

# Determining Users' Requirements Through Design Thinking Methodology for Developing Examination Invigilation Management Systems (EXIMS)

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## Abstract

Invigilation of examination is one of the important elements in examination management systems. Satisfying the duties assigned to all invigilators is not easy and requires a thorough and tedious process of assigning the invigilation duties to each invigilator. Once the duties are appointed, the tendency to change the invigilation among invigilators are still possible. The Design Thinking (DT) methods, which comprises five (5) important phases, have been applied and the determination of users' requirements among invigilators and stakeholders of the system was performed during the empathise phase in the Design Thinking. The users' or functional requirements collected through the informal telephone conversation from the invigilators were scrutinised and arranged on the empathy map. The House of Quality (HOQ) model was constructed to show the strength of the relationship between the list of functional requirements and the users' dreams. Based on the model of HOQ, a web-based named Examination Invigilation Systems (ExIMS) was developed to fulfil and consider the users' requirements as proposed by the invigilators. The implementation of ExIMS has shown a positive impact among invigilators since it comprehensively facilitated the process of invigilation exchange among invigilators. Indirectly, it increased the satisfaction among invigilators and strengthened the integrity of examination procedures.

**Keywords:** Design Thinking (DT), Examination Invigilation, Requirement, Empathy Map, House of Quality (HOQ).

## Introduction

In any educational institution, the examination operation is the most crucial and serious process besides the administration and students' record management. Examination Management Systems involves several important modules such as preparation of

examination schedules, arrangement of examination venues, the process of students' marks management, planning of invigilation schedules for invigilators and handling of printing and packaging of question papers (Quality, 2010). Each module is interrelated and proper organisation of examination management is very important to ensure that the examination can run smoothly following the standard operating procedure (SOP) of examination operation (UiTM, 2016). The operation of the examination is observed and audited by a group of internal audit committees to make sure that the examination operation runs accordingly without major defects. Failure to follow the examination standard operating procedure will affect the credibility and integrity of overall examination operations.

At Universiti Teknologi MARA (UiTM) Pulau Pinang Branch of Malaysia, the invigilation module is among the crucial tasks in the examination operation. Invigilation duties for each invigilator are processed and generated by a system called Examination Management System (EMS) (Othman et al., 2018). Once the system completed generating the invigilation duties report, the examination committees will conduct a thorough inspection to make sure that the duties are distributed accordingly to each invigilator. Normally, changes of invigilation duties among invigilators are made manually to ensure that the duties are distributed perfectly. After improvising the process of invigilation duties, the invigilation notice of each invigilator will be released one week before the examination.

Although the invigilation duties have been appropriately assigned besides several improvising steps that have been taken before the invigilation duties are released to the invigilators, there are still many requests to change the invigilation duties. About 8% of invigilators reported through examination post-mortem meetings and verbal reports to the Examination Unit that they were unhappy with invigilation duties assigned (HEA, 2019). In a few cases, some invigilators cannot invigilate due to emergency issues such as the need to attend important meetings, an appointment with doctors and critical personal matters. Furthermore, the invigilators complained about the cumbersome process of exchanging the invigilation duties among invigilators since it involves too many bureaucracies, in which the invigilators must manually find someone and mutually agree to exchange the invigilation before getting approval from the officer.

Hence, to overcome the long process of exchanging the invigilation duties, a survey of users' requirements was conducted using the Design Thinking (DT) methods focusing on the empathise phase. Many researchers used the System Development Life Cycle (SDLC) as the common method in gathering the users' requirements or functional requirements during the Analysis phase; nevertheless, this study believed that the Design Thinking methods will assist to identify the users' requirements from different angles of users' perspectives. Determination of user's requirement or functional requirement is very crucial, hence should be confirmed and approved before the system can be developed or implemented (Maguire & Bevan, 2002).

Generally, the organisation of this paper starts by introducing and explaining the main objective of the project. Next, the related projects or systems that implemented the Design Thinking (DT) methods are explained in further detail. The following section presents the methodology, which concentrates on the Design Thinking (DT) phases and tools for data collection. The subsequent section explains the data analysis and correlates with the discussion of the project findings. Finally, the overall conclusion is presented in the final section.

**Literature Review (Related Studies)**

The university timetabling or scheduling system encompasses lectures and tutorials or laboratories classes and the final examination timetable for each course. Preparing a university timetable either for classes or examination requires a lot of data such as the list of classrooms or venues, the subject or courses, the total number of enrolments for each course, the list of academic staff, invigilators, administrative staff and other related data including the maximum loading for each academic staff, contact hours for each course per week and the nature of a course (Gaspero et al., 2003). Preparation of final examination schedules at the education institution especially the tertiary education level requires a lot of complicated and unstructured hard and soft constraints (Carter & Laporte, 1997). The experts have introduced and initiated a few popular techniques of scheduling algorithms to handle complex constraints such as mathematical modelling (Sagir & Ozturk, 2010), constructive heuristic approach (Kahar & Kendall, 2010), particle swarm-based hyper-heuristic approach (Ahmed et al., 2011), bender's partitioning (Sarin et al., 2010) and graph colouring framework (Mohamed et al., 2013).

Imperial College in London has implemented the Lexis Examination Invigilation Management Systems for centralised virtual invigilation (Wyer & Eisenbach, 2001). The conventional invigilation process needs a lot of invigilators to invigilate the students in the examination halls. The system will be installed on the client's computer and acts as an invigilator. This kind of system is normally applicable whenever an online assessment is given to the students. The laboratory of the faculty will be set up by the computer technician with the system and the students have no access to the internet and any other resources for their reference during the examination. The laboratory is also equipped with closed-circuit television (CCTV) to monitor the students' activities during an examination.

The next example of a similar system was implemented at the Department of Computer Science Engineering in India (Dharshini & Sudha, 2018). The main idea of this project is to reduce the complication of assigning the examination venues and simplify the procedure of assigning the proctors for examination invigilation. The methods used for both procedures are done using the Microsoft Excel spreadsheet. Once the assigning process is distributed equally among the proctors, the data will be uploaded to the database. Nevertheless, if the proctors request to exchange the invigilation duties, it needs to be done manually by filling in the forms and get approval from the officer. The system does not provide a special platform for the proctors to perform duties exchange among them.

University of Mumbai, India, has implemented a very comprehensive Automated Examination Support System, which integrates the examination schedules, examination venues module, invigilation, examination operations and marks management module (Avinash et. Al., 2015). The systems allow the proctors or invigilators to view the invigilation duties and make the mutual exchanged of invigilation duties among invigilators. The system will do the checking of invigilation duty exchanged such as not invigilating the subject taught by the invigilator, at least two (2) days gap of invigilation before the next duties and the invigilation duties appointed based on the seniority of the invigilators either chief or assistant invigilator. These features encouraged the invigilators to perform self-exchange of invigilation duties without going through the bureaucracy steps and cultivate harmonise environment during the invigilation process.

There are several popular methodologies for system development such as System Development Life Cycle (SDLC), Prototyping methodology, System Analysis and Design Methods (SADM), Rapid Application Development (RAD) and Agile Systems Development.

Nevertheless, Steinke et al (2017) mentioned that most of the methodologies were unsuitable for gathering the requirements from the users upfront before the development starts. Therefore, the changes that should be made after developing the system based on the users' requests are quite challenging to be fulfilled as some of the requirements will affect the main objectives, scope or framework of the whole project.

Design Thinking (DT) is the new method that opens the eyes of system developers to focus on human needs (Dam & Siang, 2021). Design thinking focuses on problem-solving through the perspective of users to determine the specific user and application requirements (Shapira et al., 2017). Design Thinking concentrates on the problem-solving framework and does not emphasise the context of project execution such as SDLC or other system development methodologies.

Design thinking principles have been utilised by some of the world's most influential technology corporations such as SAP, IBM, Apple, Uber, Airbnb and Capital One for developing better products and services (Vetterli et al., 2016; Sutton & Hoyt, 2016). Design Thinking (DT) consists of five important phases known as (1) empathise, (2) define, (3) ideate, (4) prototype and (5) testing (Voltage Control, 2021). A detailed explanation regarding the data collection tools and methods of the empathise phase is discussed further in the following section.

Many successful companies are confident that Design Thinking can increase the profit or revenue growth of organisations. BURBERRY (Upadhyay, 2020) business has dropped down and disrupted since the advent of the digital era. The company has invested in the social media strategy to align with the demands of gen X and Y expectations. BURBERRY invited people to collaborate and share ideas on the design processes, comments for improvement and offers attractive rewards to boost up the sales. BURBERRY has proved that applying Design Thinking can improve the networking among the audiences or users besides creating healthy connections with giant companies.

Uber (Upadhyay, 2020) is the next example of implemented Design Thinking, which mainly focuses on the users' needs. Uber introduced the concept of cashless payment to perform the transactions straightforward to the account, thus reducing the possibilities of irresponsible actions. The consumers will be allowed to give a rating to the drivers, which will promote good behaviour and attitude between the drivers and passengers. The drivers will strive to sustain the quality of the service and consequently, it brings Uber as the best transport service.

Design Thinking is not only applied in the examination area, but it is also applicable in education 4.0 to fulfil the demands of Industrial Revolution 4.0 workforces. Design thinking enables the teachers to enhance their competency to be more creative and innovative to position the students at the centre of problem-solving (Noh & Karim, 2021). The students' skills cannot be developed if the educators do not have sufficient knowledge and experience. Hence, educators need to change their teaching approaches to Design Thinking, which is pertinent to the 21<sup>st</sup>-century teaching and learning framework and meet the current market needs (Jamaludin et al., 2020).

Bank of America (Namdarian, 2017) is another example that implemented Design Thinking in their company. They were looking for a way to increase the use of their savings accounts by customers. Bank of America applied the design thinking methodology and started engaging with customers and uncovered that people like the idea of saving more than the actual amount they save. For example, customers would get the same good feeling if they deposited \$50 a month compared to \$600 at the end of the year. Bank of America developed

the round of concept, a product that allows customers to save with every transaction that they make. Customers, as a result, can get that same good feeling after every transaction. The results were staggering with Bank of America gaining over 10 million new customers and \$1.8 billion in saving for them.

GE Healthcare (Janssen, 2016) is a subsidiary of American multinational conglomerate General Electric incorporated in New York and headquartered in Chicago, Illinois. GE Healthcare is a manufacturer and distributor of diagnostic imaging agents and radiopharmaceuticals for imaging modalities used in medical imaging procedures. Having an MRI Scan is generally not a pleasant experience for adults, let alone children. Children often struggle to stay still during the process (often crying) given the frightening experience. The Chief Designer of GE Healthcare Machines (Namdarian, 2017) was shocked by this and felt that something had to change. By applying Design Thinking, he decided to observe children going through the scanner while also having conversations with not just children but doctors and educators. Through the conversations and observations, he found that rather than being seen as an elegant piece of technology, the MRI Scanner was seen as a scary machine by young children. The MRI Scanner was then made to look like a pirate ship and transformed the traumatic experience into a kid's adventure story where the patient had the starring role. Before the transformation, approximately 80% of children needed to be sedated prior the getting their scan and after the change, this dropped to 10%. The MRI Scanner had transformed from a terrifying experience to a creative journey for children.

Netflix is an American top media service and the original programming production company. It offers subscription-based video on demand from a library of films and television series, 40% of which is Netflix original programming produced in-house. According to Forbes (Mayka, 2014), back in 2001, Netflix founder, Reed Hastings, spent \$10 million a year on streaming technology research. This fact alone shows how customer-centric Netflix has been from its very beginning. Netflix implemented design thinking to four rules. The four rules are to think big, start small, fail quality and scale fast. Netflix was not afraid to destroy its existing successful DVD delivery business and follow technological advancement. The company did not rush headlong into the implementation of a new product but waited for the right moment and early streaming attempts were abandoned. Netflix has been able to grow rapidly by moving to its original content. Netflix's design thinking goes beyond digital design. It covers the entire process of user interaction with the system. Making the customers a top priority and continually thinking about what would be better for them helped Netflix not only reshape the video rental industry but also allowed Netflix to become an essential part of how to relax correctly.

### **Methods of Data Collection**

Design Thinking is a problem-solving methodology that takes a solution-oriented approach. Understanding the human needs involved, re-framing the problem in human-centric ways, developing numerous ideas in brainstorming sessions and taking a hands-on approach in prototyping and testing are all highly beneficial in solving complicated challenges that are ill-defined or unknown. Regarding the interchange of examination monitoring systems, this study attempts to understand the issues experienced by users and potential users.

Empathy is the first stage in design thinking since it is a skill that helps us understand and share the experiences of others (Rusul, 2015). Empathy allows us to put ourselves in the

shoes of others and connect with how they may be feeling about their problems, circumstances, or situations.

Thirty respondents consisting of lecturers and academic administration staff were selected to be interviewed through phone calls. Respondents were potential users and current users. The telephone interview method was chosen to avoid face-to-face interviews to curb the spread of the Covid-19 virus and comply with SOPs from the National Security Council (NSC). Figure 1 below shows the framework to generate interview questions (Dasho, 2017).

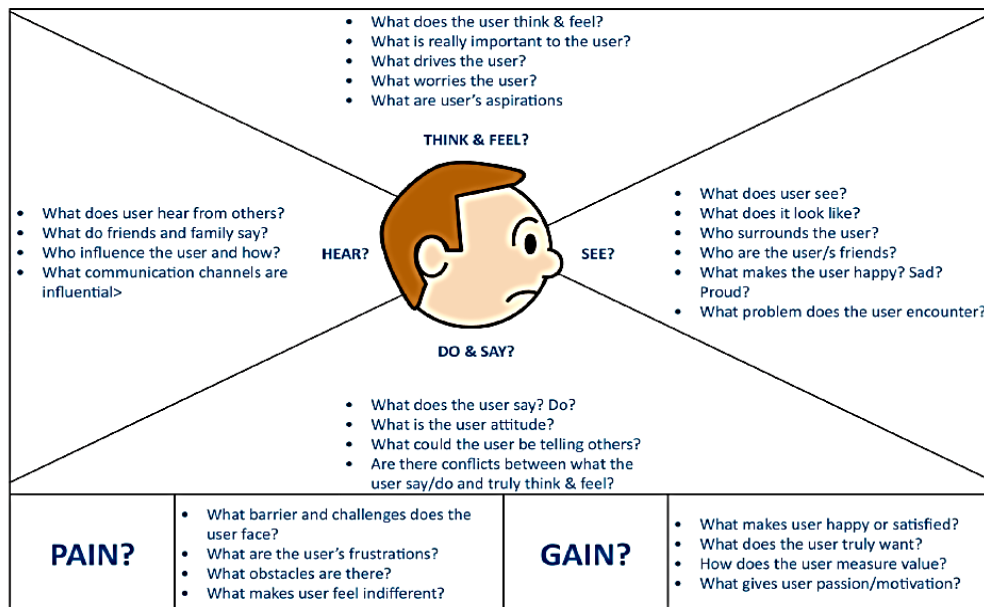


Figure 1: Generate Interview Questions

The questions focused around the consumers' perspectives on 'What do you think and feel about the application of exchange of supervision?', 'How do you see the application of exchange of supervision?', 'What is the problem you often heard about the process in exchange of supervision application?', 'What would you say and do to overcome problems in exchange of supervision application?', 'What are your dreams for a more effective application of surveillance exchange?' and 'What matter should be avoided so that application process of exchange supervision can be done more effectively?'

From the empathy map, users think and feel stressed to find a replacement invigilator, less familiar with the available invigilators, no replacement willing to replace and feeling lazy to fill out the forms provided given the lengthy procedures to go through.

On the side of what they see, users believe that the process of changing invigilators takes a long time, difficult to find administrative staff when dealing with them and that there is an issue with administrative staff carelessness, in which the form may be lost in storage or missed after it has been filed. From what they heard, applications for change of examination invigilators can only be made during office hours, the procedure is long and tedious, and administrative staff are anxious due to the amount of work they must perform on top of the real task. However, the person who wants to replace the invigilator is not interested in doing so.

Instead of that, users felt that they had to perform the work themselves, rather than relying on administrative staff. They had to locate a new invigilator and acquiesce to the situation.

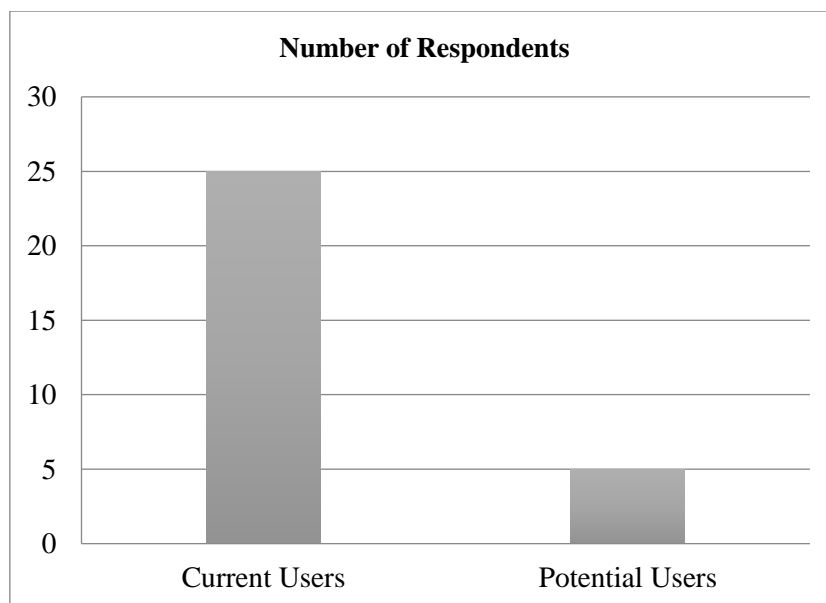
Other situations also include a slow-processing application form or one that might be dropped due to carelessness or one in which late approval is taken. Another issue is when there is no one in the office to deal with, or when the administrative staff is being very fussy. Every user wishes for a user-friendly supervision exchange application that can be completed online and displays a list of on-duty supervisors as well as integrated supervision information, making the task of selecting a replacement supervisor simple. Finally, it is hoped that this exchange procedure will be accomplished quickly and that it will be possible to do so anywhere at any time.

House of Quality (HOQ) is one of the matrices of an iterative process called Quality Function Deployment (QFD). It is the nerve centre that drives the entire QFD process. The House of Quality Matrix is the most recognised and widely used tool for new product design. It translates customer requirements based on marketing research and benchmarking data into an appropriate number of engineering targets to be met by a new product design (Praveen, 2013). HOQ has been widely used in industries in Japan and America like Toyota, Ford, AT&T, ITT and other renowned industries in various fields like Automobiles, Electronics and Integrated Circuits.

In this paper, the design thinking process was used to establish consumers' requirements and interests. This phase makes it easier to apply for a change of supervision in a short period. The goal is to guarantee that the examinations are conducted following the established monitoring schedule. As a result, it could become a pioneer in the Examination Invigilation Management System.

### **Result and Discussion**

The Design Thinking Method is used to determine the users' requirements in developing a system known as Examination Invigilation Management Systems (ExIMS). The empathise phase in the Design Thinking method is used to determine the characteristics of the audience for which the product is intended through comprehensive observations, interviews, or surveys (Steinke et al., 2017). In this project, interviews were conducted using phone calls on 30 selected respondents involved in the process of exchange of examination invigilators.



**Figure 2: Number of respondents involves in phone call interview**

Figure 2 shows the number of respondents involved during the interview by phone call. Among the respondents, there were 25 current users and 5 potential users. Current users were examination invigilators involved in the process of exchange of examination invigilators. They consisted of academic staff, administrative staff and outsiders, while potential users consisted of administrative staff who manage the examination system. The numbers of current users were more than the potential users since current users are involved directly in the process of exchange of examination invigilators compared to the potential users.

Based on the phone call interviews conducted, the behaviours of the current users and potential users were presented on a behavioural map as shown in Figure 3. From the behavioural map, the behaviours of the users were categorised into six categories namely think and feel, see, say and do, hear, pain and gain. Figure 3 below shows the behavioural map that presents all the feedback received from the users by phone call interviews categorised into six categories.



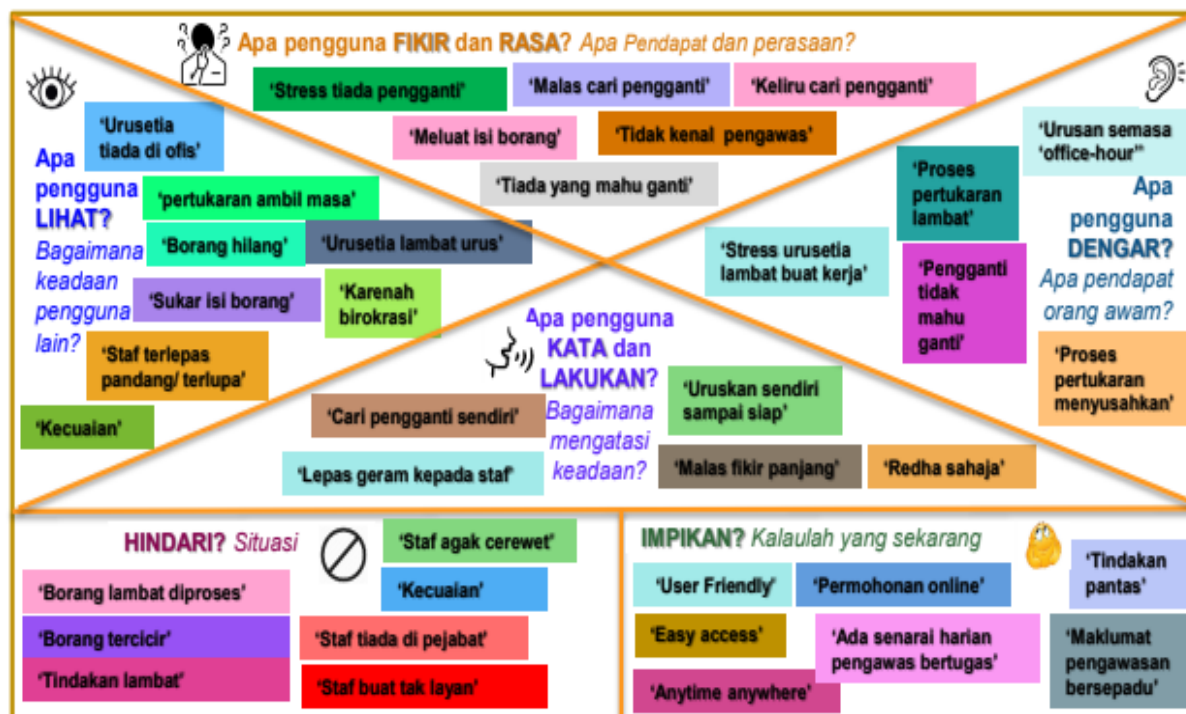


Figure 3: Behavioural map of the feedback received from users

Based on the behavioural map, analysis was done and the result demonstrated six main behaviours selected from all categories as the most popular issues faced by the invigilators during the change of invigilation duty. As listed in the behavioural map in Figure 3 above, the most popular behaviours are exchanging process takes time, bureaucracy issues, difficult to fill out the form, slow action by administrative staff, difficult to find replacement invigilator and business during working hours only. All these behaviours were chosen as the problems faced by respondents during the process of changing the invigilators for the examination.

Then, the analysis for each category based on six main behaviours was done and presented below. Figure 4 shows the analysis of the respondents' behaviours from the See category.

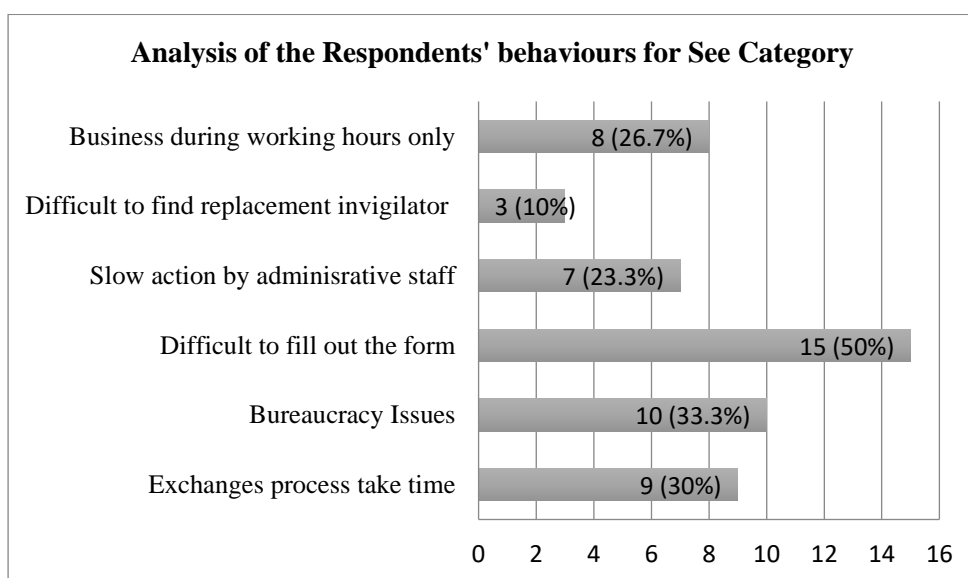


Figure 4: Analysis of the respondents' behaviours for See category

Based on Figure 4 above, 15 respondents (50%) stated that the behaviour of “difficult to fill out the form” was the most popular behaviour for the See category. Respondents saw that filling out the form is difficult since it takes a long time and they need to submit the form manually. “Issue of bureaucracy” showed the percentage of 33.3% followed by behaviour of “exchanges process take time” with 30%, “business during working hours” only (26.7%) and “slow action by administrative staff” (23.3%). Only 10% of the respondents mentioned “difficult to find replacement invigilator” as the less popular behaviour in this category.

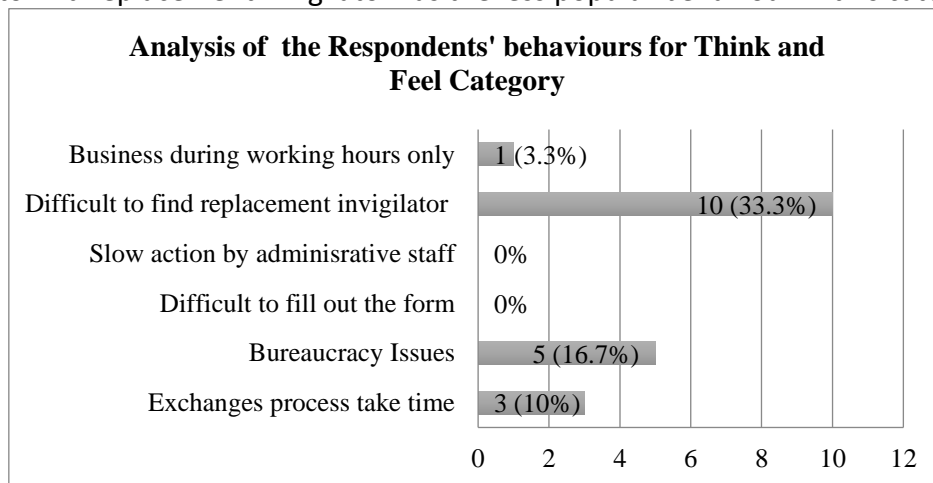


Figure 5: Analysis of the respondents' behaviours for the Think and Feel category

Figure 5 shows the percentage between all 6 behaviours for the Think and Feel category where the highest percentage was 33.3% for behaviour “difficult to find the replacement invigilator”, followed by the percentages of 16.7%, 10% and 3.3% for behaviours of “issue of bureaucracy”, “exchange process takes time”, and “business during working hours only” respectively. No respondent stated, “slow action by administrative staff” and “difficult to find out the form” as the behaviour that caused problems in the Think and Feel category. For this category, respondents think and feel that it is hard for them to find someone that can replace the invigilation according to the desired time manually since they have to send email to all invigilators and wait for their response before they can change the invigilation date.

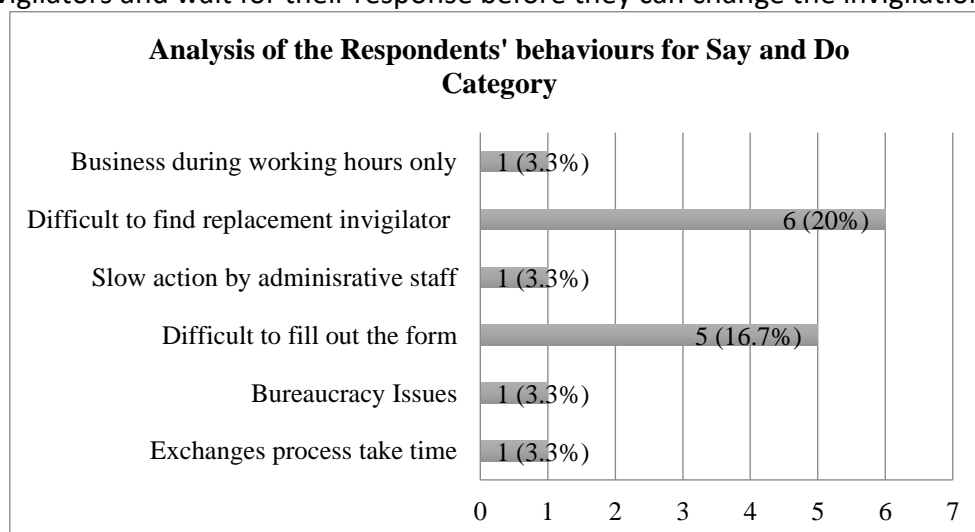


Figure 6: Analysis of the respondents' behaviours for the Say and Do category

Figure 6 above shows the analysis of the respondents' behaviours from the Say and Do category. In Figure 6, 20% of the respondents stated the behaviour of "difficult to find replacement invigilators" as the most common behaviour in the Say and Do category. This was followed by the behaviour of "difficult to fill out the form" (16.7%) and other behaviours indicating the percentage of 3.3% each.

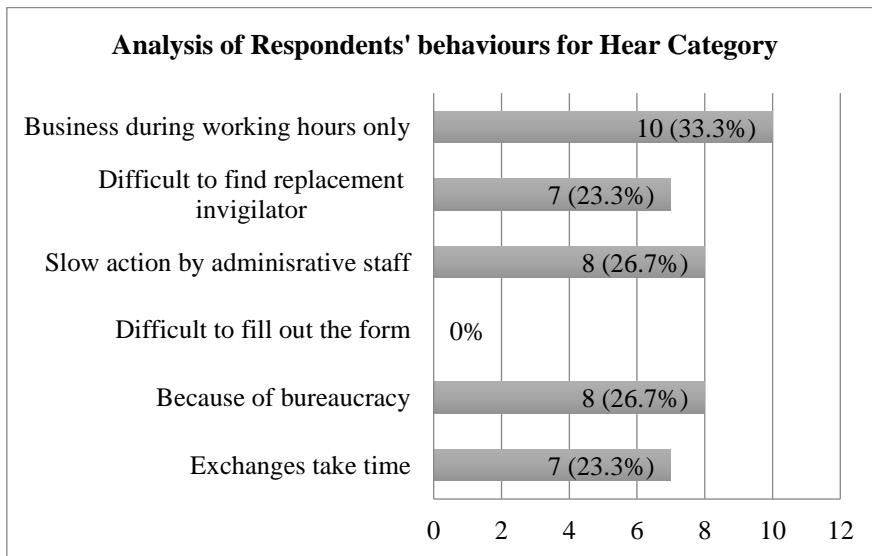


Figure 7: Analysis of the respondents' behaviours for the Hear category

Figure 7 illustrates the analysis of the respondents' behaviours from the Hear category. Based on Figure 7, 33.3% of the respondents stated "business during working hours only" as the most popular behaviour during the process of exchanging the invigilator in the Hear category. Since some of the invigilators are lecturers, they are facing problems submitting the form manually during office hours (8 am-5 pm) due to constraints including classes and research. Other behaviours such as "difficult to find the replacement invigilator", "slow action by administrative staff", "issue of bureaucracy", and "exchange process takes time" showed a percentage between 23%-27%. No respondent chose the behaviour of "difficult to fill out the form" as the problem in the exchange of invigilators under this category.

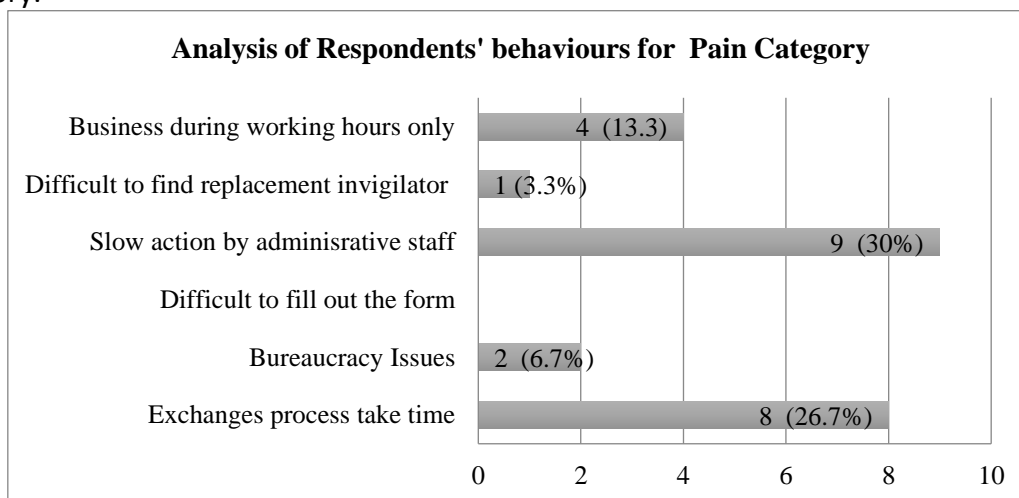
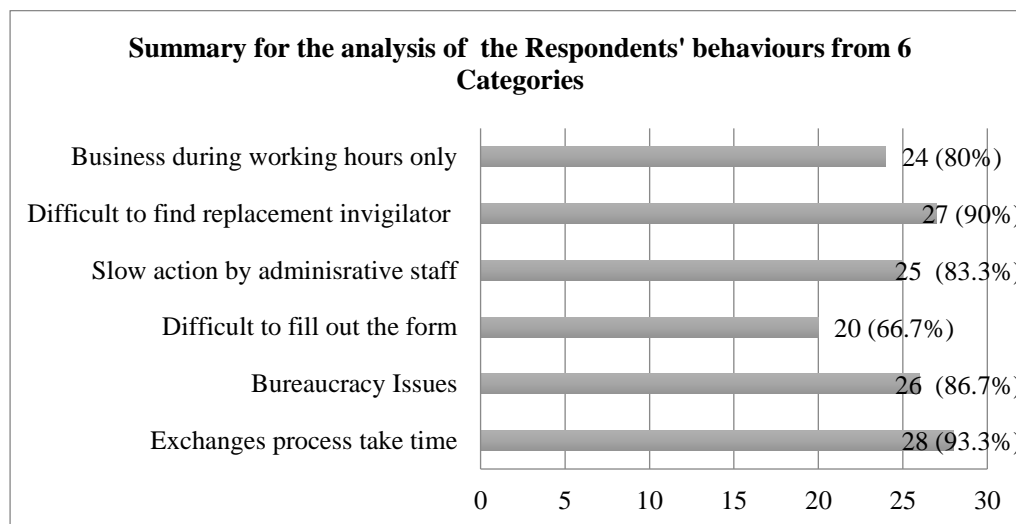


Figure 8: Analysis of respondent behaviour for the Pain category

Figure 8 above shows the analysis of the respondents' behaviours from the Pain category. Based on the result, nine respondents (30%) selected "slow action by administrative staff" as the biggest issue under the Pain category. This was followed by "exchange process takes time" (26.7%), "business during working hours only" (13.3%), "bureaucracy issues" (6.7%) and "difficult to find replacement invigilator" (3.3%). No respondents selected "difficult to fill out the form" as their problem under this category.



**Figure 9: Summary for the analysis of the Respondents' behaviours from 6 Categories**

Figure 9 represents the summary for the analysis of respondents from six categories as stated above. Overall, respondents stated that the problem of "exchanges process takes time" (93.3%) was the most critical in all six categories. This is because this problem involves both users, which are current and potential users. All users from the See, Think and Feel, Hear, Pain, Gain, Say and Do categories agreed that this behaviour gives a big impact on the smoothness of the examination operations since a lot of time is wasted during the manual process. The behaviour of "difficult to fill out the form" (66.7%) showed the lowest response compared to other behaviours since it is not a big issue to fulfil the users' requirement in a process of exchanging the examination invigilation. Therefore, a faster and efficient web-based system was developed named Examination Invigilation Management System (ExIMS) to facilitate the process of exchanging invigilators.

The main goal of this study was to determine the users' requirements using the Design Thinking Method through empathise phase. Based on the results shown in Figure 2 to Figure 9 above, it is clear that the level of users' satisfaction will increase after the implementation of ExIMS. The use of a behavioural map in empathise stage gives a positive effect on users' feedback analysis. It is because the use of a behavioural map in the early stages of the design thinking process enables examination teams to enter users' minds so that the problems can be seen from users' perspectives before creating any solutions to satisfy their needs. The behavioural map helped in many aspects, mainly in organising the information collected and understanding the users (Campese et al., 2018).

The level of users' satisfaction with ExIMS was very high. Based on the users' feedback analysis in Figure 10 below, 99.1% of respondents gave positive feedback as the system was easy to use and the process was faster compared to the manual process. Besides, 100% of respondents agreed that ExIMS takes only 1 day to complete the process for exchange of examination invigilators and fulfil the invigilator needs.



**Figure 10: Analysis of Users' Feedback**

Generally, if this project is not carried out, it will give a negative impact in terms of time, quality and image of the examination unit. ExIMS does not require any extra software to be installed on users' computers and would work on any computer platform. It would be accessible and usable by anyone with a computer and a web browser. ExIMS has increased the level of users' satisfaction that allowed all examination operations to run smoothly besides resolving all problems that arise more systematically.

### Conclusion

Based on the findings, this research has proven that the determination of users' requirements using the Design Thinking (DT) approach is very effective. Responses from the users since the implementation of Examination Invigilation Management Systems (ExIMS) showed that the level of users' satisfaction has increased and the complaints regarding the examination duties exchanged among invigilators have dropped abruptly. Identifying the users' requirements is the core or fundamental for the success of any system development. Failure to meet the users' requirements will lead to the failure of system implementation.

Developers are encouraged to apply the new Design Thinking (DT) approach, which focuses on the empathise phase by applying the tools of the empathy map. Improvement on the system is continuous; hence, the same approach can be applied repeatedly to improve the system performance gradually until the system reaches the ultimate satisfaction among the users. Exposure to Design Thinking (DT) may improve creativity and innovative application systems to fulfil the users' requirements and hence produce the most outstanding and marketable products.

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