

# Development of documentation system using cloud computing for clinical clerkship

## ORIGINAL ARTICLE BY

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## ABSTRACT

### OBJECTIVE

To develop a documentation system for clinical clerkship using cloud computing.

### METHODS

This study was conducted using the design thinking process. There were five steps in this process; analyze the needs, define the problems, generating ideas, implement the prototypes, and test the complete system. The impacts of the developed documentation system on the needs in clinical clerkship were evaluated at the initial phase (in 2014) and the maintenance phase (in 2019).

### RESULTS

The documentation system was developed using cloud computing comprising three components; online documents, real-time collaborated feedback systems, and remote repository. After implementation, the majority of sixth-year pharmacy students perceived the benefits of the cloud documentation system on cost-saving of paper, feasibility, and experiential learning in clerkship rotations. All students relied on the cloud documentation system and recommended this system to others.

### CONCLUSION

With the design thinking process approach and using cloud computing services, the developed documentation system can benefit cost-saving, and foster efficient information clerkship management during clerkship based on ubiquitous and enlighten experiential learning. To scale up this system, technology acceptance should be evaluated.

## INTRODUCTION

The Basel Statements on the future of hospital pharmacy practices have been revised and released by the International Pharmaceutical Federation (FIP) since 2015.<sup>1</sup> Hospital pharmacists take responsibility for many aspects including procurement, preparation and delivery, monitoring medication used, training, and conducting research that promotes patient safety. Pharmacy student training is also one of the Basel Statements of hospital pharmacy practices. Undergraduate pharmacy curricula should include hospital-relevant contents and experiences of hospital pharmacy practice.<sup>2</sup>

All pharmacy students involved in medication use processes must be able to demonstrate the competency in their clerkships. The augmentation of their quality assignment is a great increase in paperwork, additionally, a system of documentation should be done in any clerkships.<sup>3,4</sup> Therefore, good documentation should be an essential part to ensure the standards of practice are met. Facing huge documents, time-consuming, and delayed response, however, are the main problems for pharmacy students. Similarly, pharmacy educators from both hospitals and universities may have time constraints on giving feedback and on tracing students back to their activities.

Cloud computing is a technology design and a model that provides convenient, ubiquitous, and on-demand network access to a shared pool of services, applications, storages, and resources.<sup>5</sup> National Institute of Standards and Technology (NIST) defines, three service models of cloud computing including Software as a Service (SaaS),

Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).<sup>5</sup> Based on network technology, SaaS is an application delivery model that enables users to utilize a software solution over cloud computing. As a result, the user can use such applications without downloading and installation their computer. These characteristics of SaaS can reduce the cost of hardware and software development, maintenance, and operations.<sup>6,7</sup>

During a decade, cloud computing has been shown as a milestone and challenged to achievement in medical and nonmedical informatics development.<sup>8-14</sup> Regarding cloud computing, users can access shared resources directly through the internet, from anywhere at any time by using any devices, and without any technical or physical concerns.

Surprisingly, despite cloud computing is a much more efficient and cost-effective way to deal with information management, it is rarely used for clinical clerkships in Thailand. The reasons or problems with this point are unknown. To adopt cloud computing effectively, real and complex problems should be defined. Design thinking has emerged as a solution-based approach and has been utilized to develop better products and services which are related not only to technology but also to medical education.<sup>15-21</sup>

As a consequence, the Meta-data of Information Drilled Access System (MIDAS), a SaaS-based application has been designed, developed, and implemented. In our knowledge, MIDAS is the first project designed for Thai pharmacy students who have been trained and pharmacists who have supervised, coached, and evaluated such performance of those. This article has shown the design thinking process of MIDAS development.

## METHODS

### STUDY DESIGN

This study has been conducted using the Design Thinking model, since January 2013.<sup>15,20-21</sup> There are five stages in the Design Thinking methods including empathizing, defining, ideating, prototyping, and testing. Empathizing is the first stage to understand the collaborators and their needs deeply. Defining is the second stage to analyze, synthesize, and re-frame the problem in a human-centered manner. Ideating, the third stage, is to identify new solutions by creating many ideas in brainstorming sessions. The fourth stage, Prototyping, is an experimental phase to identify the best possible solution for each of the problems identified and then maybe shared and tested within the research team. Testing is the final stage to alter and refine to rule out problem solutions and derive an understanding of the application and its users.

### PARTICIPANTS AND STUDY SITES

The main collaborators consisted of hospital pharmacists, pharmacy students, and faculty members. The study site was mainly conducted in a regional and medical teaching hospital, Khon Kaen Hospital (KKH), where the pharmacy students were trained. At the initial stage, there were two universities involved in this study including Khon Kaen University (KKU) and Mahasarakham University (MSU). Additionally, during the testing phase, other universities also participated including Ubonratchathani University, Chulalongkorn University, Silpakorn University, Siam University, and Burapha University.

Hospital pharmacists who responsible for pharmacy students' training, preceptors, and those provided pharmacy services in ambulatory care settings, inpatient care settings, or drug information service settings were eligible for participating in the present study. Faculty members from each university e.g., pharmacy educators and student service coordinators were also included. Faculty members who were responsible for the administration of clerkship training were also eligible. Eligible pharmacy students were sixth-year pharmacy students. To empathize with their insightful experiences and motivations, those students who had been trained at KKH were selected.

### DATA COLLECTION

Data collection was performed with face-to-face interviews and brainstorming to evaluate their problems and needs. The first author observed and engaged with each collaborator and the data also were collected from these approaches. The findings from the first stage to the third stage were used for creating the solution-based approach using cloud computing as a SaaS model. For the fourth and fifth stages, the application was implemented and the findings generated during these stages were used to discuss the most recent problems. The application was developed and tested periodically as a cycle from 2014 to 2019. Variables regarding the users including technology experiences, perception of application, usefulness, and obstacles were gathered through online feedback forms. The perceptions of application, in the aspects related to needs assessment, were compared among trained students in the year 2014 with those in 2019.

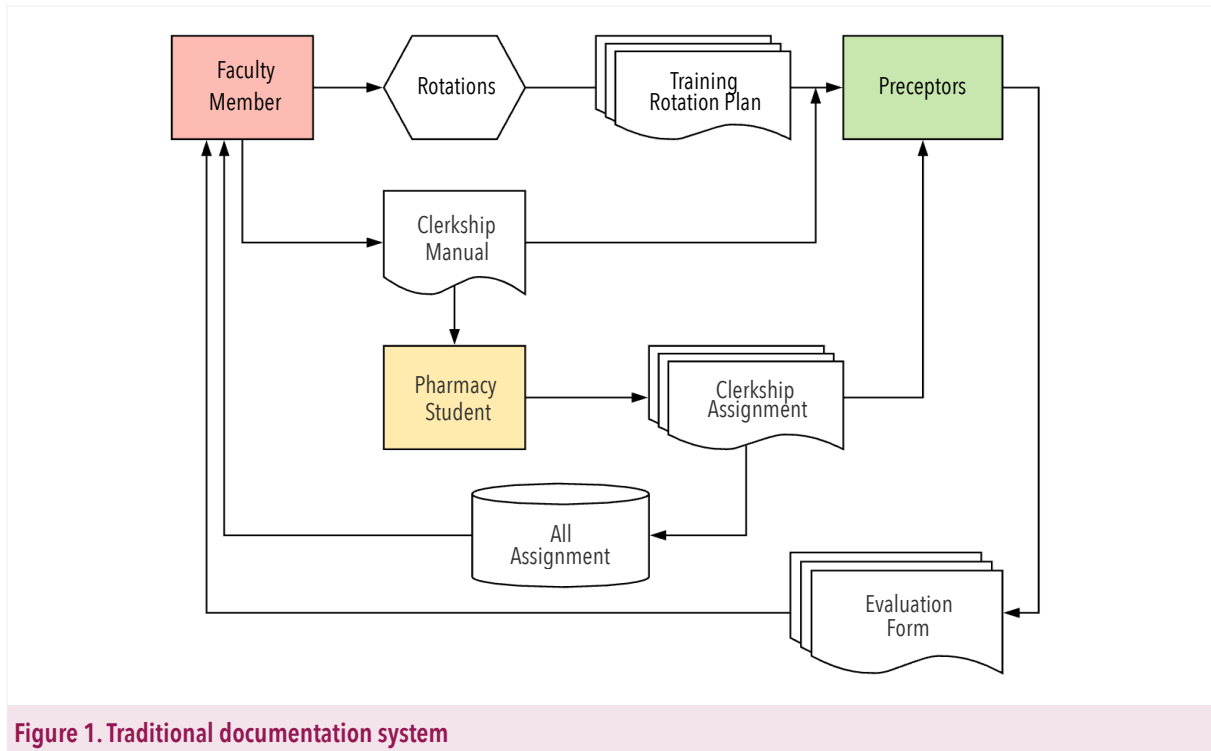


Figure 1. Traditional documentation system

### STATISTICAL ANALYSIS

The quantitative data were analyzed using descriptive statistics. Regarding gathered information during each stage, qualitative data were analyzed and synthesized the main issues not only to create a problem statement but also to rule out problem solutions.

## RESULTS

### INTRODUCTION OF THE FRAMEWORK

At the initial stage, three preceptors from KKH and six faculty members from KKH and MSU were interviewed. Regarding activities in clinical clerkship, six pharmacy students from both universities were also interviewed and observed. In terms of a rule of six, each sixth-year pharmacy student has to be trained at least six rotations

which last for six weeks per rotation. In brief, all students have to be trained in three core clerkships (outpatient care, inpatient care, and community pharmacy) and another three elective clerkships i.e., drug information services (DIS), adverse event monitoring (AEM), chemotherapy preparation, or specific ambulatory care clinics.

The traditional documentation system began with the faculty sent the documents related to the clinical clerkship training rotation plan and guide book for training as hardcopy to the preceptors and pharmacy students. The preceptors sent the evaluation form back to the faculty and the pharmacy students also sent the clerkship assignment back to the faculty (Figure 1). The training rotation plan consisted of students' names in each rotation and their clerkships. Pharmaceutical Care Clerkship Manual (PCCM) has

**Table 1. Needs and insights of collaborators**

Collaborators	Needs	Insights
Pharmacy students	To use less than 2 copies of each assignment and no paper waste	They did not want to duplicate more copies for a presentation that was used only a few hours and then thrown away. It was important to save the earth.
	To receive teacher's feedback in their assignment during training in the rotation	They receive feedback after finished the rotation. Some feedback was very useful, however, they could not improve themselves because they were rotated to other clerkships.
	To secure all their documents	Most of them found malware on their computers and then they lost all the files. In some cases, they forgot to save files
Preceptors	To search for students' document and access to those within 5 minutes	They kept all documents as hardcopy and it took more than an hour to look for the document that they wanted. Sometimes, they could not find and forget all them.
	To evaluate students' assignment efficiently	Some students responded to the assignment late and might have plagiarism which is difficult to identify.
Faculty members	To calculate each student's score accurately and efficiently	All student's written scores were transcribed into the spreadsheet. There were over 100 forms per each rotation. Those forms were sent back from many hospitals at different times. They had to wait for gathering and then doubly entered the scores.

been provided as a guide book for training pharmacy students by The Pharmacy Education Consortium of Thailand (PECT). The PCCM also included the templates of activity logbook and evaluation forms (both attitude and performance). Each template is much more different, depends on prespecified clerkship. All preceptors duplicated those templates for all pharmacy students based on their clerkships. After each rotation completed, not only students have to prepare a huge document following PCCM, but preceptors also provide a lot of evaluation form and send them back to the university.

Regarding brainstorm among each group of collaborators, their problems and needs

concerned with clinical clerkship are presented in Table 1. There were three main needs that to be the points of view; cost-effective system management, efficient repository, and real-time response. To ideate the problem solutions, the questions were used during brainstorm as following; "How might we reduce the document use, so pharmacy students could reduce their cost?"; "How might we keep the important documents that we can access anywhere, at any time, with access control?"; and "How might we increase learning from immediate feedback?". Afterward, many solutions offered by collaborators included document scanning, keeping documents in CD or flash drives, scoring in the spreadsheet, and reuse one-sided paper.

Those approaches were, however able to solve some needs and the rest important needs were still unsolved. Cloud computing was considered as another solution-based approach, due to its characteristics including efficient, flexible, scalable, and reliable. These could be explained that all documents are stored in a cloud that can be reached through an internet connection. Everyone can access those documents by using a computer or smartphone. The maximum usage of resources has the potential to multiply productivity with a minimal incremental cost. Automated changes with the tracking back system can be solved. As a consequence, the best way to either solve a problem or provide the elements required to overcome emerged from cloud computing. Therefore, we carried out a model using cloud computing to be the prototype of these solutions. The service model that we chose was SaaS. In addition, the public cloud as Google Cloud was chosen to deploy.

### **MIDAS**

The security, an issue of great importance, is the primary concern in using cloud applications. All collaborators have to be mentioned as the following: authentication, authorization, confidentiality, and integrity. Regarding the basis for access control to the cloud application, preceptors and pharmacy students were granted permission to access the application after identifying themselves as a genuine member–Authentication. All collaborators were permitted to access specific resources differently based on their roles–Authorization. Confidentiality denotes the assurance that all documents in the application are

kept secret and private and we disclosed such documents to only authorized users. Only authorized persons are permitted to create, change, and delete the document–Integrity. The Meta-data of Information Drilled Access System (MIDAS) has been designed to achieve our needs using Google application, which is an efficient tool. To follow the rule of security, all collaborators must identify themselves to access the cloud application. Therefore, all collaborators must have such a Google account as an official Gmail to identify themselves. The MIDAS composed three components, as the following: (i) online documents, (ii) real-time collaborated feedback system, and (iii) remote repository.

### ***Online documents***

The first component, the online documents consisting of a set of activity logs, case reports or SOAP notes, evaluation forms, and other online documents for pharmacy students stored in Google Drive. There were many folders in a drive. One folder was created for one rotation of one pharmacy student. Each folder contained five parts including two spreadsheet files and three folders. First, learning resources were listed in the online spreadsheet, namely Table of Content (Table 2). Pharmacy students could gain access to the link of any learning resources. Second, the students were required to do the assignments which are listed in the spreadsheet, namely Summary Activities. Third, this part was a folder of Task. The students were required to keep all assignments in this folder. Fourth, this folder included an online form and an online spreadsheet related to Activity Log. Fifth, the last folder was related to the evaluation.

**Table 2. Infrastructure based on cloud computing**

Folder	Pharmacy student	Hospital pharmacist	Academic staff
Student folder	View	View	View
Activity logs	Edit & View	Comment	View
Job assignment (Task)	Edit	Edit	Comment
Evaluation Form	Inaccessible	Edit	View
Learning Resources	View	Edit	View
Official documents	Inaccessible	View	View
Student profile	Inaccessible	View	View
Student registration	Inaccessible	View	View
Control room	Inaccessible	View	View

The individual folder, as described earlier, has been shared with an individual student. Such pharmacy students were able to access all their shared documents except two folders including the activity log and the evaluation. Their documents which are the job assignments can be edited but those which are the learning resources can be viewed only. All students' folders have been shared with preceptors who are their supervisors. Preceptors were able to access all documents related to their clerkships, however, they were able to edit only the documents of their trainees or those who were assigned. For the faculty, they were able to only view all shared documents related to their students. Nonetheless, faculty members can also request to participate to comment on the job assignment of their students.

Regarding the evaluation, the online evaluation forms stored in the folder of each

student and all evaluation forms have been listed in and linked to the folder of Control Room (Table 2). Preceptors were able to access and edit only their evaluation form of their assigned student. The faculty was able to view all online evaluation forms of their students but not to edit. An online evaluation form comprises the formulas that summarize and make the grade immediately when such preceptors provide scores of each issue. Therefore, those final scores have to be confirmed and then faculty members will use those scores for summative evaluation. To reassure that those scores must not change, the access level of all collaborators will be changed to view only. If they need to change the scores after the score confirmation, they have to provide a reasonable written request for the correction to the administrative team and authorized faculty member.

***Real-time collaborated feedback system***

Those online documents was able to easily worked on the MIDAS. Files in the MIDAS mostly match up to the format of documents, spreadsheets, and slides, according to Google application. Any updates were automatically saved and stored in Drive. Subsequently, all users was able to have the latest version of those files. Therefore, this advantage was the second component of MIDAS. A real-time collaborated feedback system provide a new style of feedback. The students were able to send their assignments to preceptors earlier than the traditional system. Both preceptors and the faculty were able to give feedback collaboratively. Then, the system sent a notification note to the shared group simultaneously. Pharmacy students also got online notifications of those comments and they were able to respond to each comment as soon as possible. After each response occurs, the system also sent the notification to the shared group as a cycle. Furthermore, students were able to work in the documents with their peers at the same time and were able to share valuable comments from their supervisor. Two-way commenting with the notification was able to reduce the gap of time lag or delayed response and, particularly, enhance student learning. On top of this, we were able to work offline and then those changes are immediately updated once online was available.

***Remote repository***

The need for document storage management was the last component of the MIDAS. The metadata was aggregated and managed in a central location

in Google Drive of the administration of the team. Regarding this remote repository, all files and folders were decided who can get access to such files or folders. The collaborators were granted to edit, view, or just add comments as individual persons or groups. All files were able to manage from anywhere on any device and at any time. Although we created the new files in the shared folder, we kept those private until we decided to share them. Interestingly, this component provides a powerful search, for any file, which reflects the security models of the MIDAS. That means the collaborators only see search results for documents they have access to.

**IMPLEMENTATION OF MIDAS**

We evaluated the capability of implementing the application and learning environments at the end of 2013. We found that the most pharmacy students lacked of experience in using Google application, although they used other online applications frequently. Moreover, some students did not have neither their computer nor smartphone. Regarding the education approach, the number of internet access points in KKH was limited. The conference room was small, and the office equipment had only a whiteboard and an LCD projector.

To implement the MIDAS effectively, therefore, the internet access points were installed. Any wireless devices were adapted to suit the system. The conference room was renovated, expanded, and upgraded (such as Digital TV), to enhance cloud-based learning. Besides, preceptors at KKH and faculty members were planned

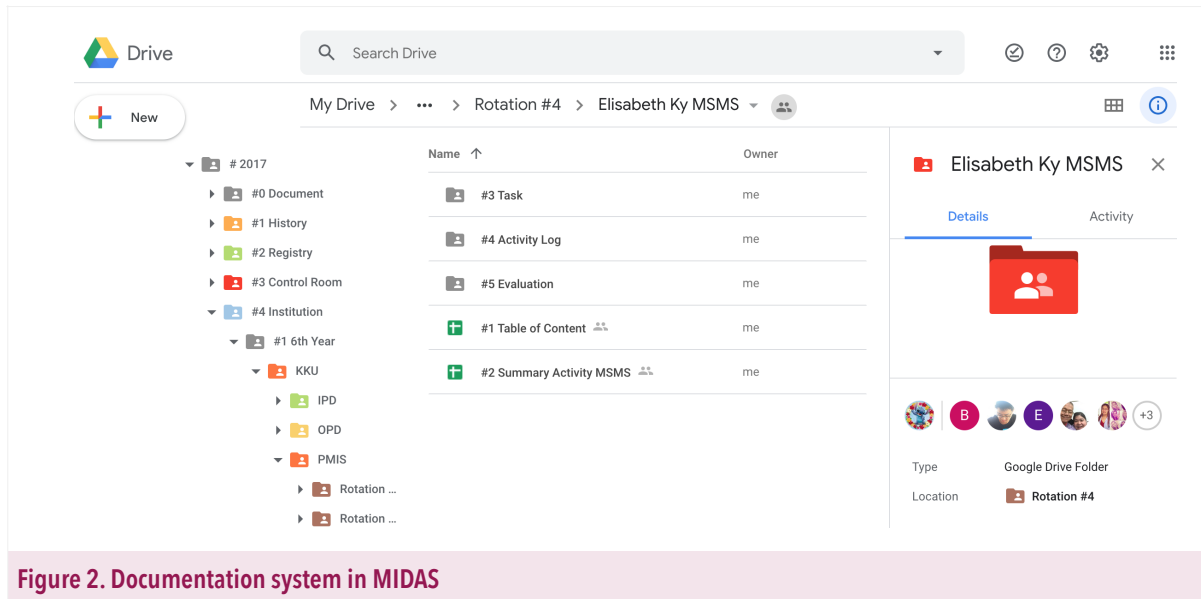


Figure 2. Documentation system in MIDAS

together to provide computer reserves for the students who have a computer problem. In terms of competency, all students who applied for training at KKH should be trained to use the MIDAS. The training program was scheduled for three hours at their universities (KKU and MSU) before starting the clerkship.

MIDAS training program consisted of three main components, including what was the MIDAS, how to manage the online documents, and how to enhanced learning with MIDAS. The first session described the advantages and disadvantages of the traditional system compared with MIDAS. The second session showed how to create, share, delete, upload, download, and set the permission of the documents using Google application. The third session presented how to notify their supervisor proof their assignments and how to respond to the notification as two-way comments. MIDAS has been launched since January 2014. Seventy-five pharmacy students applied for

training during this year. There were 147 clerkship rotations. The number of students was higher than expected, and those were from five universities (KKU, MSU, and other-three universities). The administrative team, preceptors, and the faculty discussed a strategy for creating a positive learning experience of MIDAS to their students. Therefore, we decided to provide the orientation and training program for MIDAS on the first day at the training site. The training program was rescheduled for three hours and integrated into a comprehensive orientation on the first day of each rotation.

When students arrived at the practice site on the first day of each rotation, the orientation and training program was provided to them. After the training program completed, all students were invited to create their Gmail to identify themselves. They also applied for the permission of internet access at the practice site. Later, each student was shared their folders and assessed their readiness to access the shared documents (Figure 2).

There were many core activities in each rotation. First, students had to record their activity daily. Regarding the new system, they filled the online form of activity log instead of writing on the paper. They can check their logs on the website immediately after submitting and they can also see other logs from their peers. Second, students had to provide services based on their clerkship and they were required to document their case reports or other assignments in all clinical clerkships. Third, students were also required to provide both journal club activity and academic education in all clerkships. Pharmacy students kept all files including case reports, slide presentations, and other assignments in the shared folder of MIDAS. During implementing MIDAS, some students unintentionally removed their important files from the shared drive and it might be very frustrating to lose them all. Hence, to prevent these events and to ensure the recovery of their files, they had to make the administrative team the owner of the new documents that they created. This approach has also provided the benefits of storage all files as long as the main team needed. After they completed their 6-week rotations, they had to send all documents back to the faculty. We found that some students still printed all documents as hard copy or downloaded their folder and burned those to a CD or DVD to their faculty members.

### **IMPACT OF MIDAS**

In June 2014, six months after MIDAS implementation, forty pharmacy students were trained and sixty-four rotations were provided. A follow-up anonymous, voluntary, online survey was conducted and sent to all students via email. The

survey was to measure how the pharmacy students were using MIDAS in clinical practice, and other assignments, as well as to examine their perceptions of MIDAS and their attitudes towards the impact of cloud computing through MIDAS on their workflow. This survey was developed according to the needs and insights from the collaborators involved in the initial phase. We also obtained feedback on additional needs.

Thirty-six pharmacy students (90%) responded to the follow-up survey. All respondents owned and used a computer at the time of using MIDAS. Only one respondent (3%) had no smartphone whereas only four students (11%) had an iPad or Tablet. Twenty-five respondents (69%) were unfamiliar with Google applications prior to MIDAS implementation. Over half (55%) had been trained and used MIDAS for one clerkship rotation, whereas the rest had been trained and used MIDAS for more than two rotations. Regarding Google applications, all respondents used MIDAS most frequently related to Google Drive (94%), Documents (81%), Slides (67%), and Sheets (39%).

Five approaches to MIDAS were assessed in terms of the relationship between students and preceptors, cost-saving, feasibility, experiential learning, and trustworthiness (Figure 3). Most respondents (92%) agreed that MIDAS helped them communicate to their preceptors frequently and increased relationships between preceptors and them. In terms of cost-saving, almost all respondents (97%) agreed that MIDAS can make a big saving of paper use. Ninety-two percent reported a decrease in other resources (i.e., ink, toner, and carbon), whereas 17% perceived the problem of the cost related to wifi access. Nearly

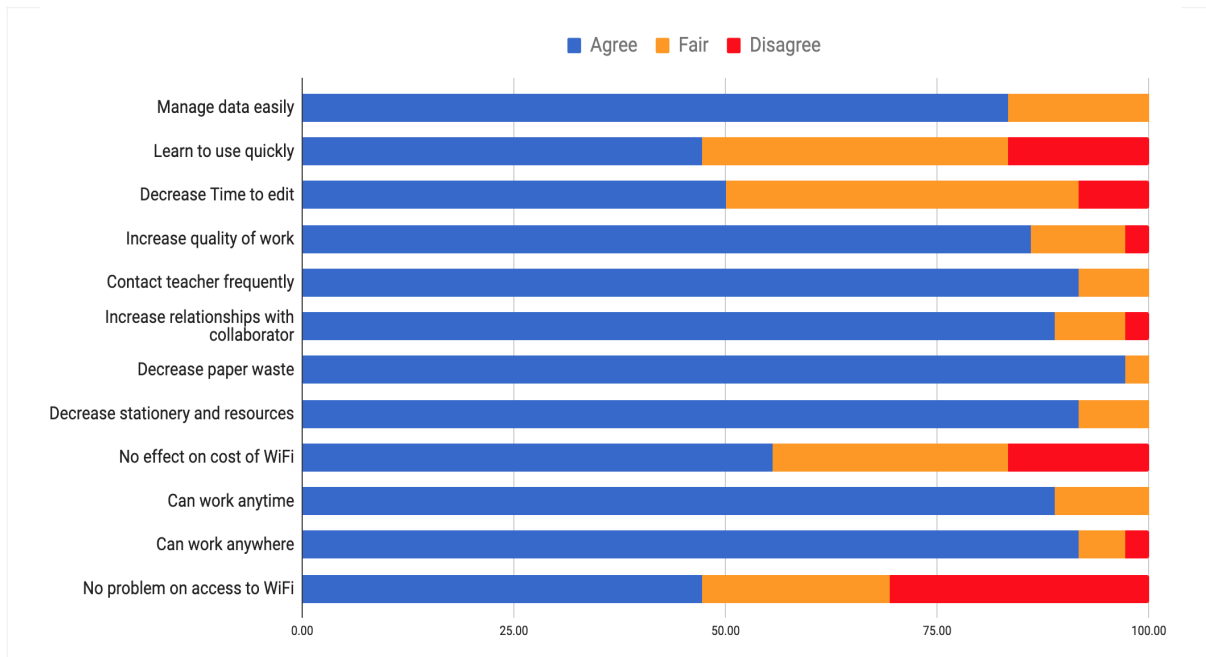


Figure 3. The percentages of perception of MIDAS in 2014

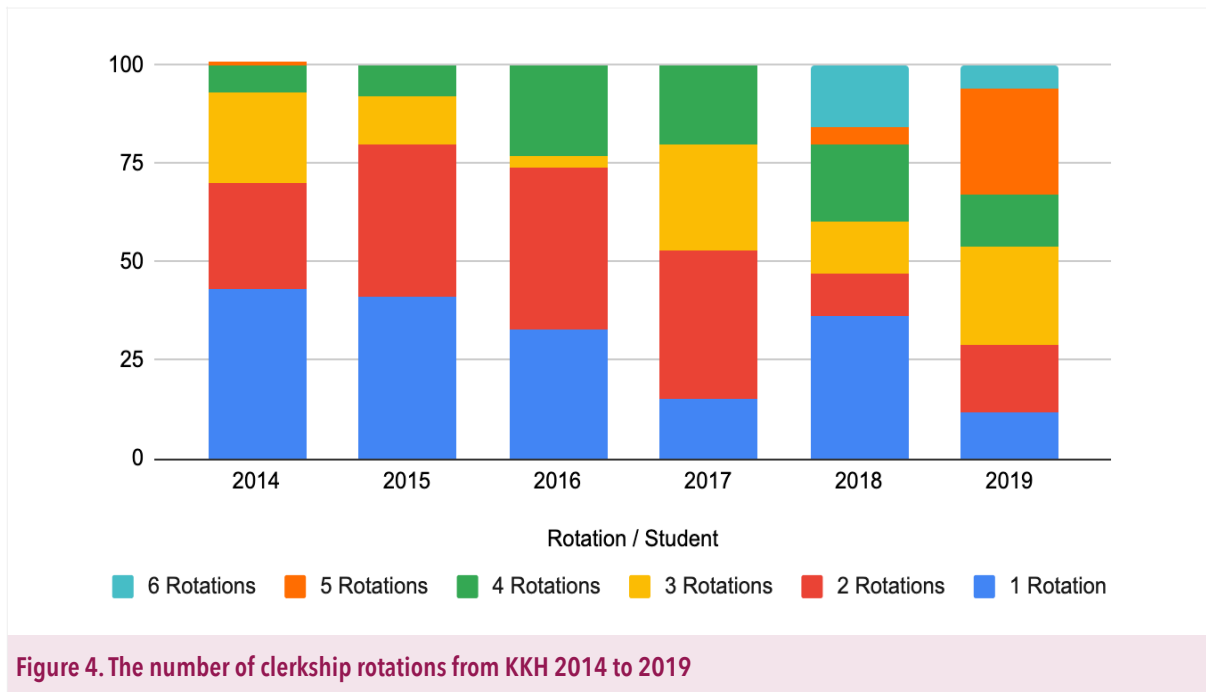
90% reported that it was feasible to access MIDAS anywhere and at any time.

Regarding experiential learnings, most respondents indicated that MIDAS increased their learning with 2-way comments and they can manage documents efficiently (69% and 83%, respectively). Over half (56%) agreed that MIDAS was beneficial not only to clerkships but also to other activities. The majority (86%) indicated that MIDAS was a trustworthy application. Most respondents perceived that autosave, quick search, collaborative work, and paperless were major advantages of MIDAS. In contrast, they mentioned font formatting in MIDAS as a big disadvantage because they were unfamiliar with limited Thai font and preferred such available traditional fonts. However, 92% reported that they recommended MIDAS to their peers and preceptors in other practice sites.

### MIDAS AND SUSTAINABLE SOLUTIONS

In December 2014, after one year implementation MIDAS, the advantages and disadvantages presented to all collaborators and were discussed. Other issues had been also adjusted to manage according to the cloud computing system. Faculty members agreed with preceptors about providing online documents instead of paperwork and agreed with pharmacy students about using cloud storage documentation instead of burning a CD or DVD. Training program for MIDAS has been widely acknowledged, by all collaborators, as one of the beneficial tools for clerkship rotations.

Later clerkship rotations had started in March 2015 and ended in March 2016. There were 90 trained pharmacy students in a total of 168 clerkship rotations. Over 40% were trained only one rotation at KKH and another 40% were trained two rotations at this site. Figure 4 shows that the



**Figure 4. The number of clerkship rotations from KKH 2014 to 2019**

proportion of those trained more than 4 rotations was higher in the year 2016 and 2017, whereas the number of total students was nearly the same (61 vs 60, respectively). Students who were trained at KKH more than 2 rotations reported that they were familiar with and preferred to use MIDAS, compared to the traditional system at other practice sites. On the contrary, those trained only one rotation indicated that they consumed a lot of time to learn to use MIDAS, however, they still perceived the benefits of MIDAS on cost-saving, experiential learning, and efficient documentation system.

For sixth-year students trained in the year of 2018, the Pharmacy Council of Thailand had announced a change in core clerkship rotations which added a new core clerkship related to medication safety management.<sup>22,23</sup> All pharmacy students who intended to be clinical pharmacists had to be trained with three core clerkships in the hospital. These clerkships included

ambulatory clerkship, acute care clerkship, and a new one, a medication safety management system (MSMS). Many students realized that consecutive hospital clerkship rotations in one practice site provided the most benefit to them. The explanation of a long-lasting rotation was that they would be familiar with the practice site and healthcare team and they were able to manage their time wisely to accomplish their enormous tasks. Therefore, most students tended to apply for training in one hospital at least 3 rotations rather than in different practice sites.

Figure 4 presents the percentages of pharmacy students from 2014 to 2019, based on the number of trained rotation. As mentioned earlier, the percentages of those trained more than three rotations at KKH increased dramatically from 20% in 2017 to 53% in 2018 and 71% in 2019. The number of students who applied to be trained at KKH in 2019 was higher than the number of those

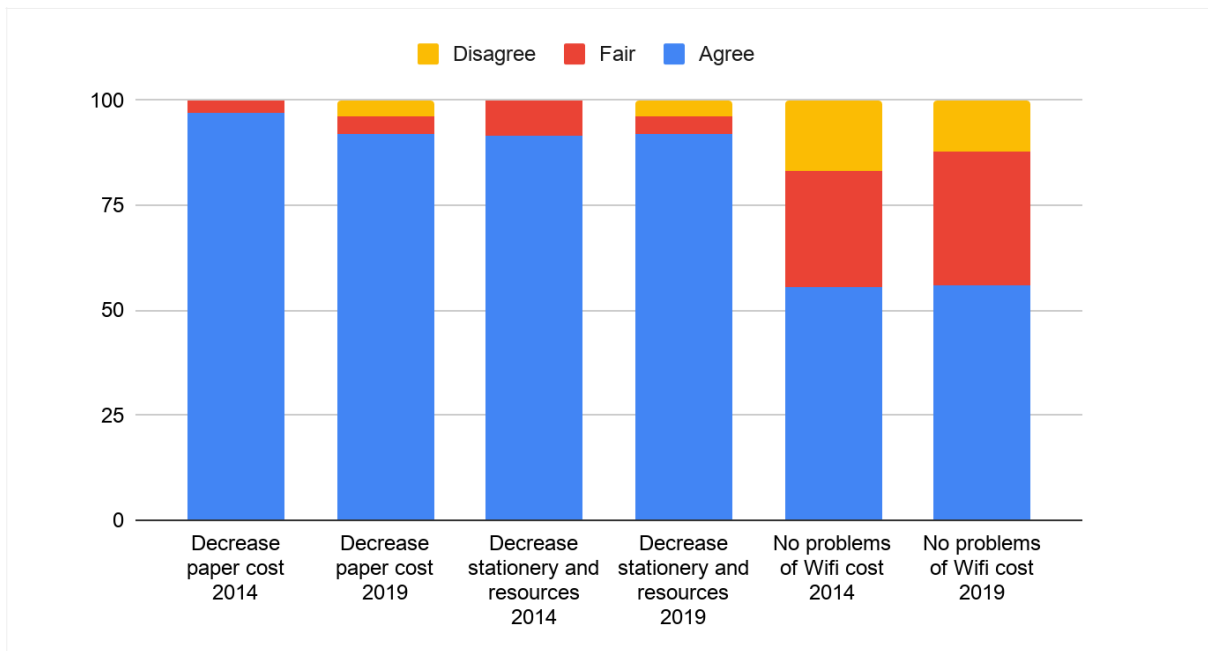


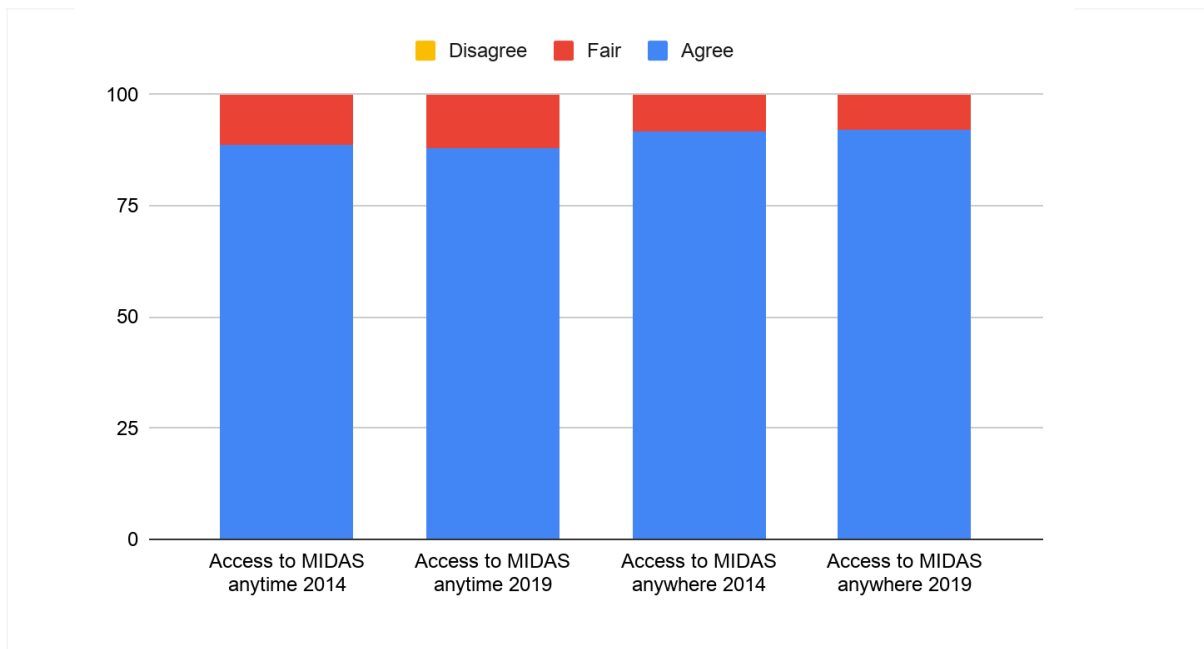
Figure 5. The perceptions of the cost related to MIDAS between 2014 and 2019

in previous years (52 students vs 45 students) and the number of all rotations was also substantially higher (179 rotations vs 132 rotations). On top of this, the students that applied to be trained for more than four consecutive clerkship rotations at KKH also increased from 20% in 2018 to 33% in 2019.

During five years of MIDAS implementation, new communications and computing technology have emerged rapidly and offered more choices to pharmacy students and preceptors. The new environment has also expanded the need to consider not only how to address students' need smarter, but also how to capture value from providing innovations, particularly MIDAS. Therefore, an online survey was also conducted to evaluate how pharmacy students, in the year 2019, perceive MIDAS as a valuable application for their clerkship. This survey included similar issues to the previous survey in 2014.

Twenty-five pharmacy students (74%) who were trained at KKH in 2019 provided their voluntary and anonymous responses to the survey. All respondents had their own computers and smartphones. There was a higher percentage of having an iPad or tablet among students trained in 2019, compared with those in 2014 (82% vs 11%;  $P < 0.001$ ). Only one-fourth of respondents indicated that they usually used the computer for education whereas others preferred to use either iPad or tablet (41%) or smartphone (33%). Experiencing with google application prior to MIDAS was significantly higher among trained students in 2019, compared with those trained in 2014 (80% vs 28%;  $P < 0.001$ ). In addition, the perception of easily use of MIDAS in 2019 was significantly higher than in 2014 (80% vs 47%;  $P = 0.039$ ).

Approach to cost related to MIDAS, almost respondents both in 2014 and 2019 perceived the



**Figure 6. The perception of feasibility related to MIDAS between 2014 and 2019**

benefits of MIDAS on cost reduction of paper (97% vs 92%), and stationery and other resources (93% vs 92%), as shown in Figure 5. The percentage of respondents who rated wifi cost as a problem in 2019 was higher than those in 2014 (18% vs 12%). In the viewpoints of access to MIDAS, all respondents accepted that it was more feasible to use MIDAS at any time and from anywhere (Figure 6). There were no differences in the percentages of having strong positive perceptions between trained students in 2014 and those in 2019 (92% vs 92%).

Figure 7 shows the perceptions of experiential learning from MIDAS compared to trained students in 2019 to those in 2014. The percentage of respondents who strongly agreed on increasing learning by 2-way comments, which was a specific feature of MIDAS, was increased from 70% in 2014 to 92% in 2019 ( $P=0.116$ ). Similarly, an increase in the percentage of those who responded to the benefit of MIDAS to efficient

documentation was also found in 2019 (from 83% to 96%). The percentage of respondents in 2019 who applied MIDAS to other activities was significantly higher than that of those in 2014 (96% vs 56%,  $P=0.002$ ). Regarding the learning environment, the percentage of respondents who reported a problem with computer use was similar between 2014 and 2019 (17% vs 16%). Those who trained in 2019 reported a problem with internet access lower than those trained in 2014 (12% vs 31%).

In 2019, 72% indicated that they easily and frequently communicated with their preceptors and 64% had a high relationship with them. These were significantly lower than the perceptions of those who trained in 2014 (92% in 2014,  $P=0.046$  and 92% in 2014,  $P=0.01$ , respectively). In terms of the trustworthiness of MIDAS, 100% of respondents in 2019 relied on MIDAS to manage their clerkship and strongly recommended MIDAS

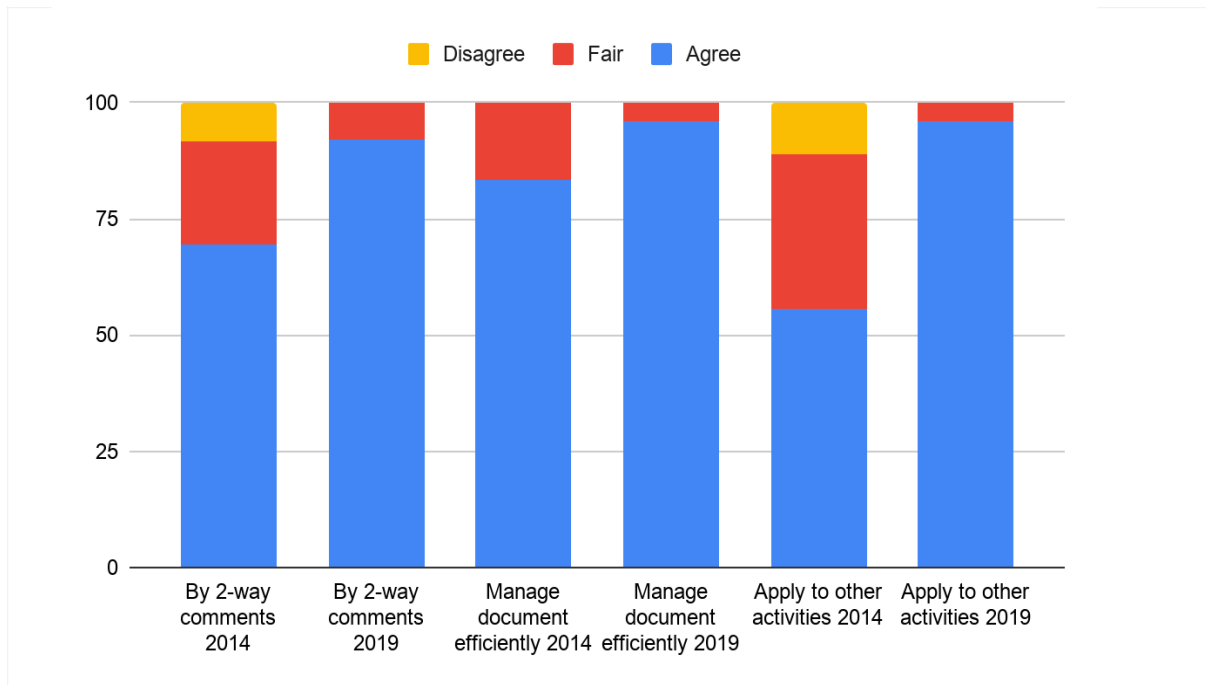


Figure 7. The perception of experiential learning related to MIDAS between 2014 and 2019

to their friends and other preceptors, compared to those in 2014 (86% and 92%, respectively). They indicated that they appreciated MIDAS for its organization's easiness, 2-way communication, ubiquitous learning, and efficient team collaboration.

## DISCUSSION

Half a decade, cloud computing in clinical clerkship was a reasonably new phenomenon in Thailand. The important step was to perform a needs assessment before any implementation, particularly new technology. We utilized the five-step of the design thinking process to provide a solution-based approach.<sup>15,16</sup> The collaborators in pharmacy training indicated that cost-effective system management, efficient repository, and real-time response were the main needs to improve the

documentation system. Our results reveal that the initiated online application, MIDAS, had achieved cloud computing characteristics including efficient, flexible, scalable, and reliable. MIDAS provided the benefits of cost-saving on paper and other resources, experiential learning with 2-way comments, and efficient organization. To our knowledge, MIDAS is the first and last-long application for pharmacy clinical clerkship in a hospital setting.

The majority of students in 2014 were new to cloud applications like Google. Some students disappointed the format and font of paperwork since they were already satisfied with their established approach. However, they were substantially interested in the benefits of MIDAS on cost-saving and ubiquitous learning. These points were able to overcome a fashion presentation and empowered them to take the time needed to learn

how to use MIDAS. In contrast, the young generations, nowadays, perceive more benefits of cloud computing on paperless and benefits of using the iPad or Tablet technology for recording their notes digitally with handwriting on the screen.<sup>24</sup> This advantage enhances their learning and they overwhelm a combination of electronic and paper notes. Hence, trained students in 2019 rated that it was worth using MIDAS in their clerkships.

There were significant differences in the perceptions of preceptor-student relationships between those in 2014 and 2019. One explanation of such higher relationships in 2014 is that the students had no more choice of the ways to communicate with their preceptors rather than face-to-face. E-mail and simultaneous 2-way comments, at that time, were the best choices for them to contact preceptors any time and take a fruitful source of information. Effective communication between preceptors and students can provide the most important element for success in student learning. Therefore, using MIDAS provided the opportunity to share and learn from each other without time constraints. In contrast, preceptors have been using other efficient mobile applications (i.e., Facebook messenger, LINE application) to ease their communication with the students and their peers since 2015. Nevertheless, students still benefit from an online discussion with 2-way comments in MIDAS.

Using mobile and iPad or tablet technology has been rapidly increasing in the young generations, as mentioned earlier. Many previous studies in medical education showed that these technologies resulted in increased productivity and learning challenges in the

classroom and experiential settings.<sup>25-28</sup> Moreover, there are several key factors contributed to technology acceptance. Students who spent a minimum of 3 rotations (18 weeks) enabled them to readily adapt to new technology<sup>4</sup> and their positive attitude toward using technology is the most important factor supporting continuance intention to use cloud services.<sup>29</sup> In the same manner, preceptors and faculty members who adopt these technologies and integrate them in class or students' assignments would also empower their students to be proficient in learning.<sup>30</sup>

In this study, there were several limitations. First, MIDAS was implemented only one practice site. As different characteristics of preceptors could affect several aspects of MIDAS, future studies should be done on the concept of the technology acceptance model (TAM). Second, brainstorming at the initial stage was conducted with only two universities, whereas some trained students were from other universities. Nonetheless, the design thinking process allowed us to reanalyzed the problems and develop the solutions continuously as a cycle. Third, the training program for MIDAS use was served only for students. Limited training was provided to preceptors and faculty members. This may have influenced MIDAS usage, however, MIDAS was easy to use in the role of preceptors and faculty members. In a recent decade, new technology and devices have been developed and innovated rapidly, and lifestyles change of our students should be considered. In 2018, positive challenges emerged that pen-friendly application was launched to integrate with iPad or tablet technology and the Thai students can own them at a reasonable price. Consequently, the

majority of students use this technology frequently in their education. The strength of this study is that there were significant different characteristics of students in 2014 and 2019. The former, low proficient in technology, were done before high efficient devices were released and compared to the latter who were familiar with cloud computing. Our findings show that MIDAS has continued to be a robust tool in spite of generational differences. In the future, we will continue to evaluate the impacts of global change affecting MIDAS.

In summary, all collaborators participated in solving the clerkship documentation system using the design thinking process. Their needs including cost-saving, efficient documentation, and well organized were solved by using cloud computing applications, as MIDAS. MIDAS also encouraged pharmacy students to manage their clerkship efficiently and enlighten them about experiential learning in other aspects. Technology acceptance should be evaluated to scale up MIDAS use.

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