

A Comprehensive Study and Development of Unified Mobile-Based Admission System for GCC Universities

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Abstract: The Gulf Cooperation Council (GCC) region has experienced tremendous growth in the higher education sector with many public but internationally recognized universities, colleges, and programs. Annually, within and outside of the GCC zone, high school students and guardians undergo repeatable and time-consuming experiences for inhomogeneous university, college, and program admission and tracking processes. This research project aims to provide a unified management tool to manage the admission and tracking process to multiple accredited GCC universities, colleges, and programs through one unified central mobile-based application. The research project aimed to achieve two objectives: exploring the GCC university admission process phenomena and developing and evaluating a unified mobile-based university admission application (denoted by HEIM) for higher education institutes' mobile applications. An Agile-SDLC methodology was employed, entailing two phases; the Exploratory phase to the phenomena of the university admission process and the development and evaluation phase of the potential mobile application. The 1st phase was based on an interview with the Ministry of Education (MOE), employing SLR and CA techniques for articles and mobile applications collection and analysis, and 1st questionnaire to collect user requirements. The 2nd phase employed several design techniques, including DFD, ERD, etc., a 2nd questionnaire to collect system requirements and coding by .NET MAUI, C#, and XAML, and a 3rd questionnaire to evaluate the usability of HEIM based on Nielsen heuristics at which the empirical findings revealed 97.7% of usability.

Keywords: Development; Evaluation; GCC; Mobile application; Unified university admission.

1. Introduction

Amongst public universities in the USA, Europe, Africa, and Asia, the GCC universities witness an increasing number of high school students/guardians applying for admission acceptance of their choices. However, students/guardians must undergo repeatable procedures and the time-consuming process of several offline/online admission applications to several universities, colleges, and programs. This is all attributed to the variances of educational systems' requirements that comply with the higher educational councils (HEC) of each region from one side [1]-[9] to variances of the online admission software systems and features [10]-[12].

Over the years, the information systems (IS) discipline has hosted several literature analysis methods, including, for instance, ontological meta-analysis and synthesis, stylized facts and critical discourse analysis, systematic literature review (SLR), web content analysis (CA), interviews, and questionnaires. However, the last four techniques have gained too much attention and emphasis over the years [13]-[15] and found best suitable to this IS research type as they were utilized to explore the literature's relevant university admission process, procedures, and the currently disseminated technologies such as web and/or mobile applications surrounding the application in diverse geographical regions and particularly the GCC region. Ultimately, a comparative study is found necessary to compare and contrast between the currently available software technologies worldwide and their distinct features in multiple geographical locations [16]. Moreover, [17] believes that surveys in IS research represent the least

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costly techniques in terms of time and the most rigorous method in terms of accuracy. Therefore, an initial interview with official entities in the HEC in Bahrain along with two questionnaires of the Bahrain population [16]-[18], were found necessary to collect the most suitable user and system requirements [19] [20] and further been analyzed and incorporated with the third stage of a seven staged Agile based system development life cycle method (Agile-SDLC) [20] to design Data Flow Diagrams (DFD), entity relationship diagrams (ERD) which depict the relevant system and database architectural blueprints, and identify the process specification of the system [21] , [22] which easily facilitates the coding of a speedy, dual mobile operating systems (OS) and efficient user interface (UI) for mobile-based information systems using .NET MAUI, XAML, and C# [23] .

Student/guardian applicants to the GCC undergraduate (UG) programs must go through repeatable procedures and time-consuming process of several online admission application processes to several universities, colleges, and programs, as every university, college, or program has its own educational systems' requirements that comply with the higher educational councils (HEC) of each region from one side and every online admission software encompasses its features and limitations.

The development of a unified admission mobile-based software denoted by HEIM is introduced to provide an acceptable unified admission application by the whole GCC higher education councils (HEC) is expected to overhaul and streamline the modern online admissions process for the public GCC universities, colleges, and programs. HEIM aims to compose the GCC universities into central locus along with its beneficial implications from the perspectives of applicants and universities. To achieve this, the research project should achieve two objectives: Exploring the GCC university admission process and Developing and evaluating HEIM. These are achieved by following an agile-SDLC methodology entailing two phases: 1) the Exploratory phase of the GCC university admission process phenomena, and 2) the Development and evaluation of HEIM have been utilized. The 1st phase was based on an interview with the MOE, employing the SLR technique for collecting best-reviewing articles, CA to analyze mobile applications, and 1st questionnaire to collect user requirements. The 2nd phase utilized several design techniques, including DFD, ERD, etc., a 2nd questionnaire to collect system requirements, and coding by employing .NET MAUI, C#, and XAML. The 3rd questionnaire was employed to evaluate the usability of HEIM based on Nielsen heuristics, and the empirical findings revealed a 97.7% usability rate.

This GCC admission application software, in comparison to the ones in the USA, Canada, Europe, and India, is mostly web portals, either unified but dedicated to specific local regions as in Riyadh- KSA, unified web portal but within the same country as the one in Oman, or unified but web portal and for Kuwaiti citizens only. The mobile-based applications as the ones in the USA, Germany, or India, however, don't provide guided instructions, lack Chatbots, have no administration dates schedule, barely provide tracking of admission status, and are short of providing standard comparative calculator, comparison between universities, events discovery, and virtual tours to campus.

Throughout the HEIM development journey, the research work contributed to exploring the worldwide and GCC admission process phenomena, designing the architectural specification of the unified HEIM mobile application, constructing the HEIM to support IOS and Android platforms, and evaluating the usability based on Nielsen heuristics.

The research project at hand is composed of five sections. The literature review is introduced in Section 2, where Section 3 is directed towards the research design methodological techniques alongside Section 4, which is aimed to analyze and discuss the findings of the previously introduced techniques, and Section 6 debates the conclusion and future work.

2. Literature Review

The systematic literature review (SLR) and the web content analysis (CA) were utilized to investigate the literature-relevant university admission process and application and the currently disseminated technologies, such as web and/or mobile applications, surrounding the process in diverse geographical locations. Moreover, several admission procedures in several programs of several countries were investigated. Ultimately, the comparison study of software technology that carries out different features in multiple geographical locations was discussed.

2.1. Literature review techniques

According to [16], [24] the systematic literature review (SLR) as depicted in Table 1 is striving at constructing a holistic revision of the all-academic works of literature and artifacts as well as research papers, depicted as a process consisting of 5 major phases, particularly phase (1) which indicate the selection of the data source, phase (2) the application of search formulas, phase (3) refining the document types, phase (4) manual revisioning and excluding and lastly, phase (5) selecting highly cited academic endeavor. In essence, by leveraging the relevant keywords with the least citation equal to 1, the method resulted in a final list of scientific artifacts that were employed to deepen the theoretical and experimental aspects of the study as well as extract the distinctive and general features that will be presented at the proposed solution. On the other side, Online content analysis, or online data extraction as the name indicates, refers to applying testing methods to search and analyze digital content to extract qualitative information based on selected samples and pre-defined categories to render valuable interpretations and results [25]. For this reason, a web content analysis was approached to identify the general and distinctive features of web and mobile applications circulated by particular parameters formulated by [16].

Table 1. The SLR method and research findings

Keywords / Phases	Thematic subject	Article
Keyword 1	Central; University; Admission	106
Keyword 2	Unified; Universities admission; Process	87
Keyword 3	Universities; Central Admission; Automation	59
Keyword 4	HE; Unified Admission; Development	35
Keyword 5	Central; Higher education; Mobile development	13
Phase1: Selection of data sources data		300
Phase2: Applying searching formula data		72
Phase3: Refining the document items		65
Phase4: Manual reviewing and exclusion		52
Phase5: Selection and review of articles		46

2.2 The admission process in HEIs

2.2.1 USA, UK, Sweden, Ghana

In the USA, student applicants must first study in the schools or institutions of interest. Letters of recommendation, an essay or personal statement, personal information, academic background, SAT or ACT test results, and a completed application form are obligatory to be sent next. The admissions committee will assess the application by considering grades, extra-curricular activities, essays, letters of reference, the applicant pool's competition level, and the program specifications you're applying to [11].

In the UK, students must adhere to the process of systemizing the admission process by procedures and policies formulated by the Quality Assurance Agency (QAA), such as the "Code of Practice (Admissions to Higher Education)," at which they have multiple admission system types but all share three stages, starting with input, processing, and ending up with the output. Therefore, according to [1], the UK uses a systematic admission approach called "Type 4: Double Selection," where the selection model enables higher educational institutions in the UK to select students intensively based on two criteria. The application process follows: firstly, students must fill and submit their admission application form with all required details along with six higher educational institutions, according to [11], whereas [9] stresses that students can apply only for five different higher educational institutions. Secondly, UCAS processes the admission form and ensures all required details are available. After that, it will be automatically distributed across the selected universities, and each university remains at its liberty to accept or reject the applicant.

However, the NyA system superseded a single nationwide admissions system for undergraduate study in Sweden. The VHS (National Agency for Services to Universities and University Colleges) uses some programs. About 38 local schemes are used to admit single subjects at universities and colleges. [10] confirms the problem in this paper, which is that Sweden

has no central admission system. Hence, creating a centralized system will help because the chain is clear, the vision is well known, and it reduces costs.

Alternatively, in Ghana, the unified admission system is a central proposed web application designed for the purpose of higher education institution admissions or in other words, for university admissions in a singular place. [12] claimed that having all admissions services provided in solitary sites would enhance and accelerate the admission process as well as provide broader access to broad universities distributed across the country.

2.2.2 Gulf Cooperation Countries (GCC)

The process of admission in the Kingdom of Saudi Arabia (KSA) governmental public universities is digitalized through enhanced technologies and the integration between the governmental systems and university systems to obtain the essential applicant information through highly accurate communication channels [3]. On the other side, KSA universities employ a standard methodology to admit students to any higher educational institution by a set of mandatory planning requirements before applying to any university admission system, which illustrates that any applicant without those requirements is rejected immediately. The requirements start with a secondary school qualification, then move towards the other requirements, according to [26], there is a set of general admission models that any higher educational institution in the world employs, whether a singular model or a conjunction of models. The KSA process uses multiple admission models (MAM), which enforce the applicant at the earliest stage to obtain the secondary school qualification regarding [27], then apply the General Aptitude Test (GAT), the Academic Achievement Test (AAT), and the Standardized Test of English Proficiency (STEP) in only universities that are taught in English languages. With only those requirements, the prospective applicant is eligible to initiate the request. From an integration viewpoint, all of these details are fetched automatically into the university admission systems, in some exceptional cases, if the admission system is unable to obtain those data, the applicant is required to submit those in the system. Henceforth, according to [26], the KSA higher educational institutions utilize multiple admission models (MAM) not limited to a singular admission model, forcing the applicant to prepare academic artifacts issued from the Qiyas Center and the Ministry of Education to accomplish the admission process.

Alternatively, the admission process in the United Arab Emirates governmental universities (UAEU and ZU) uses only one method to apply to the universities, which is called the online admission system. Both universities follow the steps for admission. In addition to [28], when the admission Schedule is announced every year, students visit the university (UAEU) site the student's parents part of the teaching and administrative members, otherwise, the student will apply through the Ministry of Education (moe.ae) This targets the citizens, National service students and re-enrollment students, next go to the admission section, look for the application form and fill out the required information honestly, and then attach all the needed documents such as (photo, certificate of secondary education, passport and ID card) as identified by [29] and lastly, send your application form. Also, some majors require other documents like EMSAT and TOEFL [6]. For example, Zayed University follows the same steps for admission [30], but the difference is that admission for all students is on the university's main website. According to [31], international students' admission process will differ. In the end, [26] concludes that both universities, UAEU and ZU, follow the model "standardized aptitude tests" system, which means your acceptance at the university does not depend only on your secondary-level marks. You must take the EMSAT, which is an entrance test for university admissions in UAE, and it is necessary for admission. It assesses the student's skills and knowledge in targeted subjects.

Oman, however, has two public universities: Sultan Qaboos University and the University of Technology and Applied Science. In the context of admission, both universities use the same system. According to [7], this system aims to enable all Omani students with GEDs or comparable certifications to apply to various public HEIs, external and internal scholarships, and awards. Accepted candidates will also use the technology to finish the steps necessary to register at the HEIs. Over and above that, it connects all the universities/colleges of Oman in one place to make the admission process easier. Alternatively, [32] claims that all students have to do the foundation program because it is mandatory and will be removed in one case if you have your TOEFL or IELTS. [33] confirms that only Omani citizens or foreigners inside Oman can register through the HEAC website. Similarly, [34] states that the number of seats for non-Omani, such as GCC, is very limited. When the registration starts

[34], it shows all the available majors for students if they want to apply. Moreover, because of the application of both universities in the same system, they follow the same steps. Firstly, go to the HEAC Oman website from the search engine. Secondly, look for the register button on the main page. Next, select the study location inside Oman. After, select the degree type that you have. Then, add your civil ID and seat number. The next page will show personal information, which is filled in, and check if the provided information is correct. It will ask for other information that the applicant will fill in, such as contact numbers, email addresses, house addresses, and status. It will ask if the applicant has any disabilities. Finally, will request the applicant to fill in the father's information. Lastly, the applicant will send the admission form and the system will provide the applicant with a username and password. In addition, [26] states that the type two entrance exam is the used admission model. This proves that no one can apply to any university without the GED exam, which is mandatory for secondary students and supervised by Oman's Ministry of Education. It offers students a wide selection of disciplines.

In addition, the admission process in Kuwaiti governmental universities is segregated into two main methodologies, the digital and the traditional admission methods, by filling and submitting admission application forms and the required documents in admission centers in Kuwaiti universities [35], [36]. On the other side, both Kuwaiti governmental universities follow a standardized methodology during the application of admission using the Kuwait Universities unified admission (KUADM) by submitting the exact details once a time and saving a PDF file of the request for the purpose of student reference in future [37]. Therefore, based on [26] we can convey that Kuwaiti governmental universities at the early stages employ an admission system model coined as the "No examination" model, which mainly prioritizes secondary-level academic competency. In subsequent stages, each university, based on the admitted major assesses the student using different system types of admission such as interviews, entrance exams, or others as the discipline necessitates.

In Qatar, the process of admission to Qatar University proceeds as a composition of steps that characterize a form of hybrid methodology. Initially, the first stage of the admission process is accomplished through the digital admission system by submitting crucial personal details along with the major details of the university [38]. Secondly, according to [39], students who graduated from schools initiated in 2015 or below are settled upon two different options: using the designated email address to submit the secondary school qualification or physically attending the admission department. On the other side, in the schools that were initiated in 2016 and above, the graduates are not required to submit or send their academic qualifications because of the enhanced technology that retains the Qatar University (QU) admission system along with the Qatar Ministry of education and higher education (MOEHE) systems in a technological communicative manner. In essence, QU, at the earliest stage of admission, necessitates all students to apply the admission request through the admission system with the presented exception that only 2016-initiated school students are not required to accomplish their documents physically or through the designated submission email. In this case, with reference to [26], QU employs the "No Examination" admission system model at the earlier admission stage, then later stages are accomplished as what the university major requires, in other words, this is just to admit the student to the university not the major.

2.2.3 Unified Admission Web/Mob Applications:

This section presents the analysis tool that will be used to evaluate the available Unified University admission mobile and website applications, highlight their features, weaknesses, and strengths, and provide a comparative list against our deliberate mobile application.

As an output of the analysis study, multiple unified admission systems exist, whether in the governmental and private sectors distributed globally, with the result that no such mobile application exists in any respectful GCC country. However, according to [6], the adoption of mobile applications is increasing from the viewpoint of the elderly impacted by social networks. Therefore, to achieve the acceleration and apply the centralization concept in the field of higher educational institutions in GCC, there appears a need for a mobile application that encompasses all GCC universities' admission under the singular umbrella is a must. Table 2 corroborates essential features of mobile and web applications distributed globally within the respectful country. Herein, the web content analysis technique is employed to extract similar web or mobile applications distributed globally along with their general and specific features grouped in Table 2.

Table 2. Comparative Analysis of Previous Technologies

App_N	App_T	App_L	General Features						Specific Features								
			Provide language support	Provide registration and	Provide guided instructions	Chatbot	Contact us	Administration dates sched-	Apply for admission	Handle payment for admis-	Track admission process	Offer programs	Standard comparative calcu-	Compare universities	Find universities	View university information	Discover events
Common APP	Mob/ Web	US	X	X		X		X						X		X	
UW Journey	Mob/ Web	US	X				X	X	X			X	X	X			
OUAC	Web	CA					X	X	X	X	X						
UCAS	Web	UK	X				X		X					X		X	X
Uni-App	Mob/ Web	Ger	X		X	X		X	X		X			X	X		
DAOG	Mobile	IN					X	X	X		X		X	X			
SUI	Web	IN	X					X	X	X	X			X			
RBU	Web	SA						X	X		X	X		X			
HEAC	Web	OM	X	X			X	X	X	X	X	X					X
KUADM	Web	KW	X	X				X	X								
HEIM	Mobile	BH	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Amongst the general features, *Providing language support* allows users to select the language that is suitable for them. For the HEIM application, the available languages are Arabic and English because they are the most used languages in all GCC countries, so the user mostly knows English if not Arabic and the opposite. This depends on the user and which school the user graduated from. Some users may know both languages, but their preferences differ. The reason for multi-language support is that it will attract more users from different places with the, gain of user trust and improve readability. Also, *providing registration and login* allows the user to register in the HEIM mobile application if the user has no account or is using the mobile application for the first time. Otherwise, if the user has an account in HEIM, the application will ask about the correct username and password. When the user registers successfully, the user will have access to all the services provided by the HEIM application. Moreover, *Providing guided instruction* allows the user to get instructions about several things , starting with if it is the first time the user is using the application, so the application will provide all the required instructions for the user to know how to use it. *Chatbot* allows users to find information by answering their questions 24/7 without human intervention, while *Contact Us* allows users to contact if there is anything regarding the application like; if the user faces any technical issue, the user can't log in or register for some reason, so the user will fill a form which will ask about the name, email so they can contact the use and the problem so they can help to user in solving it.

Amongst the specific features, *Apply for Admission* requests the applicant to fill out the admission form, asks the applicant to enter all the personal information, then the academic information, and concludes with uploading all the requirements. Finally, applicants/

guardians must select the desired university and submit an admission acceptance request accordingly. However, *Handle payment for admission* requests the applicant to pay through a preferred payment method based on the specific university fee. Also, *Track Admission Progress* allows the user to track the progress after the applicant pays; this option will be available and visible. So, the applicant has an idea about where the progress has reached, whether the representative reviews it or not, whether it is accepted or rejected or pending, whether all the documents are successfully submitted or not, and so on, while *Offer programs* allow different universities to show what programs they have and the details of the program. For example, university X offers an IELTS course and the details of that, how much it will cost the applicant, the periods, and so on. These details add more value to the application and attract applicants from different fields to use the application. Moreover, the *Standard comparative calculator* allows the applicant to know the result that the applicant will get from using the calculator. Comparing universities allows applicants to know which university suits them based on the information given. Sometimes, the applicant looks for the nearest university that offers a specific major or, which one costs less, and so on. This feature makes it special. In addition, *View University information* lists all available universities, their departments, majors, how much each major costs, their regulations and policies, the requirements and their stuff, and more. This is more like general information so the user can read it, while *Discover events* allow the applicant to check out all the events that occur in a specific period. Each university will have its event and the details of the events if the applicant is interested in participating or to know about it. Alternatively, *Visiting the campus virtually* allows the applicant to visit the campus virtually for cases, the applicant can't visit the campus in person because the applicant is busy or from a different country, so this will easily allow the applicant to visit and look at the campus clearly. This feature helps prove that the HEIM application is very helpful and a time-saver for the applicant.

3. Proposed Method

3.1 The research design model

The process model chosen to develop the HEIM is a two-phased Agile-based SDLC model based on the insights of [20], including the exploratory and mobile application development phases. The model suits small, medium, and large-sized enterprises, permits quick requirements changing, generates reasonable blueprints and documentation, and delivers HEIM in a relatively shorter time [20]. The phases are further decomposed into seven stages, as depicted in Fig.1. The fundamental components of this approach include preparation of smaller project implementation iterations based on outcomes, lessons learned, and creative ideas, as well as ongoing updates to the implementation process. The two stages are completed in parallel, while other models go sequentially. The phases are finished simultaneously, as opposed to other models' sequential methodology, aiming to produce fully functional application components more quickly by breaking the process down into discrete stages known as "sprints," each with a set length and a starting list of tasks [40].

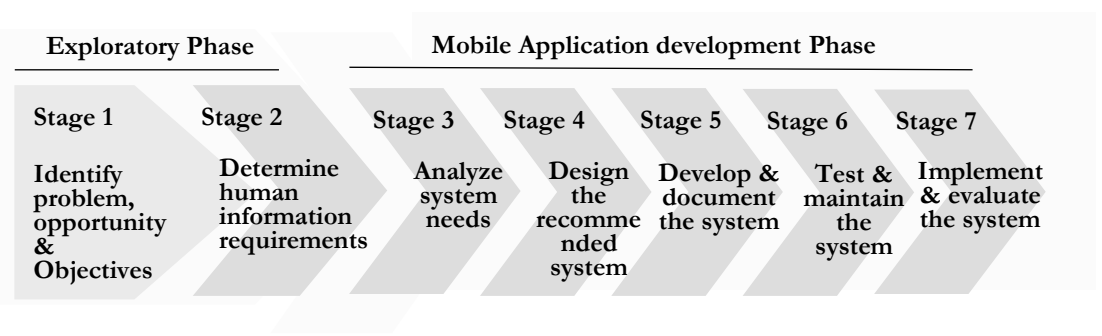


Figure 1. The Research Design Methodology Source (Source: [20])

The 1st stage affects the completion of the project. Focus on identifying the problem, specifically the centralization problem that there isn't a single web/mobile application that connects all GCC government universities, then analyze this problem and find the most suitable way to solve the problem. The team proposed a mobile application to solve problems

such as applying to more than one university simultaneously and easily finding different universities on the same platform [20]. The 2nd stage identifies human needs using electronic questionnaires, and interviewing can help. The team gathered several requirements and evaluated comparable applications in the same field to understand what needed to be added or left out and explain their perspective. The need is reported and concluded at the end of this phase [20]. The 3rd stage involves using tools, such as data flow diagrams or use case diagrams, to show how the events are processed and describe the system's structure and how it will look at the end or a proposal will be necessary to be prepared in this phase for the system, which includes data about the applicant that have been found while data retrieval, ease of use and convenience of the framework, giving a cost analysis /benefit of other options and making suggestions on what to do [20]. In the 4th stage, the information collected will be used to perform the logical information system design in this phase of the SDLC. During this phase, protocols will be established to assist users in properly entering data to access the information system. Additionally, operating a good engineering and screen or web page design, users will be prompted to complete their entry into the information system. The interface is important because it will connect the user to the system. This phase will include databases that store data that decision-makers use within the organization and design outcomes that meet needs. Additionally, this phase will include design controls and protection procedures to protect data and systems and achieve program package specifications for programmers. Each package must include input and output layouts, specification files, and processing details. It can also contain decision trees or tables, diagrams, or UML, functions, and names of all previously written code [20]. During the 5th stage, the necessary original software and effective software documentation, including process guides, will be created, with online help and frequently asked questions (FAQ) sites. The documentation phase should highlight questions that have arisen and find a solution for them.

Additionally, the purpose of the documentation is to guide the user on how to use the system and know what they should do if the software encounters problems. This phase includes design, coding, and removing errors if there are any [20]. Alternatively, during the 6th stage, before the use of information systems, it is necessary to test it because it will save time. It costs less to find problems before the system is used. System maintenance and documentation begin during this phase and are performed. The main purpose of this stage is to ensure the system operates correctly [20]. Finally, in the 7th stage, the effective implementation of the developed information system begins and includes many processes, such as Building a database, installing equipment, and putting the new system into production. This system is part of a deployment that includes distinct types of installations on the system, but each type has advantages and disadvantages depending on three things: what, when, and where it will be installed. The evaluation is also covered in all system deployment life cycle phases, but in this phase, the main criterion that must be met is whether selected users are using the new system or not [20].

3.2 Requirements collection techniques

This section covers the essential pillars of building software in compliance with the system development phase. An initial interview aimed to collect insights about Bahrain and GCC admission processes from Bahrain's Ministry of Education (MOE). Furthermore, two questionnaires were designed to collect information that aligns the system requirements of HEIM with the business requirements. The two questionnaires were conducted in October 2023 to collect respective data, and the result of the sample size was 200 for each, with an error margin of 6% and 90% confidence level, to Bahrain's population of 1,490,299 [18]. The sample size was calculated using Equation (1), where N is the population size of Bahrain, e is the error margin, p is percentage of population, and z is the no. of standard deviations of a certain proportion from the mean [41].

$$\text{sample size} = \left(\frac{\frac{(z^2 \times p(1-p))}{e^2}}{\left(1 + \left(\frac{(z^2 \times p(1-p))}{(e^2 N)}\right)\right)} \right) \quad (1)$$

The 1st questionnaire was directed towards collecting the user and business requirements with the composition of multiple sections such as demographics, applicants-specific, and university representatives. The 2nd questionnaire concentrated on the functional and non-functional requirements with operating system (OS) preferences and technical user preferences to collect what the users prefer to be included in the system. The Functional Requirements refer to the specifications provided by end-users for the various services that need to be incorporated into the mobile application under development. These requirements are expressed as the input given to the system [19], [20]. The non-functional Requirements (NFRs) are the attributes or desired features that a system that has been designed should have. Some of these qualities are usability, adaptability, performance, interoperability, and security. NFRs provide a methodical way to guarantee software system quality. NFRs aid in "building quality into" software systems [19], [20].

3.3. Application development techniques

This section explores the system techniques employed to describe the models of the HEIM system and acknowledges all the requirements collected in previous stages. Additionally, application development aims to create and design the intended application. This includes System models (level-0, Level-1 DFD), Process specifications, and System design (ERD, Data dictionary, and Dialogue diagram).

According to [19] - [21], DFD is an instrumental tool in analyzing and designing information systems, particularly for planning, developing, visualizing, and justifying systems like our HEIM system. DFD is a graphical representation of the system's requirements, including levels 0 (wide overview) and 1 (more detailed representations). A system needs these three essential elements to function: input, process, and output. The data that enters the system is referred to as an input. It then processes to produce the required outputs or services delivered to end users. The DFD represents these elements at various levels, which shows the entities, data storage, data flow, and processes that are part of the system. As per the Context Level DFD (level 0), the context diagram represents level 0 of a DFD, serving as a fundamental abstraction of the entire system. It offers a high-level synopsis of the primary functions within the system and the interaction between external entities and the system through these functions.

Process specification is a method of assessing, summarizing, and documenting the formulas and reasoning behind decisions to produce o/p results from processed input data. Its goal is to outline and convey the procedures and requirements of the regulations. Clear process criteria are necessary for high-quality, consistent data [20] - [21].

Entity relationship diagram (ERD) is defined by [19] as a graphical representation of a data FW for outlining the links among people, things, places, or ideas.

As insights by [42], the database schema outlines the relationship between different tables and how they are connected, like the concept of a blueprint of the building created by an architect. It consists of schema objects such as tables, views relationships at which it includes the table records, attributes, and their connections, and the name of the attribute and its keys (primary and foreign keys) used to manage the stored data and know the database's shape. Alternatively, a Dialog diagram is defined by [19], [20], [43] as a methodological mapping approach that shows navigability between the user and the system and how to navigate between pages in the system, which acts as the system map.

3.4 Application implementation and testing techniques

For the HEIM implementation, the .NET MAUI platform was utilized. The .NET MAUI is described by [44] as an open-source, cross-platform mobile development tool that allows developers to create IOS, Android, and Windows apps in a single project and is the evolution of Xamarin. Forms are extended from mobile to desktop scenarios with UI controls. Therefore, using .NET MAUI allows the creation of multi-platform apps using a single project with the capability to add platform-specific source code and resources and implement app logic and UI layout in a single code base [44].

Compared to other development tools, .NET MAUI provides several advantages, including programming language familiarity, integration with Visual Studio, .NET latest version support, community support, design responsiveness, control library, and debugging integration and testing [44]. In addition, regarding programming language familiarity, .NET MAUI

is based on C# and .NET, allowing developers to speed up the development process and be more efficient. Alternatively, regarding integration with Visual Studio, .NET MAUI integrates with Visual Studio, Microsoft's integrated development environment (IDE), so that Visual Studio develops .NET MAUI applications and utilizes advanced debugging features and productivity tools [44].

Alternatively, for the support of the latest version of .NET, .NET MAUI supports the latest version of .NET so developers can build faster and more efficient applications. However, the .NET MAUI community, such as Microsoft, provides many vital resources for developers. For design responsiveness, many languages such as XAML, a markup language, and C# are used by NET MAUI for UI design. These tools assist developers in creating responsive layouts that automatically adjust to the screen size of the device the app is running on. In addition, .NET MAUI provides a library of controls and components that help developers create and customize user interfaces. Finally, .NET MAUI provides advanced debugging and testing tools built into Visual Studio [44].

For the HEIM interfaces (UI) implementation, the HEIM was coded according to the distributed questionnaire responses in order to design a high-coverage mobile application according to the end-users' requirements which the user interfaces (UI) were presented from three main perspectives the mediator, university representative and the applicant accordingly. Compared to several user interface (UI) designs, the .NET Multi-platform (.NET MAUI) was selected to act as a cross-platform framework for creating native mobile and desktop apps with C# and XAML.

For the HEIM testing technique, Validation and Unit testing techniques are core phases of the SDLC and were executed when the first ensured trustworthy entry of I/P data types, while the second assured that each of the application's unit works as expected [22] [45]. Both techniques were performed during the application's development stage by isolating a part of the program code and verifying its performance.

3.5 Application evaluation technique

The usability of the HEIM mobile-based application was measured based on a 3rd questionnaire of 25 questions by following Nielsen's heuristics [46], which are composed of 8 major criteria and 22 sub-criteria of usability evaluative measures which were utilized to prevail the seven phases of the SDLC to assess the design usability of mobile software interfaces. The questionnaire was designed online and was carried out in November 2023, with a sample size of 32, while respondents were 29. with an error margin of 6% and 90% confidence level, to Bahrain's mobile application users of 1,490,299 [18]. The sample size was calculated using Eq. 1, where N is the population size of Bahrain, e is the error margin, and z is the no. of standard deviations of a certain proportion from the mean [41].

4. Results and Discussion

4.1 Requirements analysis

The 1st questionnaire showed that 78% of respondents were between 17 and 40 years old, with a 96% rate of the GCC countries citizens. However, 59% of the sample confirmed that there was no unified platform or app during the application to such universities, which clearly illustrated the need for a unified system in this regard. In the 2nd questionnaire, 78% preferred a mobile application, and 22% preferred a web application, resulting in the HEIM mobile application. Furthermore, as per the functional and non-functional requirements, the rest of the questions focused on the measures of the technical sides of the system, such as the login and registration methods, recovery approaches, and other fields of non-functional requirements. Table 3 illustrates the functional requirements of HEIM.

4.2 Application development analysis

As for the demonstration of DFD diagrams, Figure 2 presents the context diagram of the Higher Education Institution (HEI), showcasing the system's structure and relationship with external agents. On the other side, the context level DFD (level 0) is decomposed into multiple processes (also called sub-processes), showing detailed input and output data flows from one process to another as level 1 DFD is depicted in Figure 3.

Table 3. The functional requirements of HEIM.

Function No.	Function features
F01	Applicant Registration
Description	Applicants will register on the application so they can access features provided by HEIM.
Activities	<ol style="list-style-type: none"> 1. Applicants create accounts by filling in the required information. 2. Store applicant info in the database once it confirms the validity of the information.
F02	University Representative Registration
Description	Representatives of each university register on the application.
Activities	<ol style="list-style-type: none"> 1. The representative fills out the registration form by submitting the required details. 2. Registration request is sent to mediator after the app confirms valid representative info.
F03	Mediator Registration
Description	Mediators can be registered to manage the app through another app mediator.
Activities	<ol style="list-style-type: none"> 1. Mediators fill in new mediator information. 2. An account will be created once the mediator submits the request.
F04	User Login
Description	Users of the application can access it by entering their credentials.
Activities	<ol style="list-style-type: none"> 1. Users enter their email and password. 2. The application will grant access based on user email once the information is authenticated.
F05	Applicant Subscribe
Description	Request applicant subscription to enable application services.
Activities	<ol style="list-style-type: none"> 1. the application will request a subscription once the applicant is registered. 2. Applicants fill out payment information. 3. The application stored subscription details in database. 4. Grant applicant access to application services.
F06	View Universities
Description	Display all available universities to the applicant.
Activities	The application will load all universities from the database.
F07	View University Details
Description	Show all university details, including colleges and majors.
Activities	<ol style="list-style-type: none"> 1. Applicants select university. 2. The application displays all university details.
F08	Fill Preadmission Form
Description	Applicants submit essential personal and academic information to be used in the application process.
Activities	<ol style="list-style-type: none"> 1. The applicant fills in personal information. 2. The applicant completes academic information. 3. The applicant uploads academic documents. 4. The application stores applicant data and documents.
F09	Apply To University
Description	Applicants send preadmission requests to the desired university.
Activities	<ol style="list-style-type: none"> 1. Applicants click the apply button. 2. Application checks preadmission form. 3. The application sends the request as soon as the preadmission form is validated.
F10	Track Preadmission Request
Description	Applicants check the preadmission request status.
Activities	<ol style="list-style-type: none"> 1. Applicants choose application history.

2. Applicants check the preadmission requests status.	
F11	Accept Representative Registration Request
Description	The mediator validates university representatives' details to accept or reject the request.
Activities	1. The Mediator receives a registration request. 2. The mediator validates the submitted information and accept or reject it accordingly.
F12	
Add University Details	
Description	The representative adds all the university's information, such as dates, locations, colleges, and majors.
Activities	1. The representative access information page. 2. The representative Add the information.

Regarding the ERD, Figure 4 represents 13 entities and, subsequently, 13 tables for the HEIM mobile application to articulate information architecture clearly to support the technological logic of the entire process. Additionally, concerning the database schema, Tables 5 and 6 represent the application form data dictionary and the registration request data dictionary examples out of 13 tables. However, regarding the dialogue diagram, Figure 5 illustrates the HEIM mobile application with three different viewpoints distributed based on the mobile users, starting with applicants with university representatives and ending with the mediator.

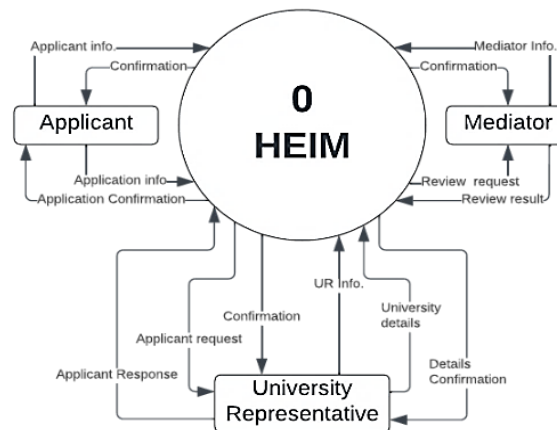


Figure 2. The Context Diagram of HEIM

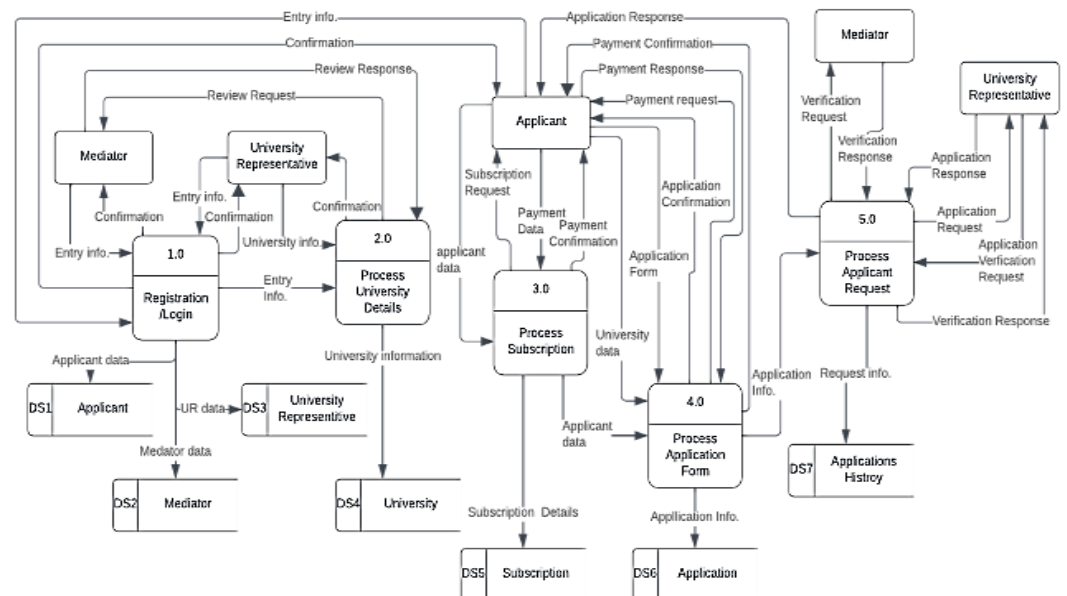


Figure 3. The Level-1 DFD of HEIM

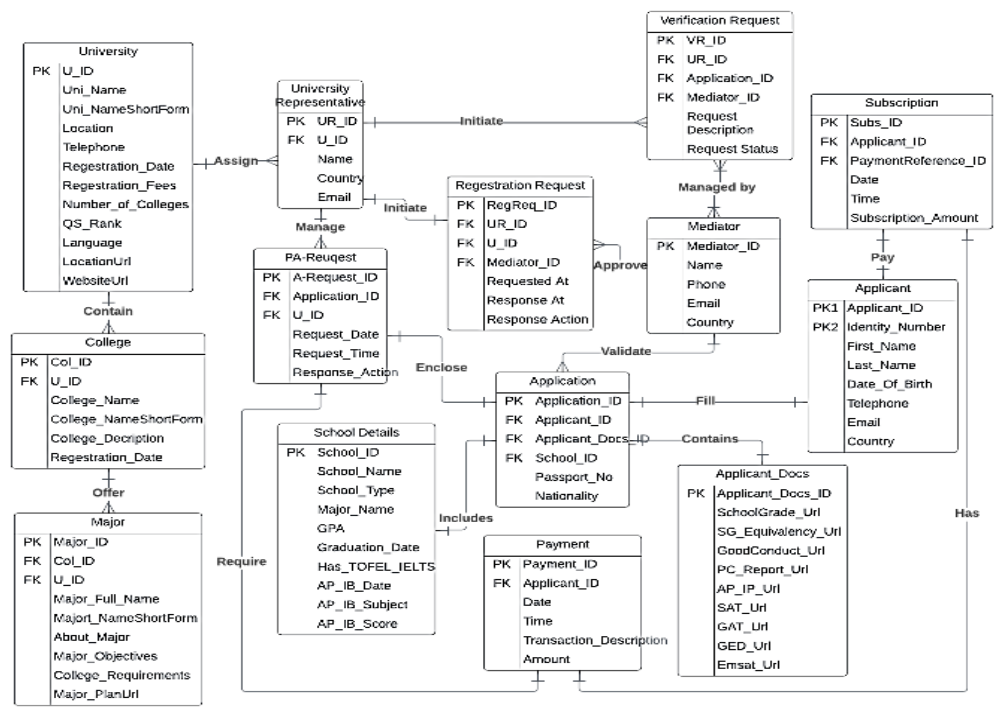


Figure 4. The Entity relationship diagram of HEIM

Table 3. The process diagram of HEIM

Process ID	Process 1.0
Process Name	Registration / Login
Description	The user signs up/registers by entering personal info.
Input	User personal info includes name, email, phone number, and country university.
Output	User Registration
Data Store	Applicant, Mediator, University Representative.
Process ID	Process 2.0
Process Name	Process University Details.
Description	University representatives submit their university details by filling in the information, which will then be validated by the mediators and displayed for the applicants in the application.
Input	University details, college information, majors' information.
Output	University details
Data Store	University.
Process ID	Process 3.0
Process Name	Process Subscription.
Description	Request applicant subscription to enable services utility.
Input	Applicant data, payment data.
Output	Applicant data, subscription details, and payment confirmation.
Data Store	Subscription.
Process ID	Process 4.0
Process Name	Process Application Form.
Description	The applicant sends a preadmission form with payment details, which will be processed by a university representative for admission registration requests.
Input	Application form, payment details, applicant data, university data.
Output	Application confirmation, payment confirmation, application info, preadmission request.
Data Store	Application

Process ID	Process 5.0
Process Name	Process Applicant Request
Description	The university representative validates the request, initiates a verification request if needed, and sends the final response to the applicant.
Input	Application information
Output	Application response
Data Store	Applications History

Table 4. The Application Form Data Dictionary Table

Attribute name	Data type	Primary Key	Foreign Key	NULL	Unique	Other constraints
RegReq_ID	Number	Yes	-	-	Yes	-
UR_ID	Number	-	Yes	-	Yes	-
U_ID	Number	-	Yes	-	Yes	-
Mediator_ID	Number	-	Yes	-	Yes	-
Requested_At	Date	-	-	-	-	-
Response_At	Date	-	-	-	-	-
Response_Action	String	-	-	-	-	-

Table 5. The Registration Request Data Dictionary Table

Attribute name	Data type	Primary Key	Foreign Key	NULL	Unique	Other constraints
Application_ID	Number	Yes	-	-	Yes	-
Applicant_ID	Number	-	Yes	-	Yes	-
Applicant_Docs_ID	Number	-	Yes	-	Yes	-
School_ID	Number	-	Yes	-	Yes	-
Passport_NO	Number	-	-	-	Yes	-
Nationality	String	-	-	-	-	-
Application_ID	Number	Yes	-	-	Yes	-

4.3 Application implementation and testing analysis

The welcome, login, and registration interfaces represent the initial HEIM interfaces, which are commonly accessible by all types of users, whereas the login UI is shared between all three respectful user types to grant user access. From the other side, the registration aspect is divided into two main divisions: the applicants’ and the universities representatives. As depicted in Figure 6, the admission acceptance requests and university details interfaces are viewable from the mediator and the university representative sides, but only the university representative can accept or reject the request. On the other side, the university details interface are accessible from the mediator and the applicant side with the dominant constraint that prevents and hides the apply button, and it will appear only for the users classified as applicants. Mediator-specific interfaces exist, which means those interfaces cannot be viewable or accessible to any other type of user. This includes the registration requests, the registered users in the application, the verification requests, and the registration of the new mediator interface. The university representative-specific interfaces, as depicted in Figure 7 to, include the university details, colleges, and majors. Finally, the applicant interfaces include home, my form, applications, and settings. My form tab consists of four main views classified as personal information section, the academic section and the documents uploads section, lastly the completed form view.

As per the application testing, a section of code was written to test specific functions in the HEIM application at which the functions were isolated to reveal unnecessary dependencies between functions being tested and other units and, therefore, verify their performance.

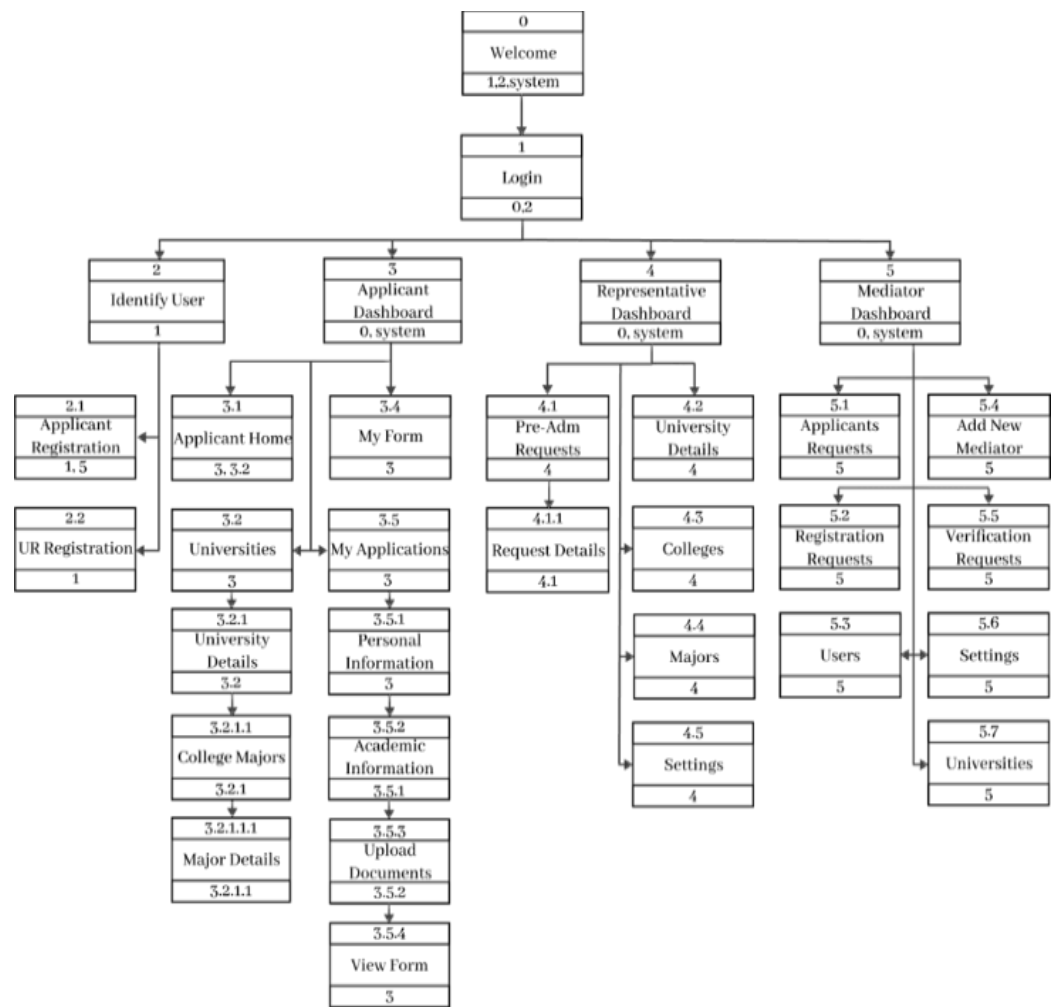


Figure 5. The Dialogue diagram of HEIM

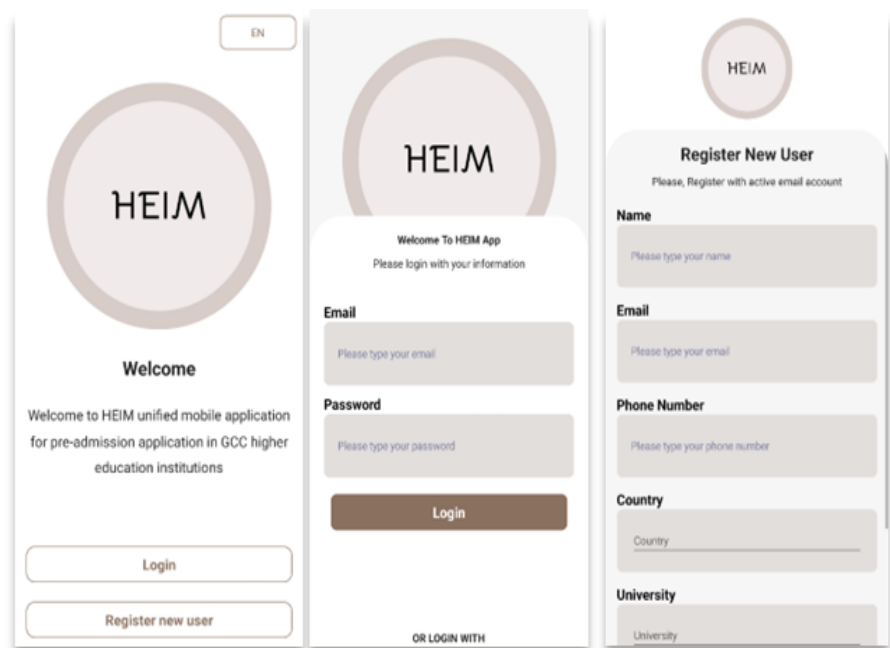


Figure 6. Welcome, registration, and login interfaces

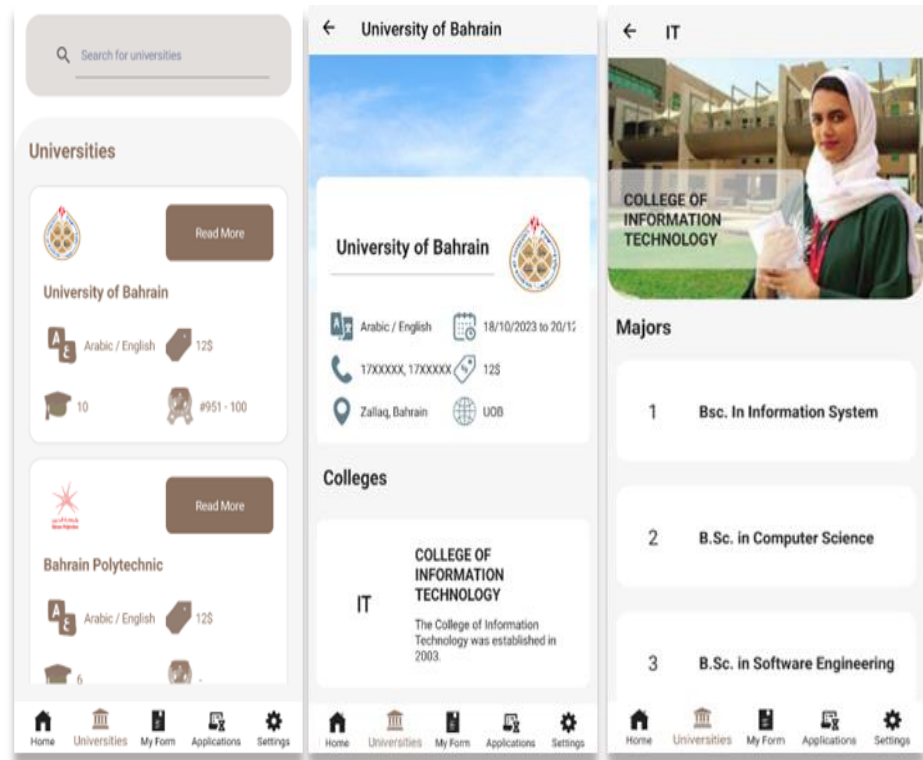


Figure 7. University & University detail interfaces

4.4 Application Evaluation Analysis

Table 7 illustrates the statistical findings of the 3rd questionnaire and reveals an overall Usability rate of 97.7%, based on Nielsen heuristics. The visibility indicates how conspicuous the system is to the users from different service viewpoints. Findings of visibility of the HEIM mobile application revealed a total high satisfaction of 77% with 42%. The model accuracy shows three main heuristics used to build the model accuracy. In terms of navigation, the menu and the simplicity of the application scored above 60% satisfaction, while in navigation and menus, the simplicity ranged between 30% and 60% satisfaction. The user control evaluation based on navigation and menus and the simplicity of HEIM scored between 35% and 69% satisfaction. The consistency of the HEIM mobile application of the users of being using such mobile application and the elegant and nicely designed UI alongside other media used within HEIM scored 70% satisfaction. Alternatively, HEIM scored 85%, 55%, and 55% in terms of error prevention, privacy, and security.

Table 6. The 3rd Evaluation Questionnaire

Heuristics	H. Satisfied	Satisfied	Neutral	Unsatisfied	H. Unsatisfied
Visibility of The Application					
Location of information	58%	42%	0%	0%	0%
Response time	77%	23%	0%	0%	0%
Selection input of data	58%	38%	0%	4%	0%
Model Accuracy					
Navigation structure	65%	35%	0%	0%	0%
Menus	69%	31%	0%	0%	0%
Simplicity	58%	38%	0%	4%	0%
User Control					
Explorable interface	46%	54%	0%	0%	0%
Menus control	65%	35%	0%	0%	0%
Process confirmation	46%	50%	0%	4%	0%

Consistency					
Design consistency	46%	54%	0%	0%	0%
Naming convention	46%	50%	0%	4%	0%
Application response	38%	54%	0%	8%	0%
Aesthetic & minimalist design					
Multimedia content	62%	35%	0%	4%	0%
Icons	73%	27%	0%	0%	0%
Menus	69%	31%	0%	0%	0%
Errors					
Error recognition	58%	42%	0%	0%	0%
Error prevention	58%	35%	0%	8%	0%
Privacy					
Clear warnings	64%	32%	0%	4%	0%
Privacy protection	54%	46%	0%	0%	0%
Security					
Timely information display	46%	50%	0%	4%	0%
Simple interface	58%	38%	0%	4%	0%
Problem assistive platform	58%	38%	0%	0%	4%
Average	57.8%	39.9%	0.0%	2.2%	0.2%

5. Conclusions

The research is grounded in the idea of attaining two main objectives. Primarily to inspect the university admission phenomena alongside web and mobile apps, and secondarily, how to develop and evaluate the HEIM mobile application. The two main objectives of the research are articulated based on the raised problem surrounding the HEI, particularly in the GCC countries, along with the relevancy. Several issues composed of limitations are confronted during the progress of the project, which resulted in multiple objective modifications to characterize the final research essence goals. Furthermore, the achievement of the primary objective was quite restricted by the scarcity of literature reviews available in this regard. Numerous academic papers along with extensive content analysis, were performed to obtain the fundamental informative pillar.

In spite of that, the implemented mobile application, HEIM, can be further evolved by adding additional features that adopt a large number of users, such as virtual higher education institution visit, chatbots regarding admission matters, and support of multi-language. Besides this, additional enhancement can be added from the DB side along with software architecture strategy and the coverage of private and public educational institutions, which leads to improved mobile applications and high user satisfaction.

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