Before Teaching Cybersecurity in the University: Usability Analysis of the Cloud Platform with Learner's Perspective

Manjur Kolhar, Abdalla Alameen

College of Arts and Science, Dept. Computer Science, Prince Sattam Bin Abdulaziz University, Wadi Ad Dawawser , Alkharj, Saudi Arabia

Abstract **– The aim of this research is to apply usability evaluation of the Cloud Service Providers (CSP) established for various development purposes, CSP also are used in teaching cybersecurity courses for undergraduate program. In order to apply usability evaluation, two CSP products are used, namely Google Cloud and Microsoft Azure. We have applied usability evaluation method to measure its appropriateness with respect to learning and the use of a product for teaching. We have categorized students in two groups, namely expert and novice. Our evaluation suggests that before using graphical user interfaces of CSP, one should have knowledge and skills in implementing Cybersecurity project.**

Keywords **– Cloud Service Provider, Usability Evaluation, Cybersecurity, University Learning, Laboratory Learning.**

1. Introduction

Online education is one of the fastest growing trends in educational technology [1],[2],[3]. Online laboratories have great potential steps for university students, as these platforms enable students to access large and various topics, allow them to conduct practically. A large number of online and real time software platforms already exist, and new ones are being developed at a very rapid rate. Most of the online educational tools or website, and even platform provide interfaces that allow students to communicate with each other. The propagation of online education platforms with low usability suggests that developers of online education platforms have less technical skills of graphical user interface and usability skills than it is required. Hence, it is serious issue which needs to be addressed appropriately by stakeholders, since platforms with poor usability can have negative effects. At the same time, we, Prince Sattam Bin Abdulaziz University, Saudi Arabia, wanted to create a platform for teaching network security for undergraduate students. We wanted online tools that were not too restricted, but enough applicable to provide sufficient management for students in order to conduct practically, with the minimum intervention of instructor. Our initial efforts yielded the name of Google cloud and Microsoft, and plethora of research papers suggested to use them as the tool for conducting cybersecurity practical for students [4].[5],[6]. However, effective use of online LABS requires not only computer science subject knowledge, but significantly practice and experience. For example, in industry, students are expected to find problem in the existing system and provide cybersecurity solution by proposing design and development of suitable architecture.

The aim of this research is to apply the usability evaluation methods on interface of the Cloud platform, because industries use these platforms for various jobs, and it is also widely recommended by the universities. Hence, before we induct into these CSP's for academic purpose or our syllabus, we want these Cloud platforms to be studied in terms of usability by the users, particularly students. According Nielsen, usability is equally important and it determines usefulness of user interface. User interfaces are easy to follow, but sometimes, they

DOI: 10.18421/TEM83-06
https://dx.doi.org/10.18421/TEM83-06

Corresponding author: Manjur Kolhar,
College of Arts and Science, Dept. Computer Science, Prince Sattam Bin Abdulaziz University, Wadi Ad Dawawser , Alkharj, Saudi Arabia
Email: *manjur.kolhar@gmail.com*

Received: 09 May 2019.
Revised: 28 July 2019.
Accepted: 02 August 2019.
Published: 28 August 2019.

will not perform in the way we expect. Furthermore, some user interfaces are not good while they supposedly do what users want, but, on the other hand, users can't move further actions on GUI because the user interface is too difficult to understand. Usability according Neilson, has the following quality components:

- Learnability
- Satisfaction

Learnability: It deals with product, how fast this product can be learned and how quickly can be used. In order to measure such features, researchers have developed pre-test and posttest methods, in which users will be asked to perform set of operation on GUI and measure their completion time [7],[8],[9]. Learnability is used with many different domain projects, and it has resulted in uplifting face of the user interface.

Satisfaction: Authors [10].[11],[12], have suggested using questionnaire to measure the satisfaction of usability.

2. Methods

This study fundamentally aims to investigate the usability of interface of the CSP. The data gathered from the students who are asked to perform practically on these CSP for their LAB sessions during the summer of 2018, and the data gathered through face to face interviews.

Table 1. The task carried by the students and LAB assistant

LAB assistant	Students
Take attendance	Be in time
Assign Job of the day	Take the assignment from the LAB assistant
Prepare the network for the jobs	Provide the solution for the assignment with the help of programing language.
Help out students during network or communication error or any other error.	Note down errors so that can be reproduces
Installation Issues	Call for help
Check their status of the jobs and upload it to the system for further evaluation	Show the result of their findings
Note the observation	Understand the behavior of the system
Prepare list of learning outcomes	Produce and note down the list of lesson learnt
Use suitable assessment strategy	
Mark the observation	

The study was conducted at Prince Sattam Bin Abdulaziz University (PSAU), Al-Kharj, Saudi Arabia. PSAU provides extensive LAB sessions to its computer science students with its nearly 1000 students including hundreds of faculty members, more than 4 campuses, each campus is equipped with computer network LABS, and 1 digital library. LAB had a total of 38 users consisting of 32 students and 6 faculty members. This is our sample for this study LAB staff at the wadi Ad Dawaser, which also participated in the study. All participants were relatively acquainted with LAB manual procedures. In order to distinguish the users by their Cloud virtual machine assignment and usage knowledge, a test was given to the users. Knowledge level of the users on Virtual machine concepts, its usage and virtual machine for network communication was identified within this test. The students were then clustered into two groups, as experts and beginners in terms of Cloud computing LAB sessions. It was found that 16 of the students were recognized as beginner users, while the rest of students were grouped as expert users.

With respect to Cloud platforms, usability is never applied by the user or student. If Cloud platforms are difficult to use, then the meeting of our Student Learning Outcome will be difficult. If the user interface miscarries information then student will unable to perform lab sessions.

Within the existing system at PSAU and its affiliated colleges, the student performed their lab sessions in the computer network LAB. Later, output of their respective practical jobs was printed by a lab assistant. When a student arrives at LAB, initially a lab assistant fills the forms regarding the student's profile file, and later this information are sent to a certain faculty, in which they can be checked and reviewed, and marked as the LAB session. The basic responsibilities performed both by students and lab assistant are listed in Table 1.

3. Proposed System

The LAB Cloud client system could work on PCs for any LAB jobs. There are many cloud service providers which are available, however, in this research we have used Google Cloud, Microsoft Azure and we have built our own cloud network PSAU-Cloud, which is running inside the campus. PSAU-Cloud has client & server software architecture, and it was developed as an application on Windows OS, while PSAU-Cloud has three-tier software architecture. Each client can request virtual machines to run via web server. In turn, server creates and manages sessions for each request and collects relevant data from the database server. Then only the results are sent back to the clients.

Students use LAB PCs to work on the assignment. Each PC can connect to the cloud provider to initiate sessions after the verification of username and password. By using above-mentioned cloud students are expected to perform their assignments. These

assignments are ranged from creation of Virtual machine to writing and installing server for threats and other purposes. Furthermore, while performing practically, students have captured various parameters with respect to the GUI usability. This experience can further enhance CSP providers.

Similarly, students also use our own cloud service which is named as PSAU-Cloud. This cloud provides various services which are covering almost all the practical assignments. However, there are many services which are not available in PSAU-Cloud. As demand grows, it becomes mandatory to update our own cloud to meet the market demand. The PSAU-Cloud retrieves data related to a student by using his/her roll number which is assigned to each student. Lab assistant use the PSAU-Cloud to register the students for the assignments, and later that can be retrieved from the central database; key in status of the lab session and to build student profile file information and closely follow up the evaluation and inspections, while the class teacher utilizes the PSAU-Cloud to view the students' records and enter recommendations (suggested or advised improvements for the particle assignments). After the student's assignment is finalized, the assignment evidences about the session are saved to the database, and then the session is terminated by "logout".

In this research, authors have also utilized these methods in order to evaluate the cloud platforms. We have used Google Cloud platform and Microsoft Azure. Both are cloud service provider. Both are being used to serve variety of services ranging from Web to mobile application, and serving every sector such as education, industries, manufacturing plants, sports, music and health.

The PSAU-Cloud system is a GUI based menu system, designed and implemented as CSP. Both PSAU-Cloud and Google & Microsoft cloud systems have the same functions. Nevertheless, their GUI designs are different. However, there are many functions such as intrusion detection, network infrastructure, security firewall setup and various operating systems as virtual machines and many more which are provided in global CSPs'. After carefully studied these CSP, we have designed and added functionalities to conduct practical session for the current student learning outcomes (SLO) regarding the network and systems LAB. Each student of the LAB and faculty members were invited to take part in representation of an icon or functionality according to the SLO used in the GUI. Then, the modules with the SLO selected to represent functions in PSAU-Cloud were added. PSAU-Cloud and commercially available CSP also provide more services with different display design strategies. Table 2 provides a comparison of both (CSP and PSAU-Cloud) systems in terms of strategy in line with the SLO.

Both systems are used by the students and faculty members, including support staff working solely for LAB. Aforementioned, investigations emphasis only on the task list of lab sessions, though it is also equally applicable to the faculty members involved in research-based projects as well.

As shown Fig 1, Google Cloud dashboard items which are listed as Project information, API, Google Cloud platform status, error reporting, traces and tutorials. These items are related to the Virtual machine which is currently being utilized. Similarly, Fig 2 shows, Microsoft's azure, beautifully designed colorful iconic dashboard in conjunction with the current project. Fig 3, shows the dashboard of PSAU-Cloud. From here onwards, we name both Cloud service giants as CSP. Both CSP have similar offerings to client, however, there are existing differences in the GUI. Azure has edge over Google Cloud platform. Azure has used iconic approach for each service offerings. Table 2, shows the focus and scope of the services with respect our SLO. These SLO are, with respect to the mission and vision of the computer science program, supervised by the University.

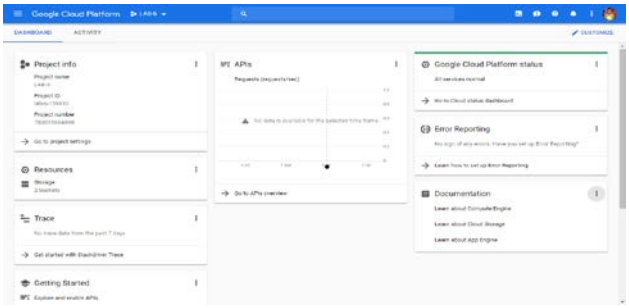

Figure 1. Google Cloud dashboard

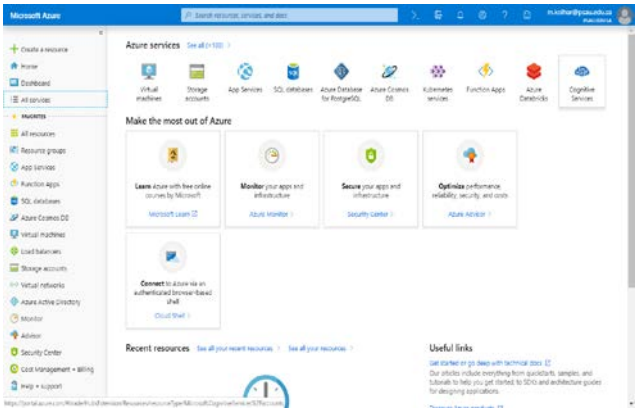

Figure 2. Microsoft's Azure dashboard

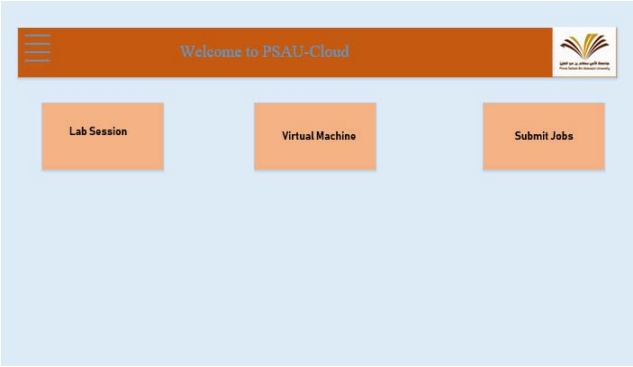

Figure 3. PSAU-Cloud Platform

Table 2. Cloud Offerings

SLO	Feature Name	PSAU-Cloud	CSP
Administrative controls to mitigate the threat	VPC service control	√	√
Intrusion detection and prevention and encryption	Infrastructure Security Layer	Encryption	√
Hardware, software and services	IaaS	Software	√
Multiple host and network architectures given requirements	Network and security function	X	√
How CPU, memory, storage and network resources usage	Usage reports	X	√
Demonstrate analytical skills	Serverless, Ingestion	X	√
Troubleshooting networking, security and performance	General Troubleshooting	√	√
IT infrastructure including devices, topologies, protocols	VPN topology	√	√
Integrate operating systems, services, network devices	RFC 1918	X	√
Technical documentation and in presentations	Know how	√	√
Small and project focused team	Group Communication	√	√

Most of the SLO are covered in the commercially available CSP's. However, very few of the SLO are not present in the PSAU-Cloud. But in future these missing features can be updated, but it requires continuous monitoring and update. To meet SLO for this course, LAB sessions approach starts from the inception of virtual machine to the platform, and then it concludes running small projects over it along with the team. The most of the feature present in PSAU-Cloud system are of iconic presentations which are very user friendly, but they will not provide many options as commercially available CSP.

Almost all services present in the commercially CSP's are grouped and have tasks with more options, for example, for running VM, CSP's which can give customer at least more than ten options of operating systems on different hardware architecture. Yet, there are some practical sessions which require continuous help from the expert to guide students. However, in some features the CSP'GUI design passes automatically to the next icon until completing the job of created and scheduled VM.

In this section, we define our systems which include commercially available system, namely Google cloud and Microsoft Azure, and our in-house developed cloud which is exclusive designed for the network security subject. Plethora of articles have studied these commercially available systems for conducting LAB session. However, these systems are complex for new comers because of many instances of virtual machines, which are available for various purposes. Some students are not familiar with these machines; thus, students are required to undergo training before they start using them. Furthermore, these machines can only be used by the professionals who have knowledge in design and efficient scheduling of jobs according to their needs. Hence, our methods of evaluation of the commercially available CSP, and our own CSP (PSAU) system both have undergone usability analysis. We have considered, heuristic and cognitive usability tests, since students look at the user interface (GUI) and identify the problems from their perspective. Heuristic evaluation is a method of usability analysis in which a number of evaluators/testers in our case students are presented with an GUI design of CSPs and asked to comment on it [12],[13]. As shown in the Table 3, there are ten general heuristics principles for user interface design, because they are more in the nature of rules of thumb than specific usability guidelines. With respect to graphical design interface, proper response for a user action is conceivably the most needed rule. In the first place, these rules help users to understand the current status, and they allow users to move in the right direction, without wasting time.

Furthermore, language with respect to iconic design and interfaces should not contain unnecessarily complicated and obscure text that only few can understand. Users of the system should be allowed to have freedom while going through site or GUI, and they should be allowed to exit easily. GUI should have a small degree of error messages, because the problem comprising the system for sensitive action regarding communication requires fewer errors or no errors to prevent problems from occurring in the first place.

There is a difference between recognition and recall. It is the number of signals that can help the memory retrieval whereas recall needs fewer cues than recognition. Hence, GUI design should take help of memory provided by the browser or ram, or programing compilers to retain users action on the design.

Table 3. Ten Usability Heuristics

Usability Heuristics for User Interface Design
Visibility of system status
Match between system and the real world
User control and freedom
Consistency and standards
Error prevention
Recognition rather than recall
Flexibility and efficiency of use
Flexibility and efficiency of use
Help users recognize, diagnose, and recover from errors
Help and documentation

We also employed, cognitive walkthrough usability evaluation method in which the students are used as evaluators who work through a series of jobs and note down their questions from the perspective of the students. The intention of this evaluation is on understanding the CSP's learnability for students. There is plethora of research in which cognitive walkthrough was used for more complex projects in order to understand the first experience of users.

4. Evaluation

The same experimental setup was used for usability analysis both CSP. In order to evaluate both CSPs', the following environment was established based on the SLO. Network Security lab sessions always disturb university policies or would be excessively unsettling the university computer networks. Hence, we formed the new LAB specifically designed for network security. This LAB uses virtual private networks can be configured to simulate security attacks. With this setup, these attacks are restricted and don not invade university network.

For the LAB experiments considered in this research, the laboratory is connected to the Internet and has more than thirty computers with high end configuration. Students are asked to implement Fig 4, network architecture using virtual machine and virtual network. This architecture covers SLO and it also convers 15 weeks course. Student created this network architecture by using "gcloud co mpute networks create", and it is further built by adding routers, and servers to host database and webserver to run demo server applications, we named this as Section A.

Section A is extended to create VLAN attachments determine which Virtual Private Cloud networks can reach our network through an interconnect, now this new segment is named Section B(which is extended from A). Section B is further secured with the firewall rules, for protecting our newly created network irrespective of their configuration and operating system, even if they have not started up. These firewall rules allow or deny any new connections. New connections are clients within cloud entity or outsider, who are willing to connect to our network segments. Each firewall rule applies to ingress or egress traffic. Furthermore, Fig 5, is connected to intrusion detection and prevention equipment. Using a secure shell (SSH) from the client PC, a student can then engage SSH to open a secure shell on the given entity of the Fig 5, for securely transferring files between client and server.

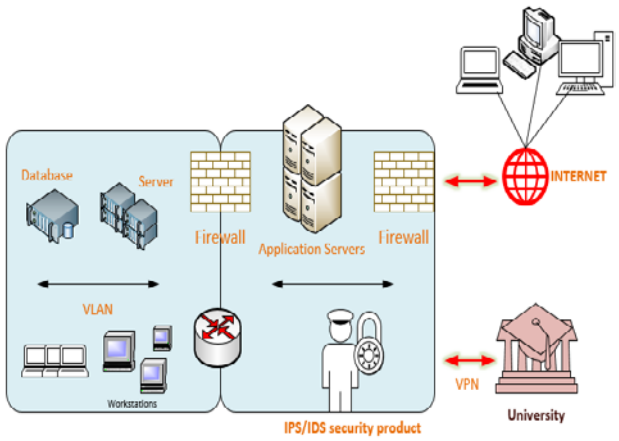

Figure 4. Network Security setup

5. Results and Discussions

Before executing evaluation system, the both cloud systems were used for feedback provided by students. Initially, individual and necessary information about VM provided to the students. Responses and enthusiasms of the students about the CSP were also measured. The technical terms used in LAB designed were corrected by both teachers and LAB technicians. Then, evaluators of the CSP were identified. According to Table 4, the students were

requested to rate each criterion on a 5-scale point from 1 ('poor') to 5 ('excellent'). In some situations, students tend to select wrong path or function, the preparedness of the CSP to convey proper and required path were also tested. During the heuristic's evaluation usability, the students built the network as shown in the Fig 5, through the GUI and inspected the interface elements and compared them with the heuristic's principles. In addition, principle of heuristics, the students apparently are permitted to add additional usability principles or results that come to attention that may be appropriate for aforementioned session. The output from evaluation was a list of problems in the interface with pointers to those usability principles that were debased by the design in each case in the view of the students. It is not adequate for students to merely say that they do not like something in the interface, however, in this case, students (Novice) were unable to understand the interface because of the lack of knowledge in the lab session. So, they got it clarified by the help of instructor. The students (Novice) were unable to provide specific problems and never listed out each usability problem with respect to the LAB session. For example, if there are dialog interfaces wrong with a certain element, these issues be recorded with respect to the heuristic's principles which clarifies why the interface element is a usability problematic.

In heuristic evaluation no issues were found. The problems were related to the knowledge of the student to operate GUI. Most important functions of Google cloud and Azure with respect to the fig 5 was to provide security. Students were unable to perform these security patches and it is found out to be the most difficult one to use. Novice students group also reported the same difficulties while performing heuristic evaluation. Hence before using these CSP's one should have sound knowledge on networking and interworking tools.

Table 4 Result of Heuristic Test between Expert and Novice

Expert	Novice	t-Value	p-value
4.56	6.93	-1.95	.0.00748

Table 4 provides mean value based on Heuristic usability test. According to participants, table 4 results indicate that there was no significant difference between novice and expert students. However, it signifies that the usability perception of the Cloud platform was correlated to the grade of student's network security skills. With respect to the Cognitive usability test, we have used paired t-test, which is before and after observations on the network course and, with respect to LAB sessions conducted online. Evaluation of two different cloud platforms, in which the evaluation was applied to the LAB session is presented in Fig 5.

Table 5, shows, mean of Pre-Lab is 18.875 and Post lab is 20.688 and p-value 0.023 at 5% level of significant. There exists a significant difference between Post Lab and Pre-Lab results. (Post Lab greater than Pre lab). i.e. Null Hypothesis rejected.

Table 5. Paired T Test of Expert users.

	Pre Lab	Post Lab
Mean	20.88	22.63
Variance	7.85	17.98
Observations	16.00	16.00
Pearson Correlation	0.74	
Hypothesized Mean Difference	0.00	
df	15.00	
t Stat	-2.44	
P(T<=t) two-tail	0.03	
t Critical two-tail	2.13	

Table 6, shows, a significant difference between the mean value of post and pre-LAB results with t-value = -2.44 [p-value = 0.03]at 5 per cent level of significance. This finding recommends that usability test based on the knowledge of the LAB session is also important, not just GUI, and expert student always edge over beginners.

Table 6 Paired T Test of Novice users

	Pre lab	Post Lab
Mean	18.875	20.688
Variance	7.850	17.563
Observations	16.000	16.000
Pearson Correlation	0.735	
Hypothesized Mean Difference	0.000	
df	15.000	
t Stat	-2.538	
P(T<=t) two-tail	0.023	

6. Conclusion

This research has made an attempt to test the usability of the Cloud platforms used for conducting practically network security. This study delivers a number of suggestions. Primarily, it is noticeable that there is a clear prerequisite for beginners or experts to have prior knowledge of working the network components in order to use Cloud platform. Thus, there is no need for any change in the GUI or making GUI simpler interfaces. Using these Cloud platforms, graduates and undergraduates can perform their practical session to meet university specified SLOs.

References

[1]. Wang, X., Hembroff, G. C., & Yedica, R. (2010, October). Using VMware VCenter lab manager in undergraduate education for system administration and network security. In *Proceedings of the 2010 ACM conference on Information technology education*(pp. 43-52). ACM.

[2]. Eliot, N., Kendall, D., & Brockway, M. (2018). A Flexible Laboratory Environment Supporting Honeypot Deployment for Teaching Real-World Cybersecurity Skills. *IEEE Access*, *6*, 34884-34895.

[3]. Plachkinova, M., & Maurer, C. (2018). Teaching case: Security breach at Target. *Journal of Information Systems Education*, *29*(1), 11-20.

[4]. Salah, K., Hammoud, M., & Zeadally, S. (2015). Teaching cybersecurity using the cloud. *IEEE Transactions on Learning Technologies*, *8*(4), 383-392.

[5]. Moravčík, M., Segeč, P., Uramová, J., & Kontšek, M. (2017, October). Teaching cloud computing in cloud computing. In 2017 15th *International Conference on Emerging eLearning Technologies and Applications* (ICETA) (pp. 1-6). IEEE.

[6]. Guo, D., & Koufakou, A. (2017, July). How Cloud Computing Is Addressed for Software Development in Computer Science Education. In *International Conference on Human-Computer Interaction* (pp. 415-426). Springer, Cham.

[7]. Bhargava, P., Antonakakis, J., Cunningham, C., & Zehnder, A. T. (2006). Web-based virtual torsion laboratory. *Computer Applications in Engineering Education*, *14*(1), 1-8.

[8]. Paymans, T. F., Lindenberg, J., & Neerincx, M. (2004, January). Usability trade-offs for adaptive user interfaces: ease of use and learnability. In *Proceedings of the 9th international conference on Intelligent user interfaces* (pp. 301-303). ACM.

[9]. Kaber, D. B., Riley, J. M., & Tan, K. W. (2002). Improved usability of aviation automation through direct manipulation and graphical user interface design. *The International Journal of Aviation Psychology*, *12*(2), 153-178.

[10]. Dong, J., & Byun, M. (2018). Enhanced Usability Assessment on User Satisfaction with Multiple Devices. In *Advanced Multimedia and Ubiquitous Engineering* (pp. 849-853). Springer, Singapore.

[11]. Pereira, R. E., Moore, H. F., Gheisari, M., & Esmaeili, B. (2019). Development and usability testing of a panoramic augmented reality environment for fall hazard safety training. *In Advances in Informatics and Computing in Civil and Construction Engineering* (pp. 271-279). Springer, Cham.

[12]. Alessa, T., Abdi, S., Hawley, M. S., & de Witte, L. (2018). Mobile apps to support the self-management of hypertension: systematic review of effectiveness, usability, and user satisfaction. *JMIR mHealth and uHealth*, *6*(7), e10723.

[13]. Saeedbakhsh, S., Isfahani, S. S., Saber, M., & Yadegarfar, G. (2017). Hospital information system usability of educational hospitals in Isfahan using heuristic evaluation method. *International Journal of Educational and Psychological Researches*, *3*(1), 69-73.