activity, the lowest score is 3.79 for the Iter2.5.TA Web Experiment activity and the highest score is 4.05 for the Iter1.DA Low-Fidelity Prototype activity. With this range of scores, it seems we might have achieved our learning outcome, but as this is our first year of survey, we do not have a benchmark to compare with. With regard to the duration or the time spent factor for **RQ2** (Student’s Learning Effectiveness), we correlate the knowledge score with the amount of time spent, instruction guidance and complexity of activities. For the duration, the result may suggest that more time spent may lead to a better understanding of the activity. The Iter1.DA Low-Fidelity Prototype Activity with a duration of 10.2 hours spent leads to the highest knowledge score of 4.05. The Iter2.DA High-Fidelity Prototype activity with duration of 20.3 hours spent leads to the second-highest knowledge score of 3.94. However, when we perform the correlation analysis for each activity, the correlation coefficients of 0.125 for the Iter1.DA and 0.25 for the Iter2.DA suggest that there is only a weak correlation between duration and knowledge score. On **RQ3** (Level of Guidance and Complexity), we initially assume that better instruction guidance and complexity ratings lead to a better understanding and proceed to correlate the knowledge score with the instruction guidance and complexity of activities. However, we find only weak correlations (most are below 0.1 with a few above 0.1 up to the maximum of 0.236) between knowledge score to the instruction guidance and complexity in our analysis.

C. Overall Activities Design Survey Result

For the survey question SQ5 on “number of iterations”, 89 students surveyed chose to reduce to 2 iterations while 14 students chose to expand to 3 iterations. Two students left the options blank and explained that they feel the current 2.5 iterations is just right. Almost all of 89 students who wanted to reduce to 2 iterations state the heavy workload as the main explanation. For those who wanted to expand to 3 iterations, 6 students feel the additional half iteration will provide more feedback, 7 students feel it leads to better learning, 7 students view it as a chance to reflect their work and 3 students feel they will be able to present their work better. We got a clear preference to reduce to 2 iterations in the SQ5 results, addressing the number of iterations factor for research question **RQ2** (Student’s Learning Effectiveness).

For the survey question SQ6 on “Coding of the design can improve your learning outcome”, there is less agreement among the students as shown in Table II with a total of 47

TABLE II. SURVEY RESULTS (COUNT) OF SQ6 BASED ON SECTION (INSTRUCTOR)

SQ6 Coding of the design can improve your learning outcome.	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Section 1 (Instructor A)	4	3	8	**13**	7
Section 2 & 3 (Instructor B)	11	18	14	**22**	5
Total	15	21	22	**35**	12

TABLE III. SURVEY RESULTS (COUNT) ON SQ7 BASED ON SECTION (INSTRUCTOR)

SQ7 Test Activity to be removed.	**Heuristic Evaluation**	**Lab Study**	**Web Experiment**
Section 1 (Instructor A)	13	4	**18**
Section 2 & 3 (Instructor B)	**26**	18	24
Total	**39**	22	**42**

TABLE IV. SURVEY RESULTS (KNOWLEDGE SCORE AND P-VALUE) ON SQ7 BASED ON SECTION (INSTRUCTOR)

SQ7 Test Activity to be removed.	**Section 1 (Instructor A) knowledge score**	**Section 2 & 3 (Instructor B) knowledge score**	**All sections knowledge score**	**p-value**
Heuristic Evaluation (HE)	4.04	3.73	3.70	0.704
Web Experiment (WE)	3.78	3.80	3.81	0.659

students either agree or strongly agree and a total of 36 students either disagree or strongly disagree with the statement. 22 students take a neutral option. For those who disagree, 12 students bring up the issue of a heavy workload, 5 students are concerned about the complexity of coding and 23 students feel the focus should be on the design. However, they also spent considerably more time on design activities (Iter1.DA, Iter2.DA and Iter2.5.DA) as shown in Table I. With regard to coding to improve learning factor for research question **RQ2** (Student's Learning Effectiveness), this result suggests that their opinion on coding can improve their learning outcome is not influenced by the total amount of time spent in the design activities. On further analysis, we notice that Section 1 taught by instructor A has more students agreeing to the statement, while the students in Sections 2 and 3 taught by instructor B has more students disagreeing to the statement. Both instructors use the same contents and materials for the three sections and have over 10 years of teaching experiences. We decide to perform the Mann-Whitney U test with between-subjects design to find out the significance of this result. Our data are the Likert items measured at the ordinal level. Our independent variable consists of two independent groups: Students can only take the course from instructor A or B, not both. The result for instructor A and B have two different shape distributions. Thus, we will only compare the mean ranks. The test results show that our p-level is 0.025 which is below our alpha α of 0.05, indicating a significant difference. The mean knowledge score for students taught by instructor A is 3.45 and instructor B is 2.88. This finding indicates that the differences are more than random chance and the instructor's teaching style do influence the student's view that the coding of design improves their learning outcome. This point has to be further validated in future studies.

For the survey question SQ7 on "Evaluation activity to be removed", students are split between Heuristic Evaluation and Web Experiment as shown in Table III. When students are asked to explain their choice in the qualitative feedback, 16 students actually have a misunderstanding of the evaluation technique, 18 students make the decision based on their workload, 8 students are concerned about the need for prior skills, 19 students have trouble getting the right testers for that technique and 5 students feel that certain techniques have overlapping learning outcomes. With regard to the test activity factor for research question **RQ2** (Student's Learning Effectiveness), we want to know if their knowledge score on that activity influences their choice of the test activity to be removed. Does understanding less of the activity lead to choosing to remove this activity? Most of the students choose either Heuristic Evaluation (HE) or Web Experiment (WE) and we focus on these two techniques. We first compute (X) the average knowledge score of students who chose to remove that activity and compare with (Y) the average score of all students for that activity. The value for (X) can be obtained from Table IV and the value for (Y) can be obtained from Table I. For the HE activity, the value of 3.70 for (X) is less than the value of 3.82 for (Y). For the WE activity, the value of 3.81 of (X) is more than the value of 3.79 for (Y). The result of the HE activity seems to agree with our assumption that less understanding leads to the removal of that activity. However, the result for WE activity does not agree with this assumption.

We further evaluate to know if instructors play a role in their decision. There are more students in section 1 who chose to remove the WE activity over the HE activity, 18 over 13. Their knowledge score is 3.78 for the WE activity which is less than the value of 4.04 for the HE activity. There are more students in sections 2 & 3 who chose to remove the HE activity over the WE activity, 26 over 24. Their knowledge score is 3.73 for HE activity which is less than the value of 3.80 for the WE activity. The mean knowledge score seems to support our assumption that understanding less of the activity leads to the removal of that activity. We calculate the p-value to see if this result is significant or not. We used the Mann-Whitney U test for Likert scale responses (ordinal variables) with between-subject design. The results in Table IV shows the p-value above our alpha **α** of 0.05. Our results show no significant in the instructor influencing why students choose to remove the HE or WE activity. We fall back to our qualitative feedback on getting the right testers, managing the workload, introducing more guidelines to understand the evaluation technique and the need of prior skills on the evaluation software.

V. Summary of our Findings

In this section, we summarise the key insights based on our survey results and the research questions.

1. The knowledge score results range from 3.78 to 4.05 on a scale of 1 to 5. This result seems to indicate that our learning activities achieve our learning outcome. However, we need more surveys to validate the result.
2. We assume that spending more time means better learning effectiveness. However, we found only weak correlation between the time spent and their knowledge score for each activity. Other factors such as student background based on other courses they took may contribute to their knowledge score. In our surveys, our participants may be novice year 1 and 2 all the way to year 3 and 4 students.
3. Within a 13 weeks semester duration, these students are taking an average of 5 courses. The instructors observe that students balance their efforts across courses. During the latter part of the semester, students get increasingly busy and this could lead student preferences to reduce the number of iterations in this course and prefer to put more effort into each iteration.
4. Students agree that coding of design improves their learning outcome, but in their explanation, 12 student feedbacks highlighted that workload is an issue. Coding of the design requires substantial time and effort as compared to prototyping. However, we are glad that this finding does show the students prioritises their needs and passion for learning over the concern of time and effort. Our result with this survey also found that the instructor may play a more influencing factor. Though the instructors use the same course contents and the students use the same instructions to carry out the learning activities, this is an interesting insight and we like to further investigate in future works.
5. Most students find the Lab Study and Web Experiment are more useful than Heuristic Evaluation. One possible explanation is the involvement of real users in Lab Study and Web Experiment as compared to usability experts in Heuristic Evaluation. In both Lab Study and Web Experiment, the students are able to test their product with the real users and validate their needs.
6. With regard to the level of instructional guidance of the learning activities, earlier studies show that minimum level of guidance impacts the learning effectiveness for novice students. However in our study, there is only weak correlation between the level of guidance and their knowledge score across the learning activities.
7. In terms of the complexity of the learning activities, there is only weak correlation to their knowledge score too. The results also show that the complexity of activities for the students increases later in the semester. A possible factor for the increased complexity is the skills or knowledge required to do the later activities. In the design of the high-fidelity prototype, students are required to use a prototyping tool, which is not necessary for the earlier paper prototyping activity. Similarly, the heuristic evaluation done earlier is based on Jacob Nelson's 10 Heuristic covered in detail in class with examples. However, to perform quantitative analysis in web experiments, students are required to use the evaluation tool to collect data and learn which significant test to use to reject the null hypothesis.

Based on the above findings, we conclude that the design of the number of iterations can be reduced to improve the effectiveness of student's learning. It is still inconclusive on adding coding and which test activity should be removed. Although more students agree that coding of their design improves their learning outcome, it is likely to take more time. Less student wanted to remove Lab study and their qualitative feedback indicates that the ease to get real testers and workload plays an important part in their consideration. The level of guidance and complexity of the learning activities have only weak correlations with their knowledge score. Other factors such as student background and teaching styles may play as important role to achieving a higher knowledge score. We seek to further study these other factors in future work.

VI. Threats to Validity

Last semester, the course was thought in three sections. There were two instructors teaching the three sections. The course contents and learning activities are the same, but the instructor's teaching style can be a confounding variable that threatens the internal validity of the survey results. This is explained in section IV.C, Survey Results. Instructor teaching style significantly affects students' view on SQ6 on "Coding of design can improve your learning outcome".

The course does not have a pre-requisite and students are not required to code their design. Students from year one to four are able to take this core course. Our survey was conducted on students from different years of study. On the question SQ6, we acknowledge that the student's answer may be influenced by the knowledge and skills of these students. Year three and four students might be more acceptable to code the design while year one students who are still learning fundamentals of programming are not. As our data are anonymized, this point remains to be quantitatively validated.

The survey is carried out with students studying the Information Systems programme and need to be further validated if the profile of the survey participants differs. For example, due to the background of these students, they might be more acceptable to code the design as compared to non-technical students.

VII. Conclusion and Future Work

Learning experience crafted carefully can be a powerful learning process. In order to craft carefully, we surveyed 104 design thinking students to evaluate the student's understanding of the activity. This survey is designed to help us answer our research questions: "Did we achieve our learning outcome?", "Did the independent variables (time spent, level of guidance and complexity) directly affect this understanding?", "How should we improve the learning activities?" More specifically: "How many iterations?", "Should the coding of the design be reconsidered?" and "What type of test activities can be removed?" We graded the student's understanding of learning outcome and analysed the survey responses to gain insights. We found that design activities take longer time as compared to other learning activities, later activities are perceived to be more complex, and other independent variables such as teaching style has a significant influence on student's view that coding of design improves their learning outcome. From these results, we recommended that the number of iterations can be reduced. However, questions relating to coding activity and removing test activity are inconclusive. The level of instructional guidance and complexity across our learning activities does not significantly correlate with their knowledge score in our results, as compared with earlier studies. We hope that our survey and the insights from the survey can help course designers better design the learning activities for experiential learning.

Future research could focus on the different teaching styles of the instructors. Another direction is to generalize our surveys to other courses. Some of the data such as teaching style and student background could be used to customized the learning activities. For student background, we can use data such as GPA, prior schools and area of study, preliminary test scores or personality test (hardworking, imaginative, scientific, etc.). For teacher teaching style, we can use data such as student feedback, years of teaching the same course, grading distribution, etc.

Acknowledgment

We would like to thank our survey participants, our teaching assistants and our teaching staff.

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