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Case Study

Developing BI Scorecards for Assessing Higher Education Quality Dashboards Using Human-Computer Interaction Concept: A Case Study

Ali Sorour[1,2*], **Anthony Atkins**[2]

[1]Cloud Computing Establishment Buraydah, Saudi Arabia
[2]School of Digital, Technology, Innovation and Business, University of Staffordshire, United Kingdom
E-mail: ali@c-computing.com

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Abstract: As Higher Education Institutions (HEIs) in the Kingdom of Saudi Arabia (KSA) have difficulties in monitoring their compliance with the national Quality Assurance (QA) standards, a Holistic Framework for Monitoring Quality in Higher Education Institutions using Business Intelligence Dashboards (HF-HEQ-BI) was used to address this challenge. This paper presents the development and evaluation of Business Intelligence (BI) scorecards for assessing BI dashboards within Higher Education (HE) context based on the Human-Computer Interaction (HCI) principles. It explores the implementation of a Holistic Framework for Monitoring Quality in Higher Education Institutions using Business Intelligence Dashboards (HF-HEQ-BI) in Saudi Arabian HEIs. The paper outlines the development of an evaluation tool for BI dashboards design based on the HF-HEQ-BI framework, emphasising usability, ease of learning, and user interaction as key metrics. A dashboard developed using the HF-HEQ-BI framework was assessed by a panel of experts in Quality Assurance (QA) from Saudi HEIs. The evaluation showed high usability and acceptance rates, indicating that the HF-HEQ-BI framework effectively supports the development of dashboards that meet QA requirements and enhance decision-making processes in HEIs. The study concludes with recommendations for future work, including further development of the HF-HEQ-BI framework and continuous monitoring capabilities in BI dashboards.

Keywords: accreditation, business intelligence, data visualisation, quality assurance, usability

1. Introduction

Business Intelligence (BI) Dashboards are emerging as a powerful tool in the context of Higher Education (HE) as it provides more insightful analytics to support decision making process. Higher Education Institutions (HEIs) are required to monitor their compliance with national Quality Assurance (QA) standards that are imposed by QA agencies. For example, in the Kingdom of Saudi Arabia, the Education and Training Evaluation Commission (ETEC) is responsible for imposing and overseeing the adoption and compliance with the national QA standards. The National Centre for Academic Accreditation and Evaluation (NCAAA), which is affiliated with the ETEC, develops and updates the NCAAA QA standards which all HEIs in the KSA are required to comply with [1]. All HEIs in the Kingdom of Saudi Arabia are required to adopt these standards and report on their compliance on an annual basis. HEIs sometimes

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have difficulties in determining the areas where non-compliance with these existing standards, which might affect their accreditation status. HEIs in the Kingdom of Saudi Arabia face significant challenges in ensuring compliance with national QA standards. These challenges were associated with the complexity of QA requirements, the volume of data generated, and the lack of advanced tools for real-time monitoring. Data related to QA in HEIs are huge and complex. Therefore, HEIs face challenges while gathering and analysing these data to determine the degree of compliance with QA requirements. Handling such big data increases the complexity of QA activities and also consumes significant time and resources [2] it is recognized as the ever-changing playing field. Those who aim to stay in the technology field need to quickly get adapted to such constant changes in this field. Due to the high pace of information technology advances, it is required to identify and implement appropriate technologies by which the organizations can effectively stay and compete in the business through the accurate and real-time efficiency delivered by such technologies as cloud computing, internet of things (IoT). HEIs tend to use manual audits to measure the level of compliance with these standards. These audits are time-consuming and lead to delayed corrective actions. These limitations highlighted the need for utilising Business Intelligence (BI) tools which provide comprehensive, real-time insights into QA metrics and support decision making by identifying the areas that require immediate action. Therefore, a BI architecture in HEIs was proposed by the authors in a previous study [3]. The BI architecture identified the three main layers of BI systems while adopting them in the context of HEIs. A Holistic Framework for Monitoring Quality in Higher Education Institutions using Business Intelligence Dashboards in the Kingdom of Saudi Arabia (HF-HEQ-BI) was proposed by authors in a previous study [4]. The use of HF-HEQ-BI in the context of HE can assist in developing BI dashboards that assist decision makers in determining areas where action is required to be taken in order to assure compliance with QA standards. An HF-HEQ-BI Framework Utilisation Tool was developed to demonstrate how the HF-HEQ-BI Framework can be used for the purpose of developing dashboards for monitoring quality in HE in KSA [5, 6]. A prototype dashboard has been developed based on the Utilisation Tool as shown in Figure 1 and outlined in a previous study [5]. However, the usability of this dashboard needs to be appraised and consequently this paper aims to develop an evaluation tool for the purpose of assisting HEIs in evaluating dashboards that have been built using the HF-HEQ-BI framework.

This paper outlines the development and evaluation of BI dashboards designed to support QA monitoring in HEIs in the context of Saudi Arabia. The main objective is to assess the effectiveness of the HF-HEQ-BI framework in improving the usability and functionality of BI dashboards within HEIs. Additionally, the study evaluates whether the HF-HEQ-BI framework can assist HEIs in efficiently tracking compliance with national QA standards and institutional KPIs.

The scope of this paper is focused on developing a BI evaluation tool in the HE context. This evaluation tool was developed after consulting a panel of experts to evaluate its usability, adaptability, and relevance to QA requirements. The paper uses a case study approach by consulting a panel of experts in QA in HEIs. This evaluation is intended to provide feedback on the HF-HEQ-BI framework to determine its ability to address real-world QA requirements. Key contributions of this paper are outlined as follows:

Provide an evaluation tool for BI dashboards based on the HF-HEQ-BI framework to show its ability to measure compliance with QA standards in Saudi Arabia.

Demonstrating how real-time analytics and sentiment analysis can improve QA monitoring and decision making processes in Saudi Arabian HEIs.

Presents a case study evaluation using qualitative feedback from experts to validate the usability, adaptability, and effectiveness of the developed BI dashboard.

Outlining future improvements such as the use of AI-driven analytics for predictive monitoring capabilities.

The paper is structured as follows: Section 2 provides a detailed review of the literature including the principles of Human-Computer Interaction (HCI) and existing BI dashboard evaluation methodologies. Section 3 outlines the study's aim and objectives and outlines the usability evaluation mechanism. Section 4 discusses the methodology adopted for dashboard evaluation in the context of HE. Section 5 presents the case study results and experts' feedback on the usability and effectiveness of the developed dashboard. Section 6 discusses the findings of the analysis, while Section 7 outlines the implications of the findings including the impact of managerial roles and HEI types on the usability of dashboards.

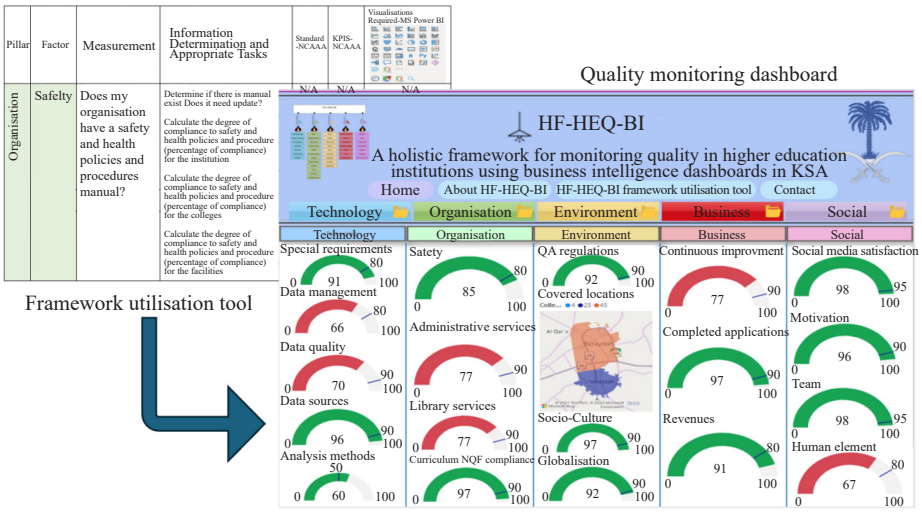

Figure 1. Dashboard development based on framework utilisation tool

2. Literature review

2.1 *Human-computer interaction (HCI)*

Nielsen [7] suggested that Human-Computer Interaction (HCI) refers to the usability of the information system. Several authors have suggested that understanding the relationship between the users and the information systems interfaces is important in order to design systems that are considered 'user friendly' [7-10].

Data visualisations provided by Business Intelligence (BI) dashboards require human intervention to obtain the benefit of these visualisations [8, 9]. This intervention depends on the type of information and the level of details required to be displayed and visualisations that might need to drill down for more insightful data. In addition, users can also decide on the colour coding required to present the data easily without the need to refer back to legends in order to understand the information presented in the visualisations. With regard to usability in BI, users need to interact with an application in a way that ensures that their decision-making is not hindered because of the complexity of the interface [8].

For the purpose of developing BI dashboards, Oppl and Stary [11] suggested that Human-Centred Design (HCD) is useful for developing diagrammatic representation schemes illustrating requirements such as usability. The HCD facilitates the involvement of end users with little or no modeling experience in the design process [11]. The involvement of end users during the design is helpful in enhancing the usability of the information system [12]. The HCD process illustrated in Figure 2 shows the four main activities of the process: (1) specifying the context of use, (2) specifying the requirements, (3) creating design solutions, and (4) evaluating these designs. This approach is also suggested by the ISO 13407 standard [13].

The HCD process illustrated in Figure 2 can be used for the development of BI systems in HE. The four main activities of the HCI design for developing BI systems based on the proposed HF-HEQ-BI framework in HE. The process activities are as follows:

1. Specifying the context of use: throughout this activity, the HEI must determine the QA aspects which need to be monitored throughout the dashboard. In this research, the HF-HEQ-BI framework is assumed to guide HEIs in determining the areas that will be monitored in order to assure quality. The HF-HEQ-BI utilisation tool presented in Figure 1 will allow the users to specify the QA context of the dashboard.

2. Specifying the requirements: the BI system requirements will be identified by the HEI. During this stage, the HEI will decide which BI architecture they may wish to adopt, data sources, KPIs, etc. The determination of the relevant BI architecture module can be determined by the HEI using the alternatives approach illustrated in Figure 2. The alternatives approach allows HEIs to determine the appropriate BI architecture module (Data Warehouse-based Business Intelligence, Service Oriented Business Intelligence (SoBI), Self-Service Business Intelligence (SSBI) based on their IT

infrastructure, size, and available technologies.

3. Produce the design solutions: the BI dashboard development will depend upon the information obtained through the requirements specified in 2 (above).

4. Evaluate the designs: during the evaluation process, the BI system will be assessed in order to decide whether the system meets the requirements. BI Scorecards may be used for the purpose of the evaluation process [10].

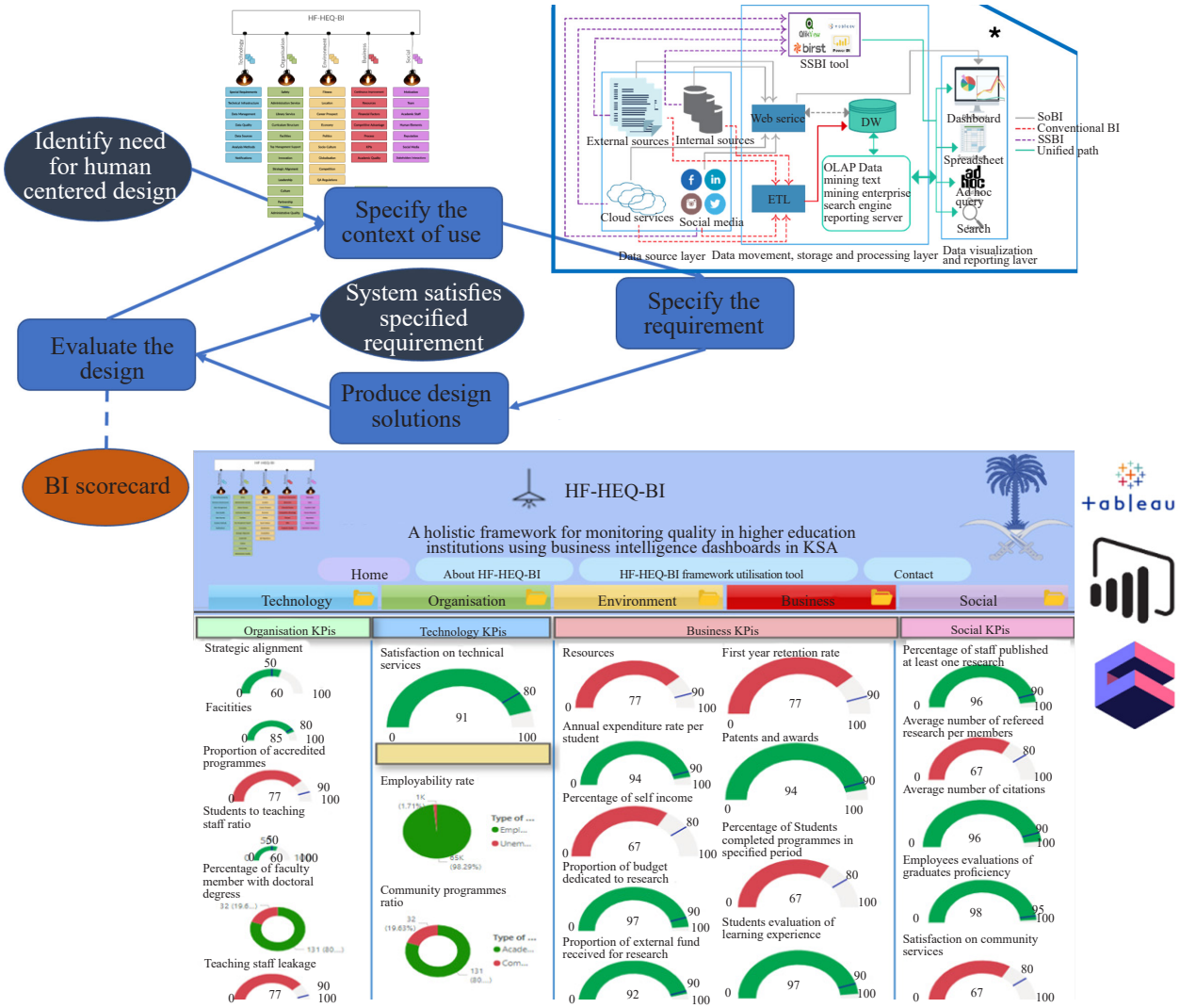

Figure 2. Human centred design process for BI systems in higher education with 'swap-in alternatives' (includes DW business intelligence architecture, SoBI architecture, and SSBI architecture) to populate the BI dashboard
Alternatives approach for business intelligence architectures in higher education institutions

2.2 *Dashboard evaluation in HEIs*

In the context of HEIs in KSA, QA monitoring is currently conducted through annual audits using checklists designed in spreadsheet format. The process of monitoring compliance with NCAAA encompasses compliance with 8 QA standards and 20 mandatory KPIs as per the latest regulations published by the NCAAA in 2022 [14]. The QA monitoring process is undertaken by obtaining analytics from different sources (including manual surveys and portal-based surveys) in the HEI. The results are summarised to indicate the degree of compliance and to monitor deviations. The developed BI dashboard for monitoring QA in HEIs will replace manual audits conducted to assure quality. The

HEIs will be able to interactively monitor QA performance through the BI dashboard and determine areas for action where the performance is not satisfactory. When using manual audits conducted on an annual basis, the HEIs are not able to determine unsatisfactory performance until the next audit, which is completed in the next academic year (as the audits are usually conducted annually). Dashboards developed based on the HF-HEQ-BI framework will be linked to the HEI's Information System, meaning that the data displayed in the dashboard will be updated automatically, allowing for continuous monitoring. The use of BI dashboards in monitoring QA in HEIs in the KSA conforms with the trend of utilising BI dashboards for monitoring in several governmental agencies.

The dashboard built using the HF-HEQ-BI Framework will be able to highlight the NCAAA mandatory KPIs and help decision-makers track compliance with the 8 NCAAA standards for QA. The next section discusses the evaluation of a dashboard for monitoring QA in HEIs in KSA that has been built using the HF-HEQ-BI Framework. The evaluation process includes the assessment of the dashboard developed through the HF-HEQ-BI by a panel of experts with experience in QA in HEIs. The dashboard presented in Figure 1 has been developed through the use of the HF-HEQ-BI Framework Utilisation Tool. This paper assesses whether the HF-HEQ-BI framework can assist in producing a dashboard that captures quality assurance requirements. An evaluation tool was developed for the purpose of the evaluation process using a BI Scorecard tool and Technology Acceptance Model (TAM) usability criteria. A case study was used for the purpose of evaluation of the prototype dashboard. This paper outlines the case study results of the evaluation process.

2.3 *Business intelligence systems evaluation*

Business Intelligence systems are often evaluated using Business Intelligence Evaluation Frameworks owned by consulting companies such as Gartner and Dresner Advisory Services [10].

Howson [15] has proposed the BI Scorecard for the purpose of providing a tool for evaluating BI systems by assessing the BI system against several criteria. Dyczkowski et al. [10] presented a comparison of selected frameworks for evaluating BI systems. The BI Scorecard is based on Norton and Kaplan Balanced Scorecards (BSC) Framework [10, 16] oriented towards Business Intelligence (BI). Dyczkowski et al. [10] defined BI Scorecards as a 'tool to support the evaluation process based on multi-level pre-defined breakdown structure of the evaluation criteria and scoring technique'. The BI Scorecard addresses 9 categories for evaluating the features of dashboards. The evaluation categories of BI Scorecard for dashboard evaluation are as follows: (1) Dashboard Layout, (2) Dashboard Design, (3) Presentation, (4) Alerting, (5) Analysis, (6) KPI/ Metrics, (7) Dashboard Interactivity, (8) Delivery, and (9) Architecture [10, 15, 17].

Balanced Scorecards (BSC) are used by High Income Countries (HICs) for the purpose of performance measurement [18]. BSC uses multi perspective measurements for the purpose of performance evaluation [18, 19]. In addition, it can be customised to meet the specific needs of performance evaluation [19]. Malagueno et al. [20] indicated that BSC is the most widely used management practice for performance monitoring.

Bach et al. [21] suggest that the Technology Acceptance Model (TAM) can be utilised for the purpose of evaluating BI systems. Chen [22] used TAM to investigate the users' acceptance of Educational Intelligence (EI) systems which are based on BI. Poropat [23] adopted TAM for evaluating users' motivation for using BI systems. Bach et al. [21] proposed a model for BI acceptance factors in USA companies based on the TAM model. Abormegah and Tarik [24] adopted TAM for evaluating BI tools in terms of usability characteristics by interviewing professionals from different industries. The evaluation of BI dashboards includes examining the user interface for the purpose of determining the acceptance of the BI dashboard and the willingness of users to use it. Therefore, the TAM model will be used for the purpose of developing the evaluation criteria for the purpose of this research project.

BI Scorecards are the standard evaluation tool for BI systems [10, 25]. The literature indicates that research on BI systems evaluation tools is limited and that most authors use the BI Scorecard approach. Therefore, BI Scorecards and TAM Usability criteria were used to adopt the evaluation tool in this research project. The evaluation tool used in this research was adapted to take into consideration evaluation of elements that are not included in the BI Scorecard such as Sentiment Analysis. Table 1 outlines evaluation criteria for the BI Scorecard approach (based on Howson in 2008) and TAM Usability criteria. Table 1 shows that most of the TAM Usability criteria can be mapped to BI Scorecard Criteria. Each evaluation criteria mapped to TAM Usability has been assigned the same colour code as shown in Table 1.

Table 1. Comparison of selected business intelligence evaluation frameworks

Evaluation Tool/ Criteria	BI scorecard	Definition on BI scorecard	TAM usability
Evaluation criteria	Dashboard layout	Multiple objects are presented on the display, the ability to resize objects, and multiple data sources are presented on the dashboard.	Easy to use
	Dashboard design	Use of consistent formatting, provides web-based design environment, and ease of design.	Easy to learn
	Presentation	Use of conditional formatting and presenting multiple visualisations.	
	Alerting	Present visual display of exceptions, email notifications, and Really Simple Syndication (RSS) feed.	Usefulness
	Analysis	Refers to whether the dashboard provides time-based analysis, ranking, asymmetrical reporting, and what-if analysis.	
	KPI/Metrics	The dashboard allows users to enter targeted KPIs and provides multiple targets per metric and shows a user defined KPIs.	Comprehensiveness
	Dashboard interactivity	Refers to whether the dashboard allows user to drill-down, drill-through, apply filters to data, sort, and organisation of data in the dashboard, use of sliders for navigation, and overall usability of the dashboard.	Adaptability
	Delivery	The dashboard can be exported to several file formats (such as Excel, PDF, PowerPoint, etc.).	
	Architecture	Refers to the BI architecture used for the development of the dashboard.	
		Refers to whether the user would use the proposed BI system if they are in a position to do so.	Intention to Use

3. Study aim and objectives

The aim of this study is to '*assess the approach of using the HF-HEQ-BI framework to support the development of a prototype dashboard to monitor QA*'. This evaluation process aims also to determine whether the designed prototype dashboard based on the HF-HEQ-BI framework enhances usability, efficiency, and functionality in QA monitoring. The objectives of this study are as follows:

1. Assess the usability and user acceptance of the developed prototype dashboard in terms of ease of learning, ease of use, and usefulness for QA monitoring.

2. Evaluate the ability of the dashboard to incorporate and visualise essential KPIs, including both national QA KPIs and institutional specific KPIs to enable real time monitoring.

3. Determine whether the HF-HEQ-BI framework facilitates monitoring compliance with QA requirements in Saudi Arabia and add value in comparison to annual audits conducted by HEIs.

To support the evaluation of the dashboard described in this paper, a panel of experts in Quality Assurance (QA) in Higher Education (HE) in KSA engaged in the demonstration and their feedback on the prototype dashboard was obtained. The selection criteria for the panel of experts were as follows:

1. The expert must have 10+ years in Quality Assurance in Higher Education.

2. The expert must be working/have worked in a Higher Education Institution in the Kingdom of Saudi Arabia.

3. The expert is aware of the QA and accreditation process and requirements of Higher Education Institutions in the Kingdom of Saudi Arabia.

Usability evaluations of newly released Information Technology (IT) solutions are essential for the purpose of assuring that the IT system is easy to use, efficient, effective, and achieves the required objectives [26] efficient, and effective to reach goals, and satisfactory to users. For example, when a software company wants to develop and sell a new product, the company needs to evaluate usability of the new product before launching it at a market to avoid the possibility that the new product may contain usability problems, which span from cosmetic problems to severe functional problems. Three widely used methods for usability evaluation are Think Aloud (TA). It was suggested by Nielsen [15] that the number of usability problems found through usability tests by incorporating 'n' users in the test can be expressed by the following function:

$$N = \left(1 - (1 - L)^n\right) \tag{1}$$

Where N: total number of usability problems found in the design (expressed as percentage of usability problems found through testing); L: proportion of usability problems found by single user testing.

Nielsen [27] suggested that the typical value of L is 31% based on their results in previous studies. Depicting 31% in Equation 1 will lead to the curve outlined in Figure 3.

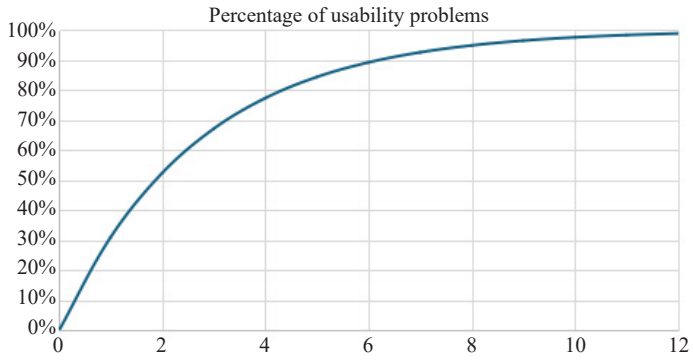

Figure 3. Probability of usability problems

As illustrated in Figure 3, single user testing may lead to the identification of 31% of usability problems, and 5 users testing may address up to 84% of usability problems. Sánchez Prieto et al. [28] suggested the use of six evaluators for using TAM model in evaluating educational development technologies. Li and Helenius [29] suggested that six evaluators are usually sufficient to address most usability problems. Therefore, for the purpose of this research project, the Sánchez Prieto et al. and Li and Helenius approach is followed and eight academics who met the selection criteria were identified.

4. Methodology

For the purpose of achieving the aim of this study, a BI evaluation tool has been developed. The evaluation criteria selected for the purpose of this study are outlined in Table 2. The evaluation criteria outlined in Table 2 were incorporated into a Microsoft Excel sheet to allow participants to evaluate the dashboard as outlined in the Evaluation Template Tool section of this paper. The reason for excluding 'Delivery' (which is related to exporting files), from the selected evaluation criteria is because the delivery method is not the primary objective of the prototype dashboard. In addition, 'Architecture' has been excluded since it is not relevant to evaluate the BI architecture as HEIs differ in their size, capabilities, and IT infrastructure as discussed in [6]. However, while this evaluation focuses on the usability of functionality in monitoring QA KPIs, the exclusion may limit the applicability of the evaluation tool in environments where 'Delivery' and 'Architecture' are considered important.

Table 2. Selected evaluation criteria for evaluating business intelligence dashboard

Evaluation criteria	Definition	Reference source
KPI/Metrics (Indices)	Refers to the inclusion of KPIs that measure essential activities within the organisation.	[15, 17, 30]
Sentiment analysis	Refers to whether the dashboard supports Sentiment Analysis for analysing data from Social Media.	[15, 17, 31-33]
Easy to learn	Refers to whether the dashboard is easy to understand and easy to use when searching for specific information.	[7, 9, 23, 24, 34]
Easy to use	Refers to whether the dashboard is easy to navigate in order to reach information quickly.	[7, 9, 23, 24, 35]
Usefulness	Refers to whether the proposed system will improve the performance within the organisation.	[7, 15, 17, 23, 24, 34, 35]
Comprehensiveness	The dashboard provides comprehensive (provides all information business needs) overview of business data.	[7, 30]
Adaptability	Refers to the degree to which the dashboard can be adapted to meet the specific needs of users.	[7, 15, 17, 36]
Intention to use	Refers to whether the dashboard is likely to be used in HEIs.	[7, 23, 24, 34]

The evaluation tool that was used for the purpose of evaluating the prototype dashboard has been developed using the HF-HEQ-BI Framework. Table 3 outlines the evaluation tool that the participants used for the purpose of dashboard evaluation. The evaluation tool uses the evaluation criteria outlined in Table 2. The evaluation tool is based on Balanced Scorecards (BSC) in terms of adopting multicriteria for evaluation that are non-financial metrics [16] and the BI Scorecard [17]. The BSC emphasizes a multi-perspective approach to performance measurement, which provides a foundation for the developed evaluation tool. For example, the developed evaluation tool contains several criteria such as 'ease of learning' and 'ease of use' foe evaluation of BI dashboards. The BI Scorecard is specifically designed to evaluate BI systems. Several evaluation criteria were incorporated into evaluation tool were based on the BI Scorecard as addressed in Table 2. The tool uses a 5-point Likert Scale to allow the evaluator to select the appropriate response for each evaluation criteria as outlined in Table 3 [9, 25, 37].

Table 3. Dashboard evaluation tool

Evaluation criteria	1	2	3	4	5
The dashboard provides analytics that cover NCAAA KPIs and Institutional KPIs	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The dashboard supports sentiment analysis for Social Media data	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The dashboard is easy to learn	Very difficult to learn	Difficult to learn	Not easy nor difficult to learn	Easy to learn	Very easy to learn
The dashboard is easy to use	Very difficult to use	Difficult to use	Not easy nor difficult to use	Easy to use	Very easy to use
The dashboard will be useful for monitoring NCAAA compliance	Not useful at all	Not useful but could be considered for use	Useful but would require modification	Useful	Very useful
The dashboard provides comprehensive coverage of QA requirements	Not comprehensive at all	Not sufficiently comprehensive	Fairly comprehensive	Comprehensive	Very comprehensive
The dashboard is adaptable to meet the specific requirements of users	Not adaptable at all	Not sufficiently adaptable	Fairly adaptable	Adaptable	Very adaptable
Intend to use	Very Unlikely	Unlikely	Neither Unlikely nor Likely	Likely	Very likely

5. Case study

The process of evaluation of the HF-HEQ-BI Framework is conducted through the application of a case study. Case studies are a widely used approach; Calitz et al. [37] used a case study in the evaluation of BI dashboards for Enterprise Resource Planning (ERP) systems using usability evaluations. In addition, Sakys et al. [38] used a case study approach for the application of their proposed framework in one university case study. The reason for using a case study for the purpose of evaluating the prototype dashboard is that the outcomes of the case study can be generalised to many other cases [39].

The case study used for the evaluation of the dashboard in this research project was modeled on a large HEI in KSA. The BI dashboard was designed at the institutional level and was based on the author's own experience in QA supported by cooperation from the institution. This allowed the research to present the participants with a realistic case study scenario that would be familiar and relevant to them to conduct tasks in terms of evaluating the usability of the HF-HEQ-BI framework. The institution has been anonymised for the purpose of confidentiality and all data presented in the prototype dashboard is a simulation. The design process of the prototype dashboard was discussed in detail by the authors in [6] and is illustrated in Figure 2. The BI dashboard was developed using Microsoft PowerBI. Several data sources such as statistics and social media were connected to the dashboard to ensure real time data updates. Different visualisations layouts were used for the purpose of presenting the KPIs in the dashboard.

5.1 *Dashboard features and design*

The BI dashboard was developed using Microsoft PowerBI, a widely used BI development platform for its visualisation capabilities and support of different data sources. The choice of PowerBI was based on the basic features it provides as follows:

1. Ease of integrating different data sources such as social media, spreadsheets, and cloud services.

2. It allows the creation of interactive reports and dashboards to suit the required purpose of monitoring QA requirements.

3. Supports dynamic data updates to ensure continuous monitoring of QA metrics.

The dashboard was designed to obtain data from multiple sources such as (1) institutional databases, (2) external QA reports, and (3) social media platforms. Data was pre-processed and formatted into standardised structure in order to ensure compatibility with the HF-HEQ-BI framework. SQL queries and Extract, Transform, Load (ETL) processes were implemented to clean and transform data into the PowerBI environment.

The BI dashboard for monitoring QA in HEIs was designed to include the following features:

1. Displaying QA metrics represented in KPIs visualisations such as bar charts, gauges, and trend lines.

2. Users can explore data by interacting with summarised metrics using the drill-down capabilities.

3. Public opinions expressed on social media were processed using Natural Language Processing (NLP) and visualised in the dashboard.

5.2 *Dashboard evaluation*

During the case study, the participants were given a standard demonstration and presentation of the prototype dashboard. The HF-HEQ-BI Framework Utilisation Tool was explained to the participants, and they confirmed that they understood how the tool can be used for the purpose of developing the dashboard. The participants understood the factors outlined in the HF-HEQ-BI framework and how they are related to the design of the BI system for monitoring quality in HE. Three of the participants involved in the demonstration were face-to-face while the other 5 participants were by video conference (because of the geographical size of KSA).

All participants showed an understanding of the process of developing the dashboard based on the HF-HEQ-BI framework and how the HF-HEQ-BI is used for this purpose through the Framework Utilisation Tool.

The NCAAA QA system in the KSA was explained to all participants and as all participants were working currently or previously in KSA HEIs, they were aware of the NCAAA requirements. Additionally, they were aware of the strategic management process that HEIs in KSA follow for the purpose of assuring quality and the adoption of additional institutional specific KPIs. The institutional QA manual and QA requirements for an anonymised KSA HEI were discussed in the demonstration with the participants in order to give them an understanding of the QA requirements of the case study and how the institution was assuring quality through the application of surveys and spreadsheets for measuring compliance. Participants were given the opportunity to navigate the dashboard and use the evaluation tool to evaluate the prototype dashboard. Participants who took part via Zoom were given control of the dashboard so they could use the dashboard interactively.

All the participants compared the visualisations provided in the prototype dashboard and the NCAAA KPIs. Additionally, the institutional specific KPIs were reviewed and compared to the visualised KPIs in the prototype dashboard together with an investigation of the Social Media analytics. Table 4 outlines the dashboard features that were evaluated by the participants in the case study. Each feature presented in Table 4 was incorporated into the dashboard for the purpose of achieving the expected outcome outlined in Table 4.

Table 4. BI dashboard features evaluated in case study

Feature	Description	Expected outcome
Real-time data updates	Automatically updates KPI metrics from connected data sources	Ensure continuous monitoring and reduce reliance on manual updates
KPIs visualisation	Presenting NCAAA and institutional KPIs in customisable layout	Provide comprehensive overview of compliance metrics in a single interface report
Sentiment analysis	Analyse and visualise opinions expressed in social media to evaluate institutional public image	Understanding public perceptions and identifying satisfaction trends
Drill-Down capabilities	Allowing users to explore detailed data behind summarised metrics	Facilitate analysis of root causes of existing non-compliance issues
User Interface design	Intuitive layout with filters	Provide an easy to use interface

The evaluation process was administered as follows:

1. Demonstration of BI dashboard

Participants attended a detailed demonstration of the BI dashboard. All features of the BI dashboard as in Table 4 were discussed with participants. All participants were given the opportunity to navigate the dashboard and shown understanding of the BI dashboard features.

2. BI Dashboard Interaction

All participants interacted with the BI dashboard independently. Each participant performed tasks such as:

Interpreting QA compliance metrics

Filtering KPIs

Exploring drill-down features

3. Obtaining Feedback

A 5-points Likert scale was used to evaluate the BI dashboard based on criteria presented in Table 4.

Figure 4 shows the types of HEIs where participants were working in i.e., Private, Public and/or Public/Private. Out of 8 experts who participated in the evaluation process, 4 worked in Public HEI, 3 have worked in both Public and Private HEIs, and 1 of them only worked in Private HEI. Table 5 summarises the participants' experience in HE and the type of institutions where they have been working. All the participants details were anonymised, and they have been assigned participant number as shown in Table 5. As seen in Table 5, the average years of experience in HEIs for participants was 17 years in KSA HEIs and 5.6 years in HEIs outside KSA.

Table 5. Case study participants details

Participant	HEI experience	Countries of experience	Academic level	Managerial level	HEI type
P1	32 Years in KSA 9 Years outside KSA	KSA, Sweden Algeria, Egypt	Professor	Head of department	Public/Private
P2	14 Years in KSA	KSA	Associate professor	College dean	Public/Private
P3	11 Years in KSA	KSA	Assistant professor	Head of department	Public
P4	25 Years in KSA	KSA	Professor	Vice chancellor consultant	Public/Private
P5	13 Years in KSA 15 Years outside KSA	KSA Egypt	Professor	Programme director	Public/Private
P6	17 Years in KSA 7 Years outside KSA	KSA UAE	Lecturer	Unit head	Public
P7	13 Years in KSA	KSA	Assistant professor	Unit head	Private
P8	9 Years in KSA 14 Years outside KSA	KSA Egypt	Professor	Head of department	Public

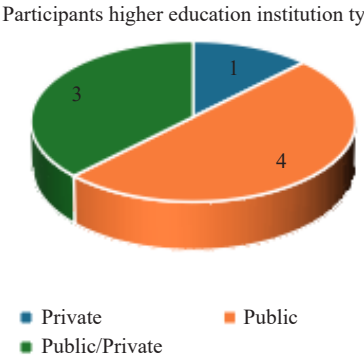

Figure 4. Higher education institution type of participants

6. Analysis and results

This section discusses the case study results based on participants' evaluation of the developed dashboard. Participants provided insightful feedback regarding the usability of the BI dashboard. All participants appreciated the dashboards' ability to present QA KPIs comprehensively and found it beneficial for tracking real time QA metrics. However, some participants suggested adding features to the dashboard such as filtering and customisable visuals to align with user preferences. Also, some participants noted that training sessions for QA staff might be required to improve usability. Table 6 outlines the average, maximum, and minimum scores based on participants' selection.

Table 6. Participants evaluation of the prototype dashboard

Evaluation criteria	Average response	Minimum score	Maximum score
Analysis	4.50	3	5
Social media	4.63	4	5
Easy to learn	4.50	3	5
Easy to use	4.63	4	5
Usefulness	4.38	3	5
Comprehensiveness	4.38	3	5
Adaptability	4.13	3	5
Intention to use	4.75	4	5

Figure 5 illustrates the ranges of responses discussed in Table 6 and the average score for each evaluation criteria based on participant selection. Figure 5 shows that 'Analysis', 'Easy to Learn', 'Usefulness', 'Comprehensiveness', and 'Adaptability' criteria received an evaluation score ranging between 3 and 5 with an average score rates of 4.50, 4.50, 4.38, 4.38, and 4.13 respectively. The remaining evaluation criteria 'Social Media', 'Easy to Use', and 'Intention to Use' was evaluated with a score ranging between 4 and 5 and an average score of 4.63, 4.63, and 4.75 respectively.

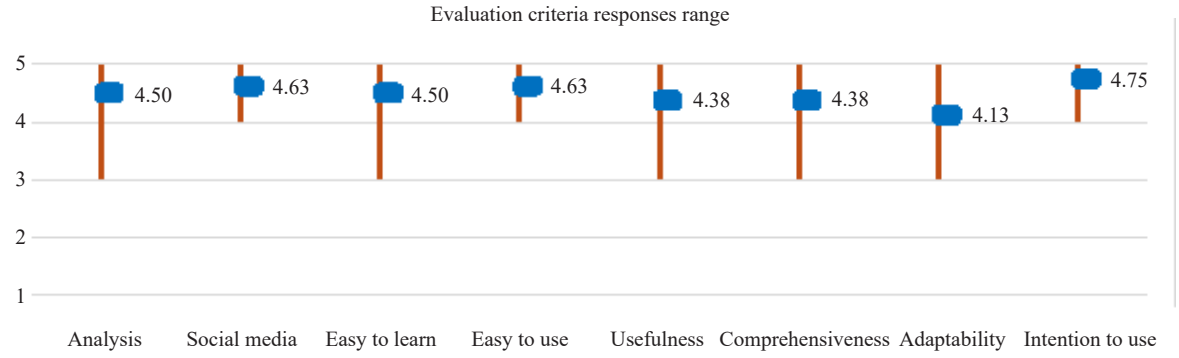

Figure 5. Participants response range for evaluation criteria

Figure 6 illustrates the overall evaluation of the prototype dashboard depicted in a radar diagram. Figure 6 shows that all average scores were between 4 and 5. Therefore, none of the evaluation criteria have an average score of less than 4 out of 5 points. For the purpose of determining whether there are statistically significant differences in mean scores between responses obtained from participants, t-test was conducted. Responses have been evaluated to determine whether differences exist based on the participants' (1) country of experience, (2) HEI type, and (3) managerial level.

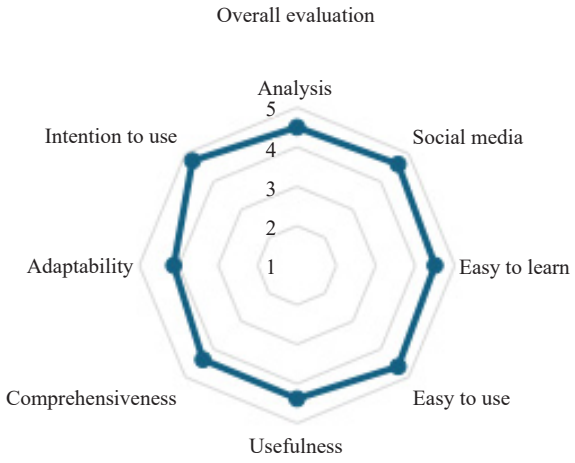

Figure 6. Radar diagram of dashboard evaluation criteria

Figure 7 shows a radar diagram illustrating the evaluation score averages for each evaluation criteria. The radar diagram shows two lines. The blue depicts the averages for participants who have worked in KSA HEIs only while the orange depicts the averages for participants who have worked in KSA and other countries. It can be shown on Figure 7 that averages for each evaluation criteria are ranging between 4 and 5.

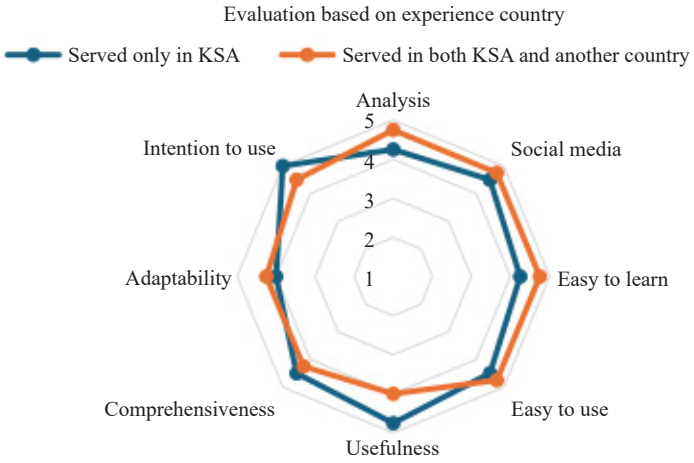

Figure 7. Dashboard evaluation based on country of experience

Table 7 shows the average scores for each evaluation criterion based on the countries where participants worked in HEIs. Average scores for dashboard evaluation criteria from participants who have their work experience in KSA only was ranging from 4.00 to 5.00. Average scores for dashboard evaluation criteria from participants who have worked in KSA HEIs and in other countries was ranging from 4.00 and 4.75. Statistical analysis through t-test indicated that there were no statistically significant differences between the average responses obtained from participants who worked in KSA only and participants who had worked in both KSA and other countries. All values obtained from t-test were not statistically significant at 95% confidence level as shown in Table 7.

Table 7. Average evaluation scores based on country of experience

Evaluation criteria	Mean ± SD		*t*-Value	*P*-Value ≤ 0.05
	Experience in KSA only	Experience in KSA and outside KSA		
Analysis	4.25 ± 0.96	4.75 ± 0.50	-0.926	0.390
Social media	4.50 ± 0.58	4.75 ± 0.50	-0.655	0.537
Easy to learn	4.25 ± 0.96	4.75 ± 0.50	-0.926	0.390
Easy to use	4.50 ± 0.58	4.75 ± 0.50	-0.655	0.537
Usefulness	4.75 ± 0.50	4.00 ± 0.82	1.567	0.168
Comprehensiveness	4.50 ± 1.00	4.25 ± 0.50	0.447	0.670
Adaptability	4.00 ± 0.82	4.25 ± 0.50	-0.522	0.620
Intend to use	5.00 ± 0.00	4.50 ± 0.58	1.732	0.134

Figure 8 illustrates the evaluation score averages based on the type of HEI where the participants were working. The blue line depicts average score for participants who were working only in Public HEIs while orange shows the averages for participants who had worked in both Public and Private HEIs. Figure 8 indicates that the evaluation score averages for all evaluation criteria were ranging from 4.00 to 4.75.

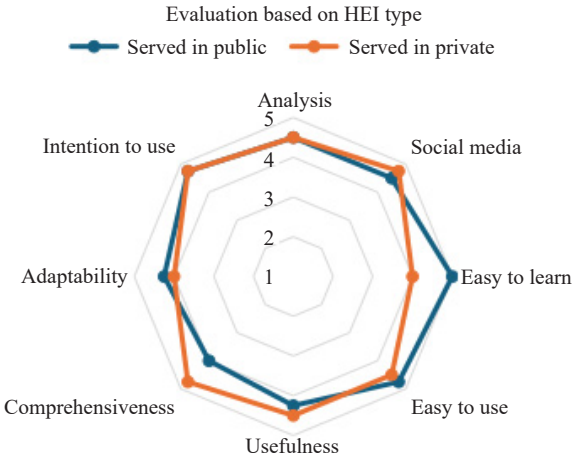

Figure 8. Dashboard evaluation based on higher education institution type

Table 8 outlines the average score received for each evaluation criteria based on the type of institution where the participant was working. Participants who had worked in Public HEIs evaluated the dashboard based on the evaluation criteria and gave an average score ranging between 4.00 and 5.00. Participants have worked in both Public and Private HEIs scores were ranging from 4.00 to 4.75. The results obtained from t-test indicate that 'Analysis', 'Social Media', 'Easy to Use', 'Usefulness', 'Comprehensiveness', 'Adaptability', and 'Intention to Use' evaluation criteria averages were not significantly different between responses obtained from participants working in Public institutions and participants who had worked in Public and Private institutions. However, 'Easy to Learn' criteria were statistically significant different as the average score was (5.00) for participants who had worked only in Public institutions in comparison to an average of (4.00) for participants who worked in both Public and Private institutions.

Table 8. Average evaluation scores based on higher education institution type

Evaluation criteria	Mean ± SD		*t*-Value	*P*-Value ≤ 0.05
	Public/Private	Public		
Analysis	4.50 ± 0.58	4.50 ± 1.00	0.000	1.000
Social media	4.75 ± 0.50	4.50 ± 0.58	0.655	0.537
*Easy to learn**	4.00 ± 0.82	5.00 ± 0.00	-2.449	0.050
Easy to use	4.50 ± 0.58	4.75 ± 0.50	-0.655	0.537
Usefulness	4.50 ± 0.58	4.25 ± 0.96	0.447	0.670
Comprehensiveness	4.75 ± 0.50	4.00 ± 0.82	1.567	0.168
Adaptability	4.00 ± 0.82	4.25 ± 0.50	-0.522	0.620
Intend to use	4.75 ± 0.50	4.75 ± 0.50	0.000	1.000

Figure 9 illustrates the average scores of evaluations of the prototype dashboard. The blue line shows the averages for participants who have worked in a top managerial position. The orange line shows the average scores for participants who have worked in lower managerial position in HEI. For the purpose of this research project, all participants with work experience as or above a Head of Department were considered top management level as they usually participate in long-term managerial activities such as strategic planning and are attending college councils. Figure 9 shows that all evaluation criteria averages were between 4 and 5.

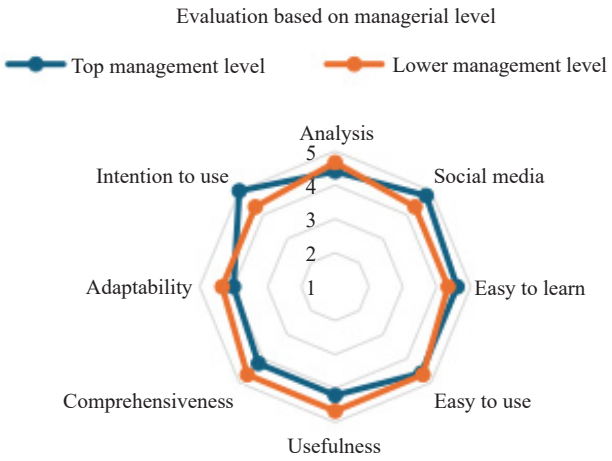

Figure 9. Dashboard evaluation based on managerial level of participant

Table 9 shows the average evaluation scores for the dashboard evaluation criteria based on the managerial level of participants. Top Management Level participants average evaluation of the dashboard was ranging between 4.00 and 5.00. Lower Management Level participants average evaluation score was ranging between 4.33 and 4.67. The results of t-test indicated that the differences in average responses obtained from participants working in lower managerial level and participants working in higher managerial levels were not significantly different for all evaluation criteria except 'Intend to Use'. As shown in Table 9, 'Intend to Use' average response evaluation was higher for participants who were working in Higher Managerial Positions (5.00) compared to participants worked in Lower Managerial Positions (4.33).

Table 9. Average evaluation scores based on managerial level of participant

Evaluation criteria	Mean ± SD		*t*-Value	*P*-Value ≤ 0.05
	Lower managerial position	Higher managerial position		
Analysis	4.67 ± 0.57	4.40 ± 0.89	0.455	0.665
Social media	4.33 ± 0.57	4.80 ± 0.45	-1.292	0.244
Easy to learn	4.33 ± 1.15	4.60 ± 0.55	-0.455	0.665
Easy to use	4.67 ± 0.58	4.60 ± 0.55	0.164	0.875
Usefulness	4.67 ± 0.58	4.20 ± 0.83	0.841	0.433
Comprehensiveness	4.67 ± 0.58	4.20 ± 0.83	0.841	0.433
Adaptability	4.33 ± 0.58	4.00 ± 0.71	0.685	0.519
*Intend to use**	4.33 ± 0.58	5.00 ± 0.00	-2.739	0.034

7. Discussion

The evaluation of the BI dashboard which has been developed using the HF-HEQ-BI framework indicated that the prototype dashboard provides the required '*Analysis*' of QA data, supports '*Sentiment Analysis*' of Social Media data, '*Easy to Learn*', '*Easy to Use*', '*Useful*' if used for monitoring QA in HEI, '*Comprehensive*' to cover the NCAAA requirements and institutional KPIs, and '*Adaptable*'. In addition, participants indicated that they '*Intend to Use*' such a

dashboard for monitoring quality in their HEIs if they were in the position to authorise it in their institution.

All dashboard evaluation criteria averages ranged between 4.13 and 4.75 which indicates that the prototype dashboard that has been built using the HF-HEQ-BI Framework is able to capture the elements required for monitoring QA in HEIs in KSA. This, in turn, indicates that the HF-HEQ-BI Framework meets its objectives of identifying the factors that are required to monitor QA in HEIs using Business Intelligence Dashboards. The NCAAA KPIs, institutional KPIs, and sentiment analysis of Social Media data are all included in the dashboard developed through the utilisation of the HF-HEQ-BI Framework.

For the purpose of determining whether there were statistically significant differences between groups of participants, a t-test was conducted. The results of the t-test indicate that there were no significant differences in the average evaluation scores between the participants that can be attributed to countries where the participants were working (UAE, Egypt, Sweden and Algeria). The results of t-test indicated that there are statistically significant differences between average evaluation scores of participants for the 'Easy to Learn' criteria that can be attributed to the HEI type where the participants were working as the average score was higher for participants who had worked in Public institutions only in comparison to on average score of participants who had worked in both Public and Private HEIs. In addition, the 'Intend to Use' criteria averages were statistically different between participants based on their managerial positions. Participants who worked in higher managerial position (Head of Department or above) were more likely to use the dashboard as the average score was (5.00) in comparison to participants who worked in lower managerial positions (below Head of Department) as the average score was (4.33). This might indicate that academics working in higher managerial positions are more interested in the type of reports provided by the BI dashboard in comparison to those who are working in lower managerial positions. However, all other evaluation criteria differences were not significant based on the HEI type or managerial position. Therefore, it can be concluded that 'Analysis', 'Social Media', 'Ease of Learn', 'Ease of Use', 'Usefulness', 'Comprehensiveness', and 'Adaptability' of the BI dashboard are not affected by the managerial position of the academic using the BI dashboard. In addition, 'Analysis', 'Social Media', 'Ease of Use', 'Usefulness', 'Comprehensiveness', 'Adaptability', and 'Intention to Use' of the BI dashboard are not affected by the type of HEI where the user of BI dashboard works. This suggests that the underlying framework has captured the required elements for QA in HEIs in KSA.

Participants who have work experience in Public HEIs only found the use of dashboards more 'Easy to Learn'. This result may indicate that the use of BI dashboards in public agencies in the KSA may have an impact on learnability as the participants can interact with different dashboards published in public agencies such as the Ministry of Education. In addition, participants who worked in lower managerial positions and also had teaching responsibilities were expected to be less interested in using the dashboards in comparison to participants working at higher managerial levels.

Two participants suggested the need for training of QA staff in HEIs to be able to use the functionalities of the dashboard. Additionally, all participants were satisfied with the presentation of the NCAAA KPIs on one screen suggesting that it provides a view of QA performance in the HEI. Social Media analytics provided by the dashboards were found useful for providing analytics related to public opinions expressed by stakeholders in Social Media.

The results of the case study indicated that all dashboard evaluation criteria received an average score ranging between 4 and 5. This indicates that the prototype dashboard is usable based on the evaluation criteria and achieves the required purpose. Therefore, the second research question '*Can a Holistic Framework for Monitoring Quality in Higher Education in the KSA using Business Intelligence Dashboards assist in Monitoring Quality in HEIs?*' has been addressed.

The relative weight of different metrics was considered based on the participants' feedback. For example, participants in higher managerial roles tend to emphasis 'Adaptability' and 'Comprehensiveness', while other participants in lower management levels emphasised 'Ease of Use' and 'Intention to Use'. These differences in priorities suggest that evaluation criteria might be weighted according to user roles and managerial level. Future studies could explore weighting methods to reflect the priorities among different user groups.

Future work on the use of Artificial Intelligence (AI) Transformers such as the ChatGPT prototype has been developed in conjunction with BI dashboards for both public and private HEIs for monitoring Learning Outcomes (LOs) [40].

8. Conclusion

This paper presents the development of an evaluation tool for a BI dashboard designed using the HF-HEQ-BI framework to monitor QA in HEIs in Saudi Arabia. The evaluation process was conducted through a structured case study. The case study demonstrated the dashboard's effectiveness in providing real-time analytics, KPI monitoring, and sentiment analysis. Feedback obtained from eight experts in QA highlighted the dashboard's usability, adaptability, and alignment with institutional QA needs. Key findings indicated high satisfaction across various criteria in features such as 'Ease of Use' and 'Comprehensiveness'. These results validate the HF-HEQ-BI framework's potential to replace traditional manual audits to ensure compliance with QA standards and support decision making process. The evaluation also showed areas for improvement in the BI dashboard. Experts suggested that there is a need for improved customisation features to satisfy diverse institutional requirements. They also suggested offering training programmes to improve dashboard adoption among QA staff in HEIs.

Future research should focus on refining the HF-HEQ-BI framework by incorporating Artificial Intelligence (AI). AI-driven analytics such as predictive modeling improve the dashboard monitoring capabilities. Additionally, the use of Natural Language Processing (NLP) for advanced sentiment analysis on different types of data sources could further improve the dashboard's capabilities. Additionally, future work will include the integration of the BI dashboards with institutional management systems to assist in monitoring QA metrics for programmes awarded by the institution. This will include the assessment of Learning Outcomes (LOs) for the courses provided in these programmes.

Conflict of interest

The authors declare that they have no conflict of interest.

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