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Situation Awareness Differences on the Use of Cloud Computing

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ABSTRACT

Grounded on the theory of situation awareness, a three-sequential-phase framework was developed. This framework was then used to investigate the situation awareness differences on the use of cloud computing. Using quasi-experimental research design, we executed the study with 33 students. To investigate the situation awareness differences, the students were divided into two groups and assigned to complete the tasks. The repeated measures ANOVA was used to analyze the collected data. The results indicate that the students' situation awareness on the cloud computing use is significantly different as the experimental environment changes. The factors that might cause the differences were explored.

KEYWORDS: Situation awareness theory; Cloud computing; Quasi-experimental research design

INTRODUCTION

A new wave of digital technology associated with the Internet has begun to reconfigure work, employment, and the relations of production in the working environment and beyond. Technologies deriving from the needs of latest years' business strategies and models are considered as new "new" technologies (Howcroft & Taylor, 2014). The wide use of these technologies has changed the working pattern and brings efficiency and convenience to the whole society. Recently, scholars' have put more attention to explore the diffusion of the new "new" technologies.

Cloud computing refers to "the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services" (Armbrust et al., 2010, p. 50). It is one of typical new "new" technologies and can be the next wave of IT innovation to change the working pattern (Chou, 2015). For example, with the help of cloud computing, blue-collar workers can collaborate online to complete some complex tasks (Millar, 2008). However, it is not easy for users of cloud computing to comprehensively perceive and acquire the associated expertise and knowledge for their work (Howcroft & Taylor, 2014). Fundamental knowledge about cloud technology is needed for workers.

Information technology (IT) diffusion process has been intensively studied by scholars. Many scholars have investigated the users' situation awareness and use of information technology. For example, Gefen and Straub (1997) explored the gender differences in the perception of information technology. Zhou et al. (2014) investigated students' perceptions of creativity in learning information technology. However, little research has included the situation factors that might influence users' perception and use during their learning process. Given the lack of research on cloud computing learning situation design, we are interested in using the theory of situation awareness to explore how situation awareness differences influence cloud computing knowledge perception outcomes. Situation awareness is convinced as a predominant concern in a variety of domains such as man-computer interactive systems (Kraut, Fussell, & Siegel, 2003). Exploring the situation awareness on the use of cloud computing will help users understand their work. As such, we answer the following research question in this study: *Are there any situation awareness differences on the use of cloud computing?*

To address the research question, a research framework with three-phase design is developed. Following that, we conducted a quasi-experimental design, in which students in introductory level of Management Information Systems (MIS) course are required to learn cloud computing applications knowledge and apply the knowledge to the real situations. Based on the research design, a survey is designed for empirically investigating students' situation awareness on cloud computing use from the two groups in three environments.

The remainder of this article is structured as follows. We first provide a literature review summarizing the cloud computing application use and the theory of situation awareness. Then, we propose a conceptual research framework to adapt to our research setting. Next, we describe the research methodology, followed by an analysis of the collected data. We close with a discussion on the theoretical and practical contributions of the study.

LITERATURE REVIEW

Cloud Computing Use and Its Applications

Cloud computing can be used as a business infrastructure that reduces the need to purchase and maintain expensive computing hardware (Ostermann et al., 2010). Cloud computing originally emerged and quickly developed because of organizations' request for the independence of computing capacity to store and process data. Organizations can gain various benefits by adopting cloud computing practice, including saving cost, improving efficiency, enhancing agility and flexibility, and environmental sustainability (Chou, 2015; Zhang et al., 2010).

There is still not a consensus on the definition of cloud computing. Generally, it is a metaphor of the information technology term that is closely related to utility and consumption of computer resources (Garrison et al., 2012). It was developed in the late 2000s and now is broadly used to provide services over the Internet. Using remote servers and software networks, cloud computing permits various types of information sources to be transferred for real-time processing, which can produce the results without the need to store information on the in-house hardware (Mell & Grance, 2009).

This technology strengthens 'pervasive computing' into "Bring Your Own Devices (BYOD)", such as mobile devices (Howcroft & Taylor, 2014; Venters & Whitley, 2012). Cloud users can get access to cloud computing services through the associated software applications and Web browsers on digital devices. According to Voorsluys et al. (2011), cloud computing providers benefit their users with the following three aspects. The first one is infrastructure as a service (IaaS). It is the service based on physical or virtual machines, such as virtual machines, servers, and network. The second is platform as a service (PaaS). It is the service of computing platform, usually including operating system, database, web server, and a lot of development tools. Last but not least, software as a service (SaaS) is provided to make the clients access to software and databases hardware much more easily.

Cloud computing is widely adopted in various industries and sectors. It also brings a lot of challenges for users because the related knowledge is prerequisite before using. However, if users have to use the advanced technologies to accomplish the tasks, they may face a big challenge (Millar, 2008). There is also an increasing recognition in academics that it is imperative to help users effectively utilize information technology during their work. For instance, using survey data in the automotive industry, Karaali et al. (2011) investigated the factors affecting blue-collar workers' decision of using a web-based learning system.

Situation Awareness Factor in IT Use

The widely accepted definition of situation awareness across domains is “the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future” (Endsley, 1988, p. 97). The task itself, environment (e.g., workload and stress), training, abilities, and other individual factors were identified as the main factors that can influence situation awareness (Endsley, 1995; Roberts, Flin, & Cleland, 2015).

Situation awareness of IT is usually the beginning of IT adoption. Scholars have intensively studied IT diffusion process from users’ perception to routine use. Many technology acceptance models and theories have been widely proposed, such as technology acceptance model (TAM) (Davis, 1989), theory of planned behavior (TPB) (Ajzen, 1991), diffusion of innovation theory (DOI) (Rogers, 2003), institutional theory (Scott, 2001; Dacin et al., 2002), theory of acceptance and the use of technology (UTAUT) (Venkatesh et al., 2003), and social cognitive theory (Compeau & Higgins, 1995a, 1995b). For example, Swanson (1988) highlighted user involvement and management commitment for IT implementation. Gefen and Straub (1997) concluded that gender differences greatly influence end users’ perceptions of e-mail. Besides gender, other socio-cultural factors, such as national/ethnic differences, influence users’ perceptions of information technology (Gefen and Straub, 1997). Zhou et al. (2014) found that students’ perceptions of group creativity in learning information technology depend on their domain-related conceptualization and tacit knowledge learning experience.

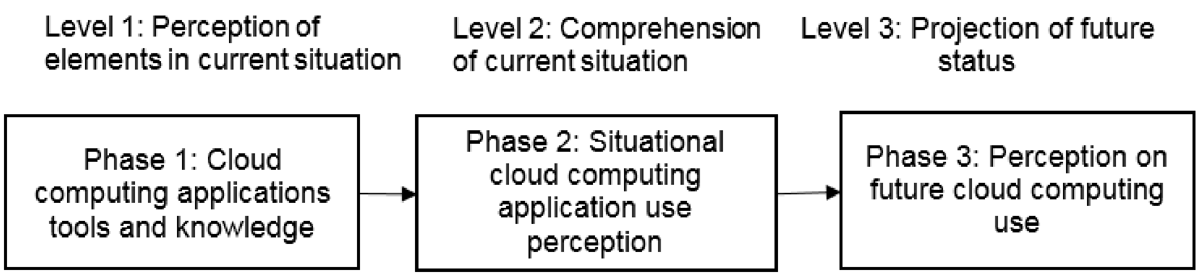
Straub (2009) summarizes the technology diffusion theories and gave some directions for informal learning. In the study, the author discusses how and why individuals adopt innovations and points out that addressing cognitive, emotional, and contextual concerns could facilitate technology adoption. The author also indicates the research about those concerns would contribute to a better understanding about IT adoption. Other scholars also suggest that the situation can affect individuals’ beliefs and emotional response (e.g., Bandura, 1986). Situational or environmental concern had caused more scholars’ attention to explore the factors of IT perception and adoption.

Conceptual Framework

From the definition of situation awareness (Endsley, 1988; Endsley, 1995), it can be further broken into three component levels to addressing and assessing team members’ operational sense independently. Figure 1 shows the three levels in detail. Level 1 is the perception of elements in an environment within certain time and space. Level 2 is the comprehension of the true meaning of elements. Level 3 is the projection of future status of the elements. The three levels of situation awareness should be considered separately to measure team members’ performance.

Based on situation awareness theory and the characteristics of cloud computing use, we designed three research environments (i.e., class knowledge learning, field experiment, and lab data interaction) to investigate students’ situation awareness differences. The conceptual framework is shown in Figure 1. The classroom learning is the fundamental learning situation in our design, in which the students can gain basic knowledge on cloud computing and its related equipment. The field work is the context in which the students can perceive cloud computing knowledge and its application as the blue-collar workers’ regular working status to locate infrastructure facilities. Lab data interaction provides students opportunity to manipulate recorded data and learn the future use of cloud computing application.

Figure 1: Conceptual framework



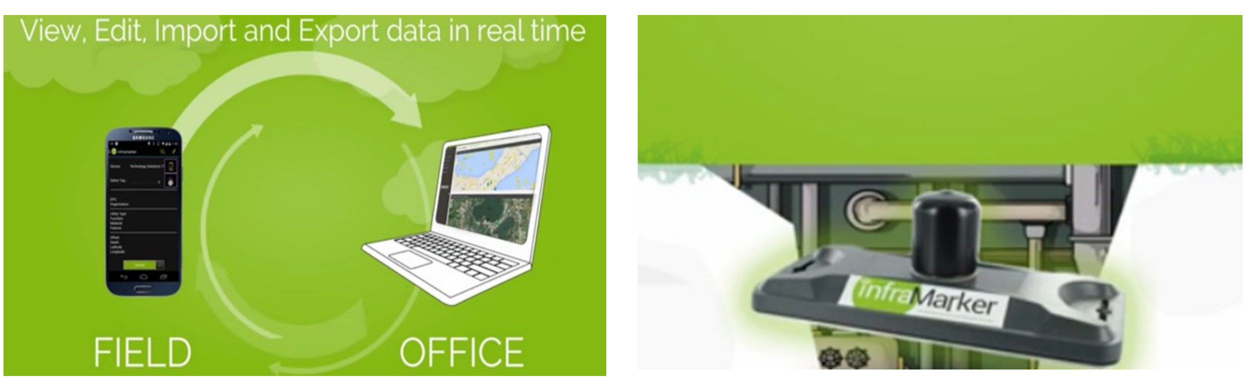
METHODOLOGY

Study Overview

This study was supported by a local company and a research center at a land-grant university in the southeastern US. This company provides technological solutions for the customers to mark their boundaries and infrastructure. The company supplies our research experiment with cloud computing services along with RFID equipment.

The students are recruited in the university. They are all enrolled in an introductory level MIS course. Participation is not mandatory, and extra credits are issued to all the participated one. 33 individuals decide to be involved in this study. Based on the research design, these 33 students were divided into two groups and asked to complete the assigned tasks by three phases. At least one instructor is assigned to each phase. We group three to four students into each team to maintain teamwork and effectively manage all the related tools. Figure 2 demonstrates the tools used in this study.

Figure 2: Cloud computing related application devices used in the experiment



According to the conceptual framework, the three phases are processed in a fixed order because of the incremental learning and perception. The knowledge gained on the cloud computing will be accumulated from one phase to the other. This will match situation awareness theory. Apart from the above design, after the three phases of situation awareness cloud computing, the students also make the presentation, including self-reported knowledge learned during the study, attitudes towards the cloud computing use for blue-collar workers, and the challenge faced during the three phases.

Research Design

Phase 1 Research Design

During phase 1, the participants are expected to learn how to use the equipment and the associated cloud computing software and how to locate infrastructure facilities with these tools. Two instructors present the knowledge that the students needed to understand before the real work in the next phase. Three short videos about the project background, writing to RFID Tags using the mobile App, and basic cloud computing equipment use were shown for the purpose of students' better situation awareness. After the demonstration by the instructors, the students are encouraged to have a closer look at the equipment. At the end of phase 1, students are requested to answer the first round questionnaire based on their situation awareness of learning from both presentation and equipment demonstration. The entire phase 1 is conducted in a classroom.

Phase 2 Research Design

During phase 2, the task was that the participants were separated into two groups to conduct the field work. After phase 1, all the 33 students agree to continue their participation of field operations in phase 2. In this environment, pre-determined utility assets, including Electric, Sewer, and Water, were identified and located. Magnet- and RFID-based markers were buried about 6-12 inches below the ground but directly above the assets.

In order to test the situation awareness differences on the use of cloud computing, we select two out-door locations for our study. One was on campus, in which new version of the equipment was buried and for use. The other field work site was located in another city, in which the equipment was old version bought from the above mentioned local company. In this location, the 48 tags buried in the city had been using for two years. They were buried along the waterline in a subdivision in the city. In both groups, student teams would mimic the role of a utility crew attempting to locate underground infrastructure with RFID technology and cloud computing applications. Correspondingly, the students were separated into two groups. 18 students volunteered to conduct the experiment on campus, while the rest were at another city.

The group located on campus is *Group A* in our experiment, and the other group located outside the campus is *Group B*. Students in both groups are asked to locate buried markers and read (write) information from (to) RFID tags. In both two groups, three or four students are assigned to one team. Each team is given one and a half hours to complete the experiment.
In order to make student teams to perceive a full blue workers' experience of the use of cloud computing application, we let the students read all the tags that are buried and only write a few of them in this phase, although we encourage students to locate as many tags as possible. By doing this, we can eliminate the situation that the same tag is getting overwritten and make sure the students experience fully on cloud computing infrastructure.

Then, the student teams navigate with the Google/ArcGIS maps, identifying the tags using a magnetic locator and read/write to the tag using the Bluetooth reader and Inframarker App. GPS points provide the general location of a buried asset. With the help of GPS information, magnetic locator pinpoints an exact location. In a situation where the same RFID tag is written into multiple times, we can have all the points on the cloud server. However, the RFID tag is only associated with the last write action. Students are requested to fill out the second round questionnaire based on their situation awareness in this phase.

Phase 3 Research Design

In phase 3, the task is that the participants use the data they collected during phase 2 and make data interaction by perceiving the cloud computing for future use. Based on their experiment results in phases 1 and 2, the students have an opportunity to manipulate data in a lab on the computer and understand how the data can be used in the future. The assignments related to the use of cloud computing and infrastructure facilities are given to test the increase of the students' understanding. The work includes exploring cloud computing client's web interface, adjusting GPS points to correct point location errors, exporting data, and importing data into maps.google.com for viewing. Data conversions to cloud computing use are conducted through the whole process. Students are also requested to fill out the third round questionnaire based on their situation awareness during this phase.

Method

Experimental research is best suited to investigate cause-effect relationships (Bhattacherjee, 2012). In this study, we used quasi-experimental research design, which requires treatment manipulation but has high internal and external validity. In our quasi-experimental research design, students who use the new version of cloud computing related equipment are assigned to the treatment group (Group A). The rest student who use the old version of cloud computing related equipment are allocated to the control group (Group B). The sample size 33 also satisfies our quasi-experimental research design and is good for our repeated measure analysis.

To assess subjects' situation awareness effect, a quick questionnaire process by intermittently interrupting a task in the real world is suggested a good means to extract the critical features of the subject's situation awareness (Sætrevik and Eid, 2014). To better serve our research purpose, we designed two open-ended questions as well as eight 5-likert scale questions. The quantitative empirical survey data, and qualitative data from interview texts with instructors and students, and students' presentation slides are analyzed to explore the differences in these two groups. By analyzing the quantitative and qualitative data together, it is good "to explore, describe, explain, predict and influence" (Onwuegbuzie et al., 2009, p 14).

It is hard to operationalize only from situation awareness definition. Based on previous study suggestion (Sætrevik and Eid, 2014), the survey with self-report item method can be used to reflect the extent to which the operators feel they are fully aware of the environment. The main purpose of this study is to measure students' situation awareness on cloud computing use for blue-collar workers' tasks and try to identify the differences in the experiment. Thus, we are not focusing on developing these constructs. The general questions about the students' situation awareness are drawn from previous academic and industry journals. The applicability of all the questions is discussed by the authors. We use a five-point Likert scale to indicate the degree of participants' agreement (ranging from 1= "strongly disagree" to 5= "strongly agree"). For the measurement, we asked participants to indicate their attitude towards the statements. For example, we measure the situation awareness of productivity through the students' attitude towards the statement "*Cloud computing can boost blue-collar workers' productivity*". (See Appendix A)

The questions are all directly used to reflect participants' situation awareness and their attitude towards cloud computing use during their tasks. Based on previous literature on the discussions of benefits and impacts of cloud computing (e.g., Catteddu, 2010; Grossman, 2009; Marston et al., 2011; Sultan, 2010; Venters & Whitley, 2012), we measure the effect of use of cloud computing for blue-collar workers mainly from the following eight aspects: usefulness, productivity, accuracy, complexity, effectiveness, collaboration, flexibility, and reliability. Usefulness is measured by students' situation awareness of the extent to which cloud computing is useful to utility blue-collar workers (e.g., Calheiros et al., 2011). Productivity is assessed by students' situation awareness of the extent to which cloud computing can boost blue-collar workers' productivity (e.g., Brynjolfsson & Hitt, 2003). Accuracy is rated by students' situation awareness of the extent to which cloud computing can increase the accuracy of blue-collar workers' work deliverables (e.g., Zissis & Lekkas, 2012). Complexity is operationalized by students' situation awareness of the extent to which cloud computing can reduce work complexity for blue-collar workers (e.g., A Vouk, 2008). Effectiveness is measured by students' situation awareness of the extent to which cloud computing can make blue-collar workers' work more effective (e.g., Buyya et al., 2009). Collaboration is measured by students' situation awareness of the extent to which cloud computing can help blue-collar workers collaborate online without generating paper-based documents (e.g., T Ograph & Morgens, 2008). Flexibility is represented by students' situation awareness of the extent to which cloud computing can make blue-collar workers' job more flexible (e.g., Foster, 2008). Reliability is delineated by students' situation awareness of the extent to which is measured by students' situation awareness of the extent to which cloud computing can make blue-collar workers' job more reliable (e.g., Armbrust, 2010).

Each participant was encouraged to answer the same questions through the three phases. For a better execution and complete the task within the team, the questionnaires are given to the students by team. Some demographic information is added to the associated response after data collection process. For example, four copies of questionnaires are given to team 1 in Group A immediately after Phase 1. The participants need to provide group number and banner ID on each copy of the questionnaire. This fashion will be used in the 2nd and 3rd rounds of data collection as well. After the three rounds, the researchers put each student's responses together as one piece.

Data Collection

Of the 33 participant, 11 are female (33.33%), and 22 are male (66.67%). 25 are in business related majors (75.76%), and 8 are in engineering related majors (24.24%).

Before conducting the investigation of their situation awareness on cloud computing use, we first ask students to report their cloud computing knowledge level. From their statements, we find that they had little knowledge about cloud computing and its related use to locate infrastructure facilities before conducting this quasi-experiment.

Data Analysis and Results

First, we analyze the correlations among the responses and the variables, such as gender and major. The correlation analysis results indicated that there was no significant relationship among gender, age, major, race/ethnicity, and the students' response towards the attitude to the use of cloud computing during their experiment. Thus, we could rule out the effects of these factors on the situation awareness differences.

Table 1 shows the descriptive analysis results for each question. We can see that the means of *Group A* and *Group B* are both very high in phase 1, which indicates all the respondents hold an active attitude towards the role of cloud computing for blue collar workers' tasks. The situation awareness effect is evident from the results. However, in phases 2 and 3, the students in different situations and learning environments produce different situation awareness outcomes.

Table 1: Descriptive Statistics

	Phase 1				Phase 2				Phase 3			
	Group A		Group B		Group A		Group B		Group A		Group B	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Q1	4.389	.7775	4.133	.6399	4.611	.5016	3.933	1.033	4.556	.7048	3.714	1.139
Q2	4.222	.8782	4.133	.6399	4.667	.4851	3.867	.9904	4.556	.6157	3.714	1.204
Q3	4.444	.7048	4.067	.7037	4.667	.4851	3.733	1.100	4.556	.6157	3.643	1.008
Q4	4.056	.9984	4.133	.7432	4.444	.6157	3.400	.6325	4.166	.7071	3.357	1.081
Q5	4.444	.9218	4.267	.7037	4.556	.6157	3.667	.8997	4.389	.7775	3.643	1.081
Q6	4.389	.8498	4.466	.7432	4.667	.4851	4.000	.7559	4.389	.6978	3.929	.9169
Q7	4.166	.9236	4.333	.6172	4.611	.5016	3.733	1.033	4.556	.7048	3.571	.9376
Q8	4.389	.9164	4.467	.5164	4.500	.5145	3.600	1.056	4.556	.7048	3.714	1.204

Note: Q1-Q8 were separately used to measure students' situation awareness of cloud computing in the characteristics of usefulness, productivity, accuracy, complexity, effectiveness, collaboration, flexibility, and reliability.

In order to further investigate the differences between the two groups in this quasi-experiment among the three phases, we conduct repeated measures ANOVA analysis to test the differences (See the results in Table 2). The results below in table 2 clearly indicate that there is no significant difference within each phase. However, when we consider the factor of the situation environment for each group, we find that the differences becomes significant.

Table 2: Tests of Within-Subjects Effects

Measure: MEASURE_1

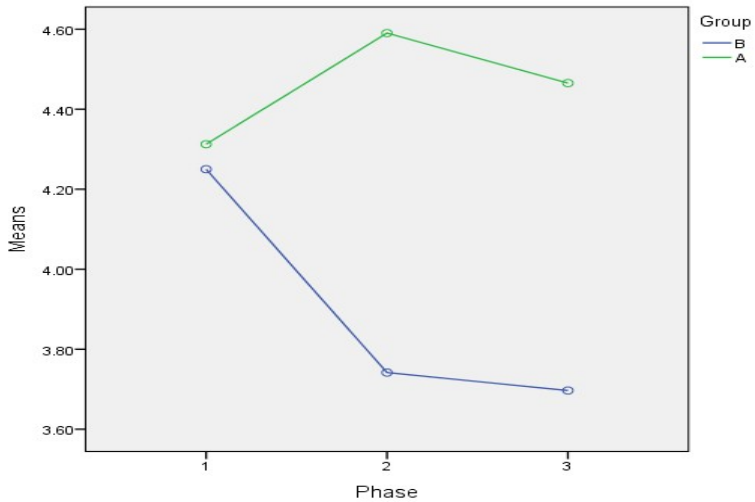
Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent Parameter	Observed Power[a]
Phase	Sphericity Assumed	.661	2	.331	.896	.414	.028	1.791	.198
	Greenhouse-Geisser	.661	1.900	.348	.896	.409	.028	1.701	.193
	Huynh-Feldt	.661	2.000	.331	.896	.414	.028	1.791	.198
	Lower-bound	.661	1.000	.661	.896	.351	.028	.896	.151
Phase * Group	Sphericity Assumed	3.062	2	1.531	4.149	.020	.118	8.299	.712
	Greenhouse-Geisser	3.062	1.900	1.612	4.149	.022	.118	7.882	.695
	Huynh-Feldt	3.062	2.000	1.531	4.149	.020	.118	8.299	.712
	Lower-bound	3.062	1.000	3.062	4.149	.050	.118	4.149	.506
Error (Phase)	Sphericity Assumed	22.879	62	.369					
	Greenhouse-Geisser	22.879	58.888	.389					
	Huynh-Feldt	22.879	62.000	.369					
	Lower-bound	22.879	31.000	.738					

a. Computed using alpha = .05

We can also find the results from Figure 3. The results show that in phase 1, there is no difference in situation awareness between the two groups. However, as the experimental situation changes in phase 2, the situation awareness difference becomes significantly different. In phase 3, two groups both conducted the learning in the lab, the situation awareness difference is still significant. This might be affected by the knowledge they got in phase 2 because the knowledge they acquired was built on previous step in phase 2.

We find the similar results from the students' self-report open-ended questions. In the survey, the first question is about their situation awareness towards cloud computing use in facilitating blue-collar workers' job. The second question is about their situation awareness of challenges towards cloud computing application use. These results are consistent to the data analysis results. We listed some typical answers from the respondents' responses as evidence.

Figure 3: repeated measures results



Evidence from open-ended questions

In phase 1, we could find the students hold the same situation awareness attitude. They all have positive attitudes towards cloud computing use in facilitating blue-collar workers' job (See results in Table 3). This is the basic step towards the cloud computing use in classroom.

However, when the study proceeded in phase 2, their attitudes towards cloud computing use in facilitating blue-collar workers' job become significant different. More and more challenges were faced by the students because of hard field work. The students in Group A held more active attitude towards cloud computing use that students in Group B. Students in Group B held the feelings of more and more challenges than those in Group A. We could even noticed that some students doubted the reliability of cloud computing application (See results in Table 4).

In phase 3, the attitudes toward cloud computing use in facilitating blue-collar workers' job is till significantly different. Although all the students in both groups were conducting the learning situation awareness in the same lab, the students in Group B still hold negative attitudes towards cloud computing use (See results in Table 5). Students in Group B produced more complaints on equipment than those in Group A. The results confirmed the finding from the survey data. This might also be because of the close relationship between phases 2 and 3.

Table 3: Selected Answers of Open-Ended Questions in Phase 1			
Situation awareness of attitudes towards cloud computing use in facilitating blue-collar workers' job		Situation awareness of challenges towards cloud computing application usage	
Group A	Group B	Group A	Group B

"If it makes uploading the data easier, there is a sufficient reason to use cloud computing." *"Yes, it would allow for immediate storage of data and possibly for more accurate recording."* *"Cloud computing would be helpful for a collaborative effort in detecting RFID tags and storing data once the tags are logged."* *"Yes, I like the accuracy of the technology."*	*"Yes, it makes locating tags easier and would make underground assets more reliable."* *"Yes, it would make the community much more effective and efficient."* *"Yes, it would be helpful and create effective work."* *"Yes, you could use data collected by anyone else who uses cloud completing access easily."*	*"No, I thought the videos were very helpful."* *"It seemed pretty straightforward."* *"So far: all is understood."* *"No, it seems fairly simple."* *"I did not find any challenges. Pretty easy to use."* *"No."*	*"No."* *"No, I do not find any challenges."* *"Not really. I find myself finding it ok to follow and to understand."* *"No, it's pretty straightforward."*

Table 4: Selected Answers to Open-Ended Questions in Phase 2

Situation awareness of attitudes towards cloud computing use in facilitating blue-collar workers' job		Situation awareness of Challenges towards cloud computing application use	
Group A	Group B	Group A	Group B
"Yes, it really makes things less complicated." *"Yes, it was easy and accurate when locating assets which would be helpful."* *"Yes, because it helps transfer information awhile."* *"Yes, it allows easy and instant access to the information written on tags."*	*"If more reliable technology, it would be helpful."* *"It is a great way to find and locate, but we had a few problems with tagging the magnets."* *"Yes, with updated tech would make it simple."* *"Yes, I can see it being very useful."*	*"No, it was straightforward."* *"We had some difficulty finding a few assets, but we eventually found them by putting the reader/writer closer to the ground."* *"Writing tags and connection issues."* *"The technology was difficult to use at times."*	*"Problems with tagging the magnets."* *"Hard were issues between versions."* *"Yes, we wouldn't find many of the RFID."* *"Yes, having trouble reading tags."*

Table 5: Selected Answers of Open-Ended Questions in Phase 3

Situation awareness of attitudes towards cloud computing use in facilitating blue-collar workers' job		Situation awareness of Challenges towards cloud computing application use	
Group A	Group B	Group A	Group B
"Makes the job easier, as well as makes the data more understandable."	*"To be honest, ours failed but if it worked then it would be awesome."*	*"Very easy phase for our group. No challenge, but enjoyed."*	*"The tags wouldn't write. Also, the few that did were not accessible online."*
"Cloud helps make jobs for blue-collar workers easier."	*"It needs to actually work when locating and editing the tags*	*"No. Phase 3 was very simple and easy to understand."*	*"Data didn't show up."*
"It makes seeing assets that are buried easier, and can be displayed in a way that's easy to understand."	*"The idea is really good, as it can be easily accessed and edited, but the actual product does not work."*	*"Nope. Simple and efficient."*	*"None of our original points showed up. We had to use another group's login."*
"It can help pinpoint locations on google and other websites."	*"I see the purpose of the technology. However, it is very reliable. "*	*"No, though it appears one of our points didn't write to the cloud."*	*"Yes, our data didn't show up. But the other people's data did."*
"It definitely can ease most blue collar work depending on know-how and reliability. Some things didn't happen in the end as they should, which in the real world make things difficult."	*"Cloud computing encourages collaboration in data collection for blue-collar jobs. As more collaboration occurs, the more reliable the data becomes."*	*"Not in phase 3 specifically, but I have security issues with cloud computing in general. For example, it was the apple cloud that all those celebrity pictures leaked from."*	*"Our only challenge was that our tags in Foley were not recorded to the cloud and we were unable to use our original data."*

DISCUSSIONS

By applying the three-level situation awareness model, we developed a quasi-experimental research design and identifying the situation differences on the use of cloud computing. Based on the repeated measure ANOVA analysis results, we generalize the following aspects. The first one is that students in the same cloud computing use situation can gain the similar situation awareness. The other aspect is that students' situations awareness on cloud computing use changes significantly with the change of environment. The last one is that students' situation awareness is affected by their previous experience.

To further investigate the potential factors that might influence the situation awareness differences, we review the process of the research design. We try to list all the factors in these two experiments (See Table 6) and give the audience a full judgement for the cause of above results. For example, in addition to the change of the experiment location, we can not overlook the training effect either. Different training environments might produce different learning outcomes. The difference might be caused by the training effect. In fact, we used different tutors in phase 2 for students' training. Different tutors are likely to demonstrate the knowledge to the students in different ways. The training approach might be an important factor for producing students' situation awareness. This is because that a better understanding of the knowledge distributed through training can easily lead to a better of situation awareness. We may even posit that students might have very little trouble once they are well trained.

Previous studies have discussed many factors such as gender and age on the situation awareness of information technology use. Our research provides a preliminary understanding of situation awareness difference in information technology diffusion process.

Our study first extends the situation awareness theory in explaining information technology knowledge learning in different experimental environments. Unlike most past studies that use one phase to create a situation to identify situation awareness design, this study is designed with three environments to test learning effects and identifies the differences. The learning outcomes from students' situation awareness results show that the experimental learning effect might be affected by learning situations. This indicates that the situational factor need cause scholars' attention for experimental learning design.

Table 6: Potential Factors That Might Influence Situation Awareness Differences

Factors category	Is it the same between Group A and Group B?		
	Phase 1	Phase 2	Phase 3
Equipment version	Yes. Same version demonstration.	No. Group A used the new version while group B used the old version.	Yes. Same tools used.
Time used	Yes. Same time used.	No. Students in Group B spent more time on average than Group A.	Yes. Same time used.
Task requirement	Yes.	Yes.	Yes.
Environmental distribution	Yes. Same classroom.	No. Group A's field work was conducted on campus and group B's field work was conducted in another city.	Yes. Same lab.
Training and tutors	Yes. Same tutors and training method.	No. Different tutors and training process.	Yes. Same tutors.

Our study provides a better understanding of situation awareness on the use of information technology. Because our research design is based on students' learning context, this can contribute to information systems (IS) education literature. Although the purpose of the study is to find situation awareness differences on the use of cloud computing outcomes, students' learning process has also been investigated. The design can be used for students' learning in introductory level MIS courses in business schools.

The difference may be also caused by the information technology itself. In our study, the students in *Group A* located infrastructure facilities more easily. All the equipment used in this group is the latest. However, the tags used in *Group B* are the old versions. This might affect the reliability of equipment, and, in turn, influences the students' situation awareness of cloud computing use. Thus, the information technology with the best condition can help increase the users' situation awareness.

There are several limitations to this study. First, the generality of the results might be limited. As we just measured the situation awareness differences of cloud computing use to locate infrastructure facilities. The subjects are students in IT related class. Because of surrogate issue and the weakness of quasi-experimental design, the generality of the findings might also be affected. Second, we tested the students' situation awareness with very general questions. These questions were not tested from a pilot study. This may cause the validity bias in methodology. Last, except the version of equipment and field work in different places, we controlled as many factors in our design and discussed all the factors that caused the results. But other potential factors may still exist. For example, some studies suggest that individuals' experiences can influence their situation awareness (e.g., Endsley, 1995). However, it is hard to identify and measure the characteristics that are truly affecting the situation awareness.

Admittedly, the study could not identify all the factors that caused the situation awareness differences. However, it opens up new topics on the situational factors on information technology use in the future. The research design that was conducted could be replicated by controlling other situation factors. We encourage more studies to test the environmental factors in future empirical studies. We provide the following recommendations for future research. First, a lot of other advanced information technologies can be tested. Other situational factors can also be included, which will make a better generality of our research results. Second, in order to better measure the situation awareness on specific information technology use well, we call more studies to develop instruments that can measure and assess situation awareness. Third, besides the three phases design of situation awareness environments presented in this study, other situated research designs are also encouraged.

CONCLUSION

Grounded on the three level situation awareness theory, a conceptual framework with three phases design was proposed to explore the situation awareness outcomes of the use of cloud computing. Specifically, based on the proposed formwork, we executed the research design with two groups of students in three different learning environments (i.e., classroom learning, field work, and lab learning). Following that, the situation awareness differences from the students were discussed by analyzing the survey data. The different learning outcomes were identified by repeated measures ANOVA analysis. The results indicate that situation awareness on cloud computing use is significantly different when the experiment environment changes. The potential factors that might influence this change are discussed. The study findings extend the IT perception literature by taking account of situational factors.

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APPENDIX A: Questionnaire for Each Level of Situation Awareness

Please specify the extent to which you agree with the following statements:	**Strongly Disagree** ←				→ **Strongly Agree**
(1) Cloud computing is useful to utility workers.	1	2	3	4	5
(2) Cloud computing can boost workers' productivity.	1	2	3	4	5
(3) Cloud computing can increase the accuracy of workers' work deliverables.	1	2	3	4	5
(4) Cloud computing can reduce work complexity for workers.	1	2	3	4	5
(5) Cloud computing can make workers' work more effective.	1	2	3	4	5
(6) Cloud computing can help workers collaborate online without generating paper-based documents.	1	2	3	4	5
(7) Computing can make workers' job more flexible.	1	2	3	4	5
(8) Computing can make workers' job more reliable.	1	2	3	4	5

(1) If your job is to use handheld devices to detect RFID tags and record geographic data of the tags for a community, would you be happy to take advantage of could computing for your work? Please explain.

(2) Do you find any challenge(s) during this phase? Is any challenge related to the cloud infrastructure? Please specify.