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Spatial Decision Support System for Student Data: A Case Study of Yemen

Ali Mohammed Bazarah

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Completed Research

Ali Mohammed Bazarah
Claremont Graduate University
Claremont, CA, USA
ali.bazarah@cgu.edu

Abstract

This study aims to examine the effectiveness of using Geographic Information System (GIS) technology to create a geospatially-enabled student data management system (SDMS). Although there are many applications available to create SDMS, GIS has some unique features that would make managing student data more convenient. This research gap was identified via stakeholder interaction and systematic literature review where no current geospatially-enabled SDMS was discovered that utilizes GIS technology to accommodate and share the information between multi-stakeholders. As such, this research aims to utilize GIS and visualization tools to design and implement Geospatial SDMS that help different stakeholders, such as scholarship organizations, employers, and students to speed and improve their decision outcomes. The project is based on a case study in Yemen. Using a qualitative assessment method, this system was evaluated in a real-world scenario where different stakeholders were introduced to the system and their feedback was collected via a focus group.

Keywords

GIS, geospatial, student data management system, visualization, decision support.

Introduction

Group support system (GSS) research has found that for group members to arrive at a "better" decision, information needs to be understandable and shared among all group members (Dennis et al. 1998). One way to make information understandable among group members is by using Information visualization, which represents an important tool for decision making. Information can be exchanged and visualized using different techniques such as groupware (Hilmer & Dennis 2000), visualization tools (Miller et al. 2012; Ko and Chang 2018; Rivard et al. 2019), and value charts (Bajracharya et al. 2018; Conati et al. 2014).

Visualization tools for information exchange have been shown to be effective because they increases the possibility that important information will not be overlooked by individuals (Hilmer & Dennis 2000), it provides easy channels where firms can obtain useful insights from information and use them in their decision process (Ko and Chang 2018; Lin and Chang 2018; Rivard et al. 2019), and it allows the decision maker to have a comprehensive view of information that can support decision making (Ko and Chang 2018).

Visualization tools can be defined as the methods that are used to solve a visualization function, such as navigation, filtering, or selection (Conati et al. 2014). It involves a visual or interactive presentation of information in a clear and compelling manner (Miller et al. 2012). They have been used in many fields such as healthcare, information systems, supply chain management, education, and so on (Miller et al. 2012; Ko & Chang 2018). These visualization tools have become very popular for decision making, and they can be designed to fit the specific needs of each user (individual or organization) and support users with different background and abilities (Conati et al. 2014; Ko & Chang 2018).

The aim of this paper is to create a geospatial platform that utilizes visualization features to improve the decision outcome of every stakeholder. The platform will visualize the information in a way that every

stakeholder can look at the same information from their own perspective to fulfill their own needs and to improve their decision outcomes.

This online platform has been designed to solve a problem in the country of Yemen and is related to the education system there and its linkage to market needs. The problem has its roots in the fact that the number of Yemeni students who study abroad has increased dramatically over the past few years. This, coupled with an increase in the number of charitable or non-profit organizations that provide fully funded scholarships to qualified students, has resulted in a lack of coordination between these organizations and the students.

This lack of coordination creates the problem of how to track student academic majors and of how to decide on what majors the funding organization, country, or market needs, to make sure that there is a balance among all majors, and not clustering on specific majors. Currently, these organizations are totally isolated from each other, and each one makes their decision based on the information that they have (unique information) without having access to what other organizations are doing or what the market needs. This is also relevant for students who need to decide on what major to study and their professional goals. Therefore, the research question raised in this paper is:

> How effective is the geospatial enabled SDMS technology in improving the decision making of every stakeholder?

Thus, to address this problem, the researcher designed a platform that contains data of students from different scholarship organizations. Using GIS-based tools, a web and mobile story map platform was developed that can help stakeholders support their decision.

This platform has three main objectives:

1- Provide guidance for students who recently graduated from high-school to choose their majors and support that decision-making process.
2- Assist scholarship organizations to focus their scholarship efforts on specialties in which there is a shortage, and
3- Assist the public and private sectors in selecting qualified students to recruit, as well as assisting students in obtaining jobs in their area of specialization.

Methodology

Even though there are many Information System and Technology design approaches that deal with solving a problem by using technology, this project used the design science research (DSR) methodology to guide the platform development and evaluation. DSR was chosen as it is particularity well-suited to solving problems of this type, ones that require close interaction with various stakeholders, is research-based, and allows for rapid, iterative, development cycles.

Over the last decade, DSR has become an important research method in the information systems field (Chatterjee et al. 2018). It is basically a research method that is concerned with building artifacts to solve human problems. DSR strives to answer questions that are relevant to humans by creating artifacts. Chatterjee and Hevner defined DSR as an "Iterative process and resulting product that deals with building artifact to solve a human problem in an efficient manner" (Hevner & Chatterjee 2010). Iteration is an integral part of DSR because it starts with identifying the problem, designs and builds a solution, evaluates the outcome, and then seeks possible improvements. Therefore, the main process cycles of DSR are building and evaluating the artifacts.

Based on the DSR iterations, this research problem is identified as the lack of a geospatially-enabled SDMS platform that brings different stakeholders together in one platform to support their decision-making process.

The overall design of the platform was based on the theory of social exchange; this theory helps to provide guidance for exchanging information between different participants. The theory of social exchange (TSE) has been used to explain individual social behaviors from benefit and cost perspectives. Serenko & Bontis (2016) define it as "a joint activity of two or more players when each actor possesses and may offer something valuable from the other actors' perspective". TSE can be depicted as when you do a favor to others, people would do the same to you.

The idea underlying this platform is that each stakeholder has unique information that other stakeholders might need to make their decision. Therefore, based on theory of social exchange, to make this platform more effective, each stakeholder needs to share its unique, but not sensitive, information and make it common to others so they can use it for their needs. To avoid the problems associated with the information each stakeholder is going to share, the platform specifies what information to share and how to share it. This helps to avoid biases issues (Dennis 1996) and confusing power and politicking problems (Homburg 2000).

Some problems, such as data ownership and control, might emerge by having different stakeholders on one platform. To avoid the conflict of data ownership, students will enter their data into the system (unique information) in a pre-specified format in the system. Once the data is in the system, it will be presented in a visualized way (common information) where all stakeholders can have access to it without claiming data ownership or conflicting power. Once the data becomes common, each stakeholder can use it to support their decision-making process. The following figure shows these processes.

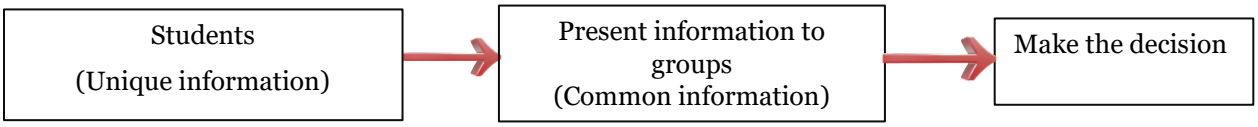

Figure 1. The flow of the information

Since the main purpose of this project is to utilize geospatial technology in designing a SDMS, and solve the identified problem, a search was performed to identify an appropriate platform for hosting this kind of system. Esri's ArcGIS for Insights and Story Maps were found to be the best options that provide the necessary features and functions. These features include the ability to involve different stakeholders in one platform, the opportunity to utilize location features, and the capability to present the data in an interactive manner and visualize it in a way that facilitates the decision-making process.

The assessment of this platform, for its effectiveness, will be conducted via a focus group discussion among various stakeholders.

Data Collection

Data were collected from the students' Association database in Yemen; the name of the association was removed for privacy issues. This association was established in 2013 with the purpose of building a database for the country's students who study abroad. The researcher received full access to the students' database and use it to build this platform hoping that it would support the students, donors, and recruiters' decision making. The database included information about student majors, countries of education, graduation status, academic levels, expected graduation dates, job status, job details if any, and contact information.

Platform Design Description

To answer the research question, the researcher first designs a geospatially enabled system and then demonstrate its effectiveness. The researcher follows the DSR method and its three main cycles; relevance cycle, build and evaluate cycle, and rigor cycle, to design this geospatial platform. The relevance cycle means that this platform is intended to solve a real problem in the environment. The rigors cycle means that the design of this platform is based on the theories, models, and best practices tools on the IS knowledge base. In this cycle, the researcher decides on the theory that can be used to guide the research and identify what technology to use to build the platform. Finally, the build and evaluate cycle is maintained in this research in terms of designing the platform and then evaluating it using a case study.

In order to achieve the abovementioned objectives of this research, all users (stakeholders), such as students, scholarship organizations, and employers, need some information to guide their decision. This information includes, for example, the number of students in each major and in each country, the number of graduate students who find a job or not, the number of students sponsored by each organization and so on. Therefore, the platform should be designed to present and organize this required information in a way that makes it easy for each user to take the decision.

Three main requirements are needed to design the platform. The first requirement is to identify what data will be collected and entered into the platform. In this platform, the researcher identified the needed information from the student's association database as explained below in steps 1 and 2. The second requirement is to visualize and present the information in an interactive way that allows every stakeholder to easily navigate through the platform. This requires the designer to evaluate the possible technology options that provide adequate visualization techniques. In this research, Esri's ArcGIS for Insights and Story Maps were found to be the best options that provide the necessary features and functions. These features include the ability to involve different stakeholders in one platform, the opportunity to utilize the location-based features, and the capability to present the data interactively and visualize it in a way to facilitate the decision-making process.

Based on these two requirements, the designed platform will work as following: the needed and identified information will be entered into the platform. The platform will then present the information and make it visually interactive and ready to be used by stakeholders. This will allow stakeholders to have access to comprehensive, new, and relevant information that is not known to them before and which they can use for their decision making. For example, a stakeholder such as an employer might be interested to see how many students already graduated from a specific major in order to recruit them.

The third requirement is to evaluate the effectiveness of the designed platform. This requirement is done by performing a focus group discussion that involves participants from different stakeholder categories to evaluate how effective the platform is in speeding up the decision process, as explained in the results section.

The development of this platform has gone through many steps using ArcGIS software. These steps can be summarized as follows:

Step 1: Data preparation: after obtaining the data, the researcher cleaned and arranged it using Excel, and then decided on what to present in the platform. This meant that the platform presented only the data that was relevant to stakeholders to support their decision making without invading students' privacy.

Step 2: After the data preparation, the Excel file was uploaded onto the online ArcGIS, then the map was created. Based on the data that was selected in the Excel sheet, the ArcGIS identified the countries where the students study and indicated how many students resided in each country. The pop-up configuration was set to show the data based on clicks at any location.

Step 3: After the map was created and locations were identified, the web application was created using the Story Map Journal function offered by ArcGIS. Using this function, the researcher organized the data that needed to be shown on the platform, wrote the objectives of this application, and presented some relevant pictures.

Step 4: Once the story map was created, ArcGIS Insights was used to build the graphs that show data correlation and statistics. Data were uploaded into Insights, analyzed, and then linked back to the story map to show it in the platform application. The graphs that were built using insights are interactive which means they show different results based on the area or on the country that is clicked on.

Step 5: This step is similar to insights in step 4 but uses Tableau software. Tableau allows for analysis of the data and presents it from different perspectives; this process cannot be executed using insights only.

Step 6: After making sure that the platform application matched all the objectives that were designed for and met its purpose, the application was shared on the web and mobile to test its functionality.

Step 7: Finally, the application was tested on different platforms including Mac, PC laptops and desktops, and IOS and Android mobile phones. The application provided similar results in all the mentioned platforms with the only difference being that the application view on laptops is quite a bit larger from those in mobile phones.

Below are some screenshots from the platform with further explanation. It worth mentioning that to make it easier for stakeholders to interact with the platform, the platform is presenting the information in the Arabic language. However, below is an explanation for each figure and what information it represents. The first screen of the application shows the world map and indicates the total number of students in each country. This will help the stakeholders (Donors, students, organizations…etc.) to get a comprehensive overview of the total number of students in each country (figure 2).

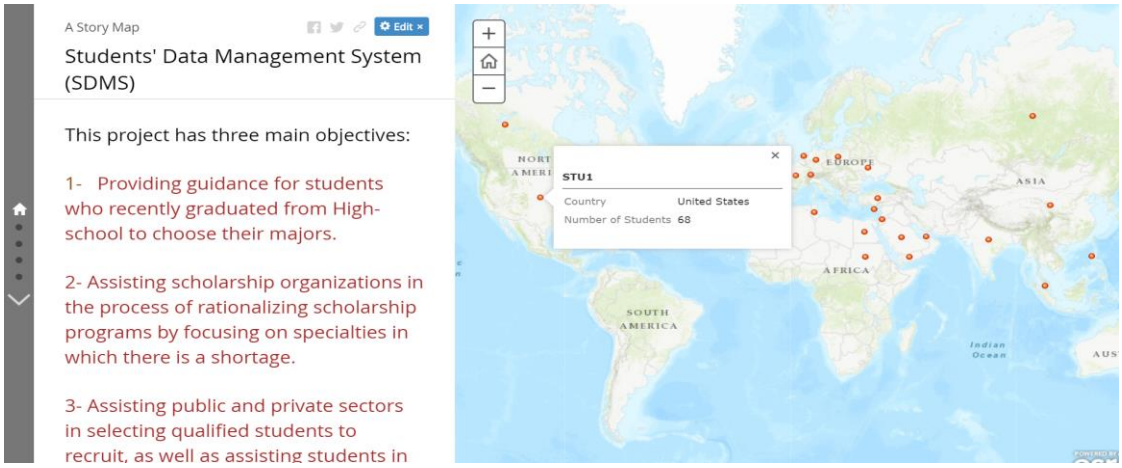

Figure 2. Story Map shows the students locations

The first screen also shows statistical figures about the number of students who belong to each scholarship organization, organizations' names were removed for privacy issue (Figure 3) and the total number of students in each major with respect to their academic levels, such as Bachelor's, Master's, or Doctorate (Figure 4). For instance, about 200 students are studying Civil Engineering, whereas there are only 10 students studying journalism. From the first screen, the total number of students that each organization is accountable for is easily identifiable.

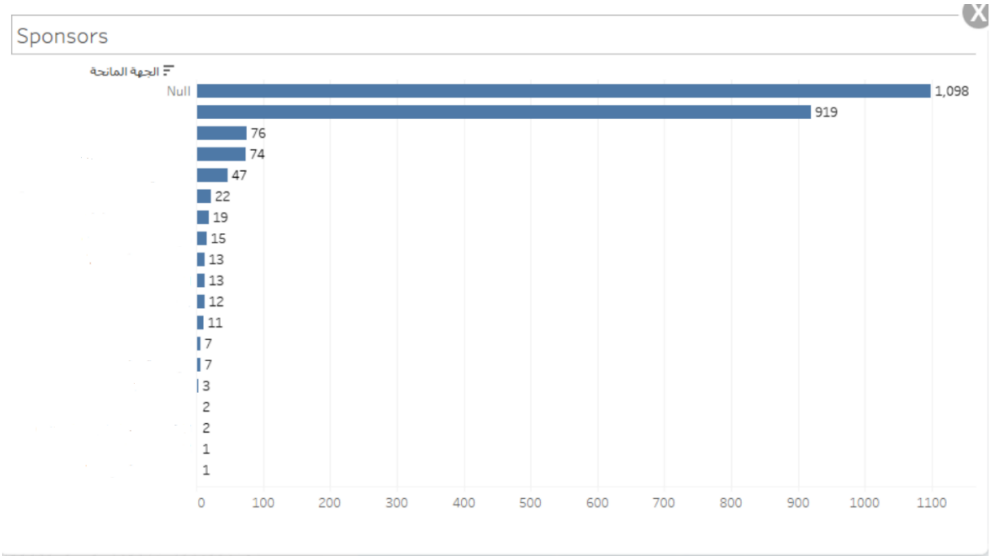

Figure 3. The number of students per each scholarship organization

These three graphs on the first screen would help in meeting the first and second objectives of this project. The first screen, on the one hand, would help high school students to see the majors that are still available and provide guidance for choosing their major; it also helps students to choose a scholarship organization that they might consider applying for. On the other hand, the screen provides support to scholarship organizations in rationalizing the overall scholarship program by focusing on specialties or majors for which there is a shortage of students.

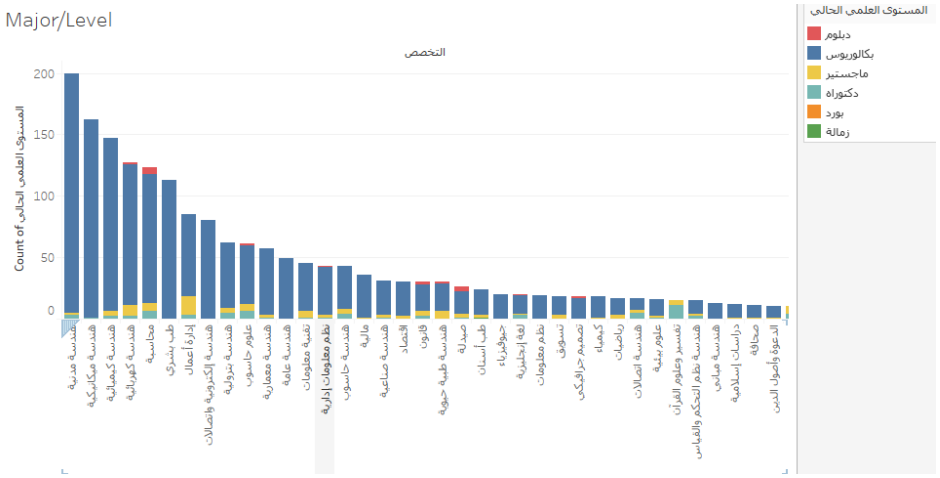

Figure 4. The number of students in each major

Figure (4) provides statistics about the number of students in each major with respect to the already graduated students versus those who are still enrolled. The blue color is the number of graduated students, and the orange color is the number of students who are still enrolled in the program. For example, for Civil Engineering students, 66 students already graduated while 134 are still in schools. This figure would help the public and private sector to find students to recruit.

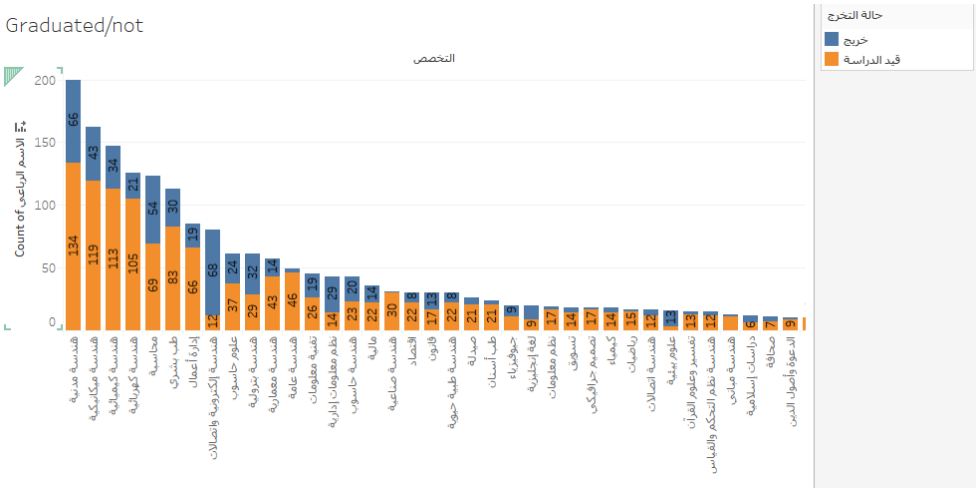

Figure 5. The number of graduated VS enrolled students in each major

The second screen provides more statistical details in an interactive way. The graphs show the statistics for the following categories:

1- Academic levels in each country (Figure 6).

2- Graduated versus enrolled students at each academic level (Figure 7).

3- Graduated versus enrolled students in each country (Figure 8).

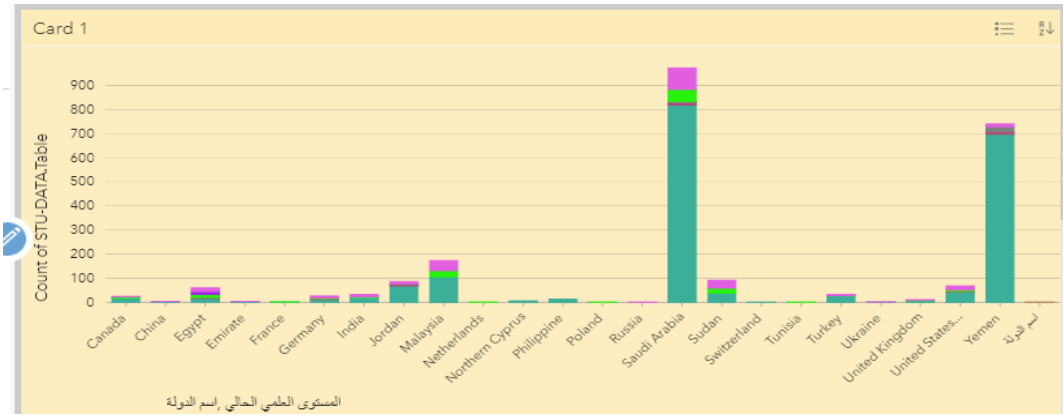

Figure 6: Students' Academic Level in each country

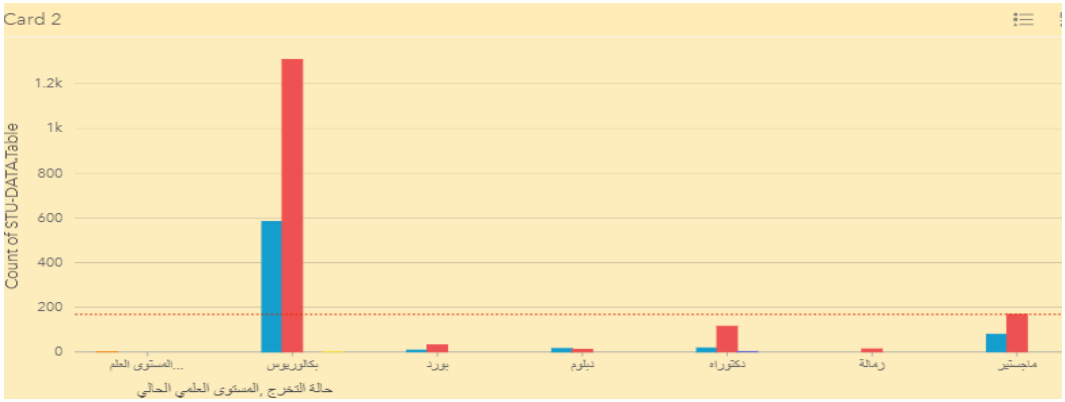

Figure 7: Students' graduation status per academic level

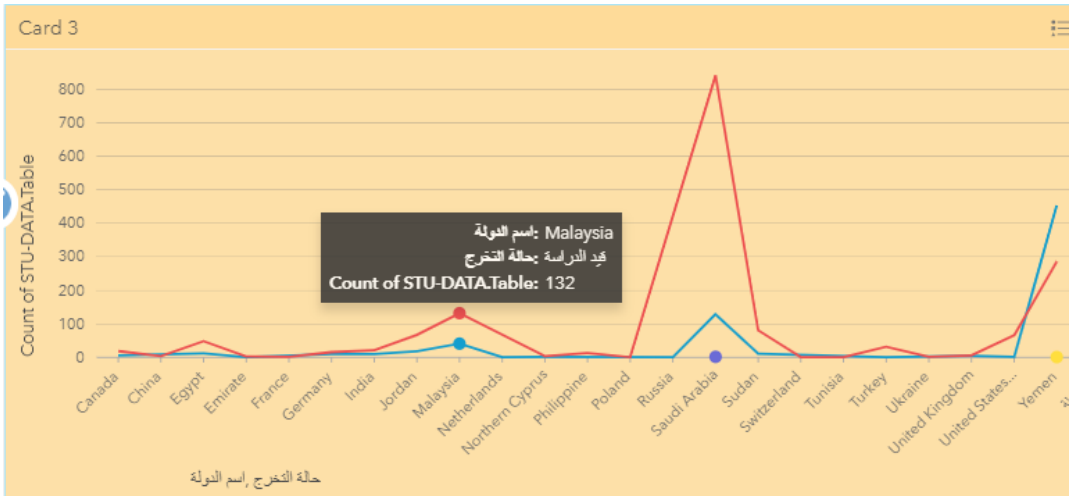

Figure 8: Students' status in each country

Unique Features of the GIS

As discussed in the introduction, there is a need for designing a platform that utilizes geospatial technology and visualization features for different stakeholders. This platform application was created with the

purpose of supporting students, scholarship organizations, and business recruiters with speeding up the decision-making process. The unique feature of this application is that it links different stakeholders in one simple platform which expedites the process of performing the required actions. another advantage of this application is that different stakeholders can look for different data based on their needs, and all of this is done without threatening the privacy of the students.

This application differs from others in its ability to provide comprehensive and visualized information to different stakeholders. Stakeholders can use it to have an overview of the scholarship program, or simply to see what students around the world are doing.

Case Study

The evaluation cycle is considered a crucial part of DSR because otherwise the research method will be incomplete. In this study, to assess the effectiveness of this platform, a focus group discussion was conducted with highly knowledgeable representatives in leading positions from different stakeholder groups including scholarship organizations, employers from the public and private sector, and students. A total of nine individuals attended the focus group discussion: four from scholarship organizations (including CEO, Board member), three employers (from government and private sector), and two students (Ph.D. and Master's). The group discussion took about one hour. The meeting started by illustrating the problem that the researcher was trying to solve and highlighting any shortcomings or obstacles in the scholarship programs and the recruitment process relating to the lack of information for decision making. The researcher demonstrated the GIS platform and its ability to solve the highlighted problems. Finally, the researcher led the discussion to get the group's opinion about the platform and seek their feedback for further improvement.

Results /Discussion

Using the focus group discussion, stakeholders were made familiar with the platform and provided feedback, including suggestions for improvement. All participants in the focus group recognized the value of the platform and were able to see the problem of the inability to access comprehensive information that lies beyond their control when it comes to dealing with different stakeholders.

> *"We invested a lot of money to improve our internal system of the scholarship program, but we never thought of considering other stakeholders in our plans or decisions", scholarship participant said.*

The good thing about the platform that all participants confirmed is its simplicity and clear visualization of the information. This gave the stakeholders the ability to see the comprehensive information, got some insights, and consider them in their decisions, without even communicating with another stakeholder. For instance, if an employer is willing to recruit someone with specific qualifications, he/she will not need to contact scholarship organizations and ask if they have someone who is qualified. With a simple look at the platform, the employer will be able to see and decide whether there is a qualified person.

> *One employer said that "finding a qualified person is always a challenge for us, I knew that the scholarship programs are doing a great job, but when I want to recruit someone, it is very hard to locate them, which forces us to look for qualified people outside the governorate or even the country". He added, "I believe this platform will work as a human resources' database for the entire governorate".*

As a result of the platform's above-mentioned features, such as data representation and visualization, the platform was able to achieve the third objective of assisting public and private sectors in selecting qualified students to recruit.

Regarding the first objective of guiding students who recently graduated from high school to choose their majors, both student participants agreed that the platform did a good job of achieving this objective.

> *"Sometimes I need to talk to someone who is studying a specific major or in a specific country to get some information, but you can't imagine how hard is that. If you don't personally know someone to ask, you won't be able to find an answer", one student said.*

However, one piece of feedback raised by participated students was that the platform should accommodate direct communication between students, which the platform does not currently offer due to privacy concerns. The way the platform works is as follows: if the student who is seeking help wants to meet someone in a specific major or in a specific country, the platform will show the total number of the students in that major or country, as well as the scholarship organization information. So, the student who is seeking help needs first to contact the organization to get connected with the person in that major or country. However, this was valid feedback and will be considered for improving the platform in the future.

The second objective of assisting scholarship organizations in the process of rationalizing scholarship by focusing on specialties in which there is a shortage has received a considerable amount of discussion by the focus group participants. By far, this is the most critical goal of the project. This is due to the fact that, by bringing together different scholarship organizations, not only we can improve the scholarship program outcomes but also save many resources and plan better for the future. Instead of planning the scholarship program based on internal information of each organization as is currently done, the platform will provide a paradigm shift by considering information from different organizations' information. This will help in having a balance of students studying in different majors and meet the market needs in the future.

> *"Even though I am working in a scholarship program for many years, I 've never seen some detailed statistics about students like what presented in this platform", it is clear that we need to stop sponsoring students in specific majors and focus more on others where there is a shortage", Scholarship board member said. "not only that, but it provides a location-based statistic which is a plus", the CEO said.*

When asked about areas for improvement, great and insightful feedback were provided that will be considered for improving the platform. The first suggestion was to provide more detailed statistics, such as students' gender differences with regard to majors and countries. Another suggestion was to provide a window for employers to announce their jobs and needs, which can help students to see market needs trends in a way that will both help students to get a job and employers to reduce employment and acquisition costs. Furthermore, the direct communication point, mentioned above, is a valid suggestion that needs to be considered. Finally, the overall cost of using the GIS platform and obtaining the required licenses is a concern for many of the stakeholders and will be addressed with people who are in charge of this technology.

Conclusion

This project is based on building a platform using Insights for ArcGIS and Story Maps to solve a problem in a Middle Eastern country. This online platform has been designed to solve a problem that is related to the education system and its linkage to market needs. Using the designed platform, and based on feedback from the field experts, the platform has been able to answer the research question and achieve the identified objectives in this paper efficiently, which highlights the effectiveness of the Geospatially enabled SDMS to improve the decision making of every stakeholder. The focus group discussion brought some valuable suggestions and insights for improvement that will be considered in future work. Even though the solution is implemented in a Middle Eastern country (Yemen), it can generalize to different countries or educational institutions to bring together different stakeholders in one platform.

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