

Original Research Paper

# A Conceptual UX Model for Designing and Developing the Business Intelligence Dashboards

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**Abstract:** Interactive dashboards are becoming increasingly popular for aiding users with data discovery and BI analysis. As UX is an important factor in developing Business Intelligence (BI) dashboards, the majority of current research centers around the evaluation of the User Experience (UX) in Business Intelligence (BI) dashboards, but there are only a few studies that focus on the UX aspect of designing and developing such dashboards and most of the dashboards were developed without considering the human aspects. Therefore, the absence of UX in dashboard development can make it difficult for users to understand and fully utilize the dashboard, which leads to a lack of effectiveness. Therefore, there is a need to consider UX factors while designing and developing BI dashboards. The main aim of this study is to develop a UX Model by including both user experience and business intelligence dashboard elements for designing and developing the BI dashboards. In this research, we proposed a user experience by considering the elements of UX and BI dashboards from the existing literature, validated the model by conducting FGD, and analyzed FGD comments by applying the thematic analysis method. Based on the result after conducting analysis we updated the proposed model. The developed model can guide the developer while designing and developing the BI dashboard.

**Keywords:** User Experience, Usability, Business Intelligence Dashboards, Data Visualization, Thematic Analysis

## Introduction

BI systems are software applications designed to help companies and organizations make informed strategic business decisions. Using data analysis through BI systems can enhance a company's competitiveness in its industry (Jooste *et al.*, 2018). The purposes of BI systems include increasing productivity, developing the company, improving customer relations, lowering costs, and making strategic business decisions (Eriksson and Ferwerda, 2021). To ensure effective use of BI systems in making informed strategic business decisions, the systems' interfaces should be user-friendly and accessible. User experience (UX) is a crucial aspect in determining the effectiveness of BI systems, which refers to the end user's perception of using the system (Hassenzahl and Tractinsky, 2006), including their previous experiences, emotions, mental and physical reactions, expectations and goals for using the system. The functionality, presentation, performance, interactivity, and usability of

the software system all impact the user's perceived experience (Eriksson and Ferwerda, 2021).

UX design aims to develop a simple and efficient dashboard design that enables users to interact with them effectively, resulting in higher productivity (Eriksson and Ferwerda, 2019). Many researchers have shown that UX procedures attempt to design systems efficiently and effectively, which is in accordance with usability that aims to achieve effectiveness, efficiency, and satisfaction in attaining particular goals (Persada, 2018). Usability depends on a successful UX; thus, both are crucial for good interactive design and a satisfying user experience (Jooste *et al.*, 2018). Where dashboards are segmented into various sub-modules based on the type of user, their requirements, and the kinds of decisions they make. The research on visual analytics also defines that the dashboard should display accurate information that is simple to read and extract (Burnay *et al.*, 2020), with a fast and easy loading time, simple to understand, interactive, adaptable, and not too expensive (Noonpakdee *et al.*, 2018).

Usability and end-user satisfaction are critical UX aspects as BI systems are utilized to make significant business decisions (Bouchana and Idrissi, 2015; Eriksson and Ferwerda, 2021; Jooste *et al.*, 2018).

In the context of dashboards, the level of interactivity provided to users depends on the purpose and features of the dashboard. It is crucial to maintain a balance between the complexity and usability of dashboards, as excessive features and feedback can negatively impact decision-making. Therefore, the dashboard must provide the user with the required information instead of presenting them with excess data.

To ensure that the dashboard provides the user with the required information, user aspects should be considered from the initial stages of developing BI systems. This includes understanding the user's needs, preferences, and the types of decisions they make. Incorporating the user aspects from the beginning of dashboard development will meet the user requirements and result in a positive user experience. UX is an important factor in BI dashboards to create intuitive visualizations, organize information efficiently, promote user engagement through interactive elements, increase user satisfaction, and increase decision-making which helps to increase the overall productivity of the organization and contributes to the organization's success.

Although there are various studies exploring UX in different domains, not many dashboards are developed based on UXD (Magnus and Rudra, 2019). This is a significant issue since the lack of UXD elements can affect the dashboard's usability, leading to a negative user experience. This is not just due to irrelevant data being included, but also because poorly designed visualizations can lead users to make incorrect decisions (Orlovskiy and Kopp, 2020). Therefore, it is essential to incorporate UXD elements when developing dashboards to ensure that users can make informed decisions quickly and easily.

A new UX model is required to assist developers in making interactive Business Intelligence (BI) dashboards that aid decision-making. This model included both UX factors and BI dashboard elements which guide during the dashboard development process. In this research, we proposed a UX model for BI dashboard development, based on previous literature studies. Then we validated this model by conducting focus group discussions and incorporating feedback from experts to revise the proposed UX Model. This research aims to enhance the UX in the BI dashboard domain and guides developers in creating effective BI dashboards.

### *User Experience*

Human-Computer Interaction (HCI) has expanded into various fields, including digital technologies in culture and media, as well as interaction/user experience (UX) design consultancy work in homes and workplaces

(Jooste *et al.*, 2018). The International Organisation for Standardisation (ISO) defines user experience (UX) as the end user's perception of a product, by considering their prior experiences, expectations, and goals (Eriksson and Ferwerda, 2021). UX design aims to create enjoyable, efficient, relevant, and overall positive experiences for users, focusing on their perspectives while interacting with interactive software products (Burnay *et al.*, 2020). UX also takes into account human aspects such as emotions, physical and mental reactions (Eriksson and Ferwerda, 2021; Jooste *et al.*, 2014), beliefs, preferences, perceptions, behavior (Persada, 2018) and accomplishments that occur before, during, and after product use (Quiñones *et al.*, 2018).

In today's business environment, a good UX is becoming increasingly important for an organization's success. By identifying new opportunities and implementing effective strategies based on insight, businesses can make informed decisions that promote growth and benefit the company. There are different UX factors stated in different studies followings are the studies which stated UX factors like Relatedness, stimulation, competencies, security, autonomy, influence/popularity (Schulze and Krömker, 2010) User belief, physiological, ideology, psychological, Cognitive action (Persada, 2018) playability, communicability, and learnability (Quiñones *et al.*, 2018; Sivaji *et al.*, 2014; Smuts *et al.*, 2015). Memorability, engagement, enjoyment (Saket *et al.*, 2016) Visibility, flexibility, error control (Sivaji *et al.*, 2014) and help, operability, task completeness, task-times and satisfaction, usability (Jooste *et al.*, 2014; Smuts *et al.*, 2015), End-user satisfaction (Timeliness, Accuracy, Ease of use) (Bouchana and Idrissi, 2015), User need, Existing Experience, Expectations (Zahidi *et al.*, 2014).

### *Business Intelligence Dashboard*

Howard Dresner, an analyst at Gartner Group, introduced the term "Business Intelligence" (BI) in the mid-1990s (Azeroual and Theel, 2019). Business Intelligence (BI) is a technology-driven process for analyzing data to provide useful information for the executives, managers, and employees, which enables them to make informed decisions that can positively impact the company's performance by increasing productivity, reducing costs and enhancing customer relations (Eriksson and Ferwerda, 2021; Hassenzahl and Tractinsky, 2006; Jooste *et al.*, 2018; 2014; Noonpakdee *et al.*, 2018). These BI Dashboards are designed to provide a consolidated view of data on a single screen, allowing users to monitor information at a glance (Quiñones *et al.*, 2018), to improve the timeliness and quality of inputs to the decision-making process. The effectiveness of Business Intelligence (BI) is gauged by

evaluating the productivity and performance of BI staff, optimal utilization of existing resources, excellence of BI outputs, and the level of satisfaction of its users (Orlovskiy and Kopp, 2020). Dashboards and visualization technologies are widely used in the corporate world to monitor and measure performance Key Performance Indicators (KPIs) (Azeroual and Theel, 2019; Schulze and Krömker, 2010). By providing real-time information, dashboards help organizations make informed decisions that improve their overall performance. It encompasses various tools and techniques such as reports, dashboards, scorecards, notification alerts, ad hoc queries, user-defined queries, statistical analysis, multidimensional analysis, predictive modeling, and simulation (Schulze and Krömker, 2010).

Business Intelligence (BI) refers to a collection of methods, systems, and technologies used by organizations to convert unprocessed data into useful insights that inform decision-making processes. BI components provide business users with the means to analyze and manage data, resulting in better business decisions. These components, which are incorporated into a BI dashboard, encompass a range of elements such as data sources, data marts, data warehouses and data mining, exploration and analysis, OLAP applications, ETL processes, KPIs, data visualizations, balanced scorecards, query and reporting tools, methodologies, and programming languages.

All these features are tailored to aid business users in the management and analysis of data, allowing them to make more informed decisions that drive business success. One crucial aspect that must be considered while designing and developing BI dashboards is the quality of the data. (Bouchana and Idrissi, 2015; Wieder and Ossimitz, 2015) (Dimensions, Uniqueness, KPI'S as Completeness, Validity, Timeliness, Accuracy, Freshness, Consistency) (Bouchana and Idrissi, 2015), output information accuracy (Bouchana and Idrissi, 2015; Yigitbasioglu and Velcu, 2012), Visualization (Jooste *et al.*, 2014; Orlovskiy and Kopp, 2020; Scholtz *et al.*, 2018; Schulze and Krömker, 2010; Yigitbasioglu and Velcu, 2012; Young and Kitchin, 2020), Usability (Bouchana and Idrissi, 2015; Eriksson and Ferwerda, 2021; Schulze and Krömker, 2010; Young and Kitchin, 2020), dashboard balanced (Well-structured, Organized) (Burnay *et al.*, 2020; Jooste *et al.*, 2014), Dashboard development process (Orlovskiy and Kopp, 2020), Requirements (Dashboard purpose (Scholtz *et al.*, 2018), dashboard user, user requirements (Schulze and Krömker, 2010; Yigitbasioglu and Velcu, 2012), Color (Scholtz *et al.*, 2018).

### *UX in Business Intelligence Dashboard*

The goal of a Business Intelligence (BI) application is to provide accurate and relevant information to the right person at the right time (Jooste *et al.*, 2014). The

implementation of UX principles for different applications varies based on the application's purpose. In the case of a BI system, a good UX design can significantly improve the productivity of decision-makers (Eriksson and Ferwerda, 2021). User interaction is crucial for the successful implementation of BI systems in organizations. In today's complex business environment, the usability of the BI application is essential for business performance since it can help business analysts make informed decisions.

Where effective management requires an integrated view of each business unit's functions and how their activities and decisions impact other units. Existing usability criteria lists often focus on interface design instead of supporting business activities, so it's vital to have a good understanding of the context of use and involve users in the design process (Jooste *et al.*, 2014). Following are the studies that present the frameworks, and models related to UX and BI dashboards.

Eriksson and Ferwerda (2021) created a framework for developing a user experience (UX) approach specifically for Business Intelligence (BI) systems, by combining existing research with empirical data gathered from BI industry professionals in Sweden. The framework encompasses factors including UX strategy, product-user interaction, content, performance, usability, education, context, agile/lean methodologies, and evaluation.

Burnay *et al.* (2020) proposed a quality framework (BIXM) for BI dashboards, by using Action research as a methodology, they included "dashboard relevance", "dashboard balanced", and "dashboard efficiency" as elements in their framework.

Jooste *et al.* (2014) Presents a set of refined usability evaluation guidelines for BI applications based on existing studies. They conducted Heuristic Evaluation (HE) and user-based evaluation (SUMI survey) guidelines including the factors "visibility", "learnability", "flexibility", "operability", and "error control and help".

Jooste *et al.* (2018) Present a literature-based conceptual UX framework for BI front-end application by applying SLR as a methodology. Based on the existing studies they consider "UX strategy", "UX goals", "UX tools", "designer", "UX design", "technology", "product", "product-user interaction", and "user" as the main elements which included in their conceptual framework.

Smuts *et al.* (2015) developed design guidelines used to refer to designing, evaluating, and selecting BI tools that aid novice users. Which includes the elements "visibility", "learnability", "flexibility", "operability", and "error control and help".

Bouchana and Idrissi (2015) conducted a product-focused evaluation of two primary components of Business Intelligence Systems (BIS): End-user satisfaction with the intelligence generated by BIS and the

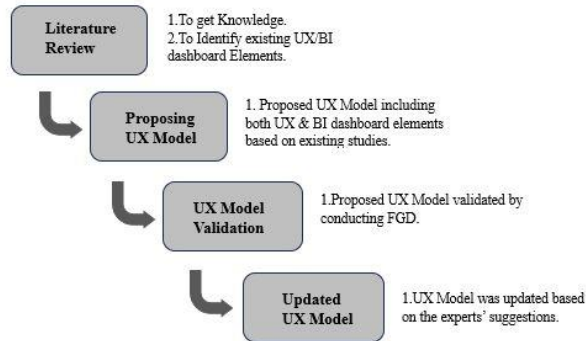
quality of data provided to the end-users. The evaluation model comprised several dimensions, such as “accuracy”, “consistency”, “timeliness”, “completeness”, “validity”, “freshness” and “uniqueness”.

Scholtz *et al.* (2018) Used design science methodology to suggest a Business Intelligence (BI) framework for strategic sustainability information management. The dashboard design includes several categories of guidelines, such as “interaction”, “visualization”, “media”, “aesthetics”, “feedback”, “relevance”, “information detail” and “purpose”.

## Materials and Methods

In our research, we conducted focus group discussions to evaluate the proposed model, while conducting FGD we received some comments from the experts so for analyzing the qualitative data we used the qualitative data analysis software NVivo 12 by applying the thematic analysis method. We extracted a few figures from the NVivo 12 software after completing the analysis process. So, for the software installation and for other work we did for our study by using an HP(B&O) with Windows 10 operating system, 8 GB RAM with Intel i3 processor.

For the development of the UX Model to design and develop the BI Dashboard we go through different phases. Following Fig. 1.



**Fig. 1:** Methodology

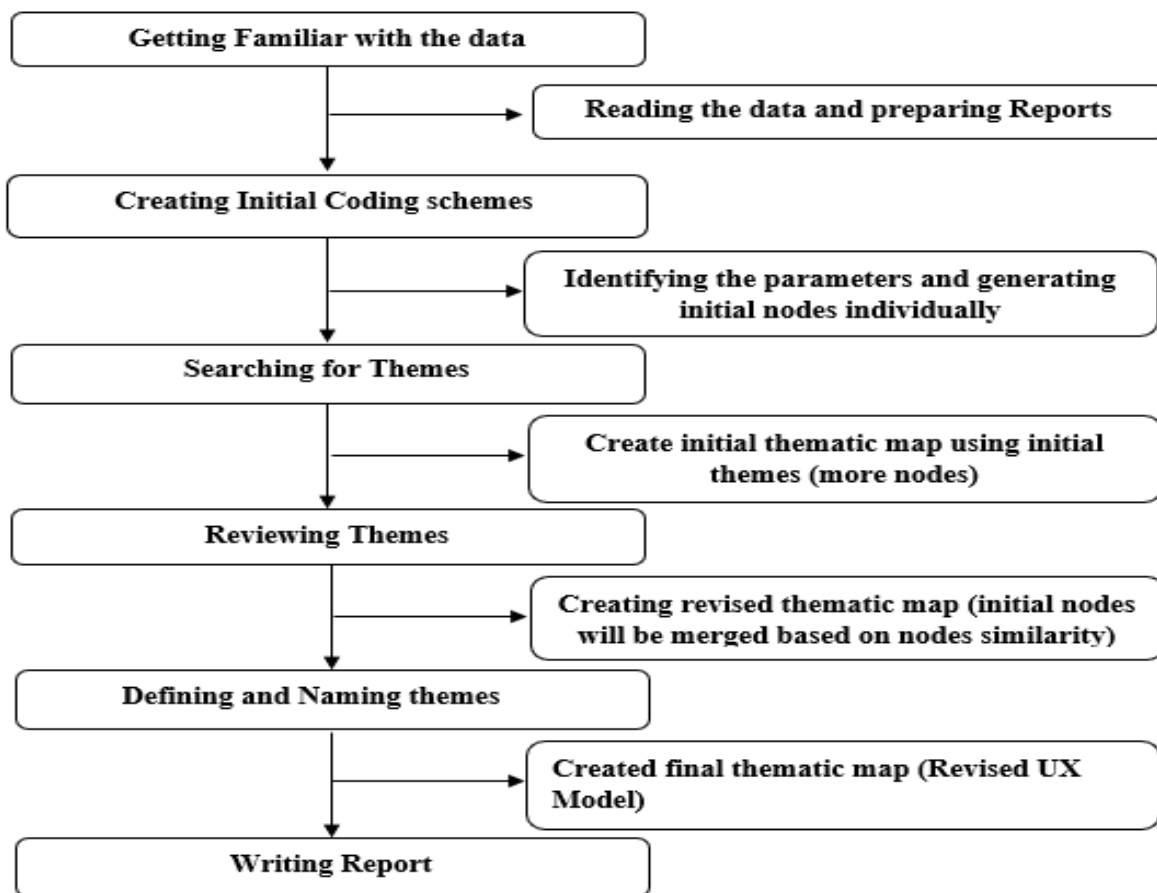
**Table 1:** The existence of elements in previous studies

Elements	Number of studies
Visualization	10
Data quality	8
Requirements (dashboard purpose, dashboard type)	7
Usability	7
Efficiency	6
Satisfaction	5
Dashboard development process	5
Accuracy	5
Effectiveness	4
Dashboard balanced	3
Error control helps	3
Others	1,2

Phase 1 literature review: To conduct a literature review, we used specific search keywords such as "user experience", "usability", "business intelligence dashboards", "data visualization", and "thematic analysis". We limited our search to articles published between 2006 and 2023, with a primary focus on existing research related to user experience and BI dashboards. Our search particularly emphasized the exploration of models, frameworks, and studies related to UX development for different domains. However, we excluded studies that focused solely on BI dashboards regarding big data analytics.

Phase 2 proposing UX model: While conducting the literature review, we identified the existing UX factors, BI dashboard elements from the existing models, frameworks, and other UX, and BI dashboard research. Those UX factors are already stated in the literature review section. After identifying the UX and BI dashboard elements we conducted analysis to identify the important elements by knowing the importance of each element from the previous studies and also by considering their number of existences in different studies. Table 1 shows the important elements and number of studies used. Based on the elements we identified from the existing studies we proposed the UX Model by including both UX and BI dashboard elements.

Phase 3 validating the proposed model: To validate the proposed UX model, a focus group discussion was conducted to gather insights, opinions, and beliefs about the importance of UX in BI systems. The objective was to determine whether the UX/BI dashboard elements integrated into the proposed UX model were sufficient for designing and developing dashboards. The number of experts needed for a Focus Group Discussion (FGD) can differ based on the specific context and objectives of the discussion. As a general guideline, having five experts can be seen as a suitable number for conducting an FGD. It's important to ensure that the chosen experts represent relevant backgrounds and expertise related to the topic being discussed. So, in our focus group discussion, five domain experts are involved. Two of the experts are from the UX and Usability who have good knowledge in that domain, another two experts are from the industry who are currently working on BI dashboards and another one expert has good knowledge on both UX and BI dashboards who is currently working in industry. While conducting FGD we presented our proposed model to the experts and we received some comments from the experts. All the discussions have been recorded, transcribed, and arranged all the data into proper reports. Those comments are analyzed by using the qualitative data analysis software NVivo 12 by applying the thematic analysis method (one of the qualitative data analysis methods). Following are the steps involved in conducting thematic analysis by using NVivo 12 software: Becoming familiar with the data, establishing initial coding schemes, identifying themes, reviewing themes, defining and naming themes, and writing the report (Fig. 2).



**Fig. 2:** Thematic analysis method (Adopted from (Alhojailan, 2012; Kiger and Varpio, 2020))

Thematic analysis is a qualitative data analysis method that is used for, reading and reviewing the transcribed data multiple times in order to identify the themes for data analysis (Dawadi, 2021; Alhojailan, 2012; Kiger and Varpio, 2020). We conducted thematic analysis by using NVivo 12 software. In the first step, we transcribed the recordings of FGD and arranged all the data into proper reports we created a new project in NVivo 12 uploaded all our data reports, and reviewed all the data. After uploading the file, we review the data and try to understand the data. After getting familiar with the data, we started coding the data as nodes. In the second step, while coding the data initially, we coded  $n = 50$  ( $n =$  Number of nodes) nodes here codes are nothing but the label or tag assigned to a specific portion of data, Nodes serve as containers for organizing and managing coded data. After coding the nodes from all the documents, based on those node's similarities we merged some nodes and created themes (Themes are nothing but grouping related nodes together based on their relationships and similarities) for those nodes. We used main themes like 'include', 'remove', 'combine' and

'add' which helped to identify the elements that experts suggested to include, remove, add new elements, combining the existing elements. After creating the initial themes, we named it as initial thematic framework, after combining the similar nodes into themes the node count is reduced i.e.,  $n = 30$  by using the initial thematic framework, we created an initial thematic map as shown in Fig. 3. In the third step we again review the nodes and compare their similarities and merged few nodes in the revised thematic framework with  $n = 22$  nodes and created a revised thematic map which is shown in Fig. 4. In the fourth step we reviewed all the nodes from the revised thematic framework and finally based on the similarity, by comparing our proposed UX model with the Comments given by the experts we finalized the themes which have  $n = 16$  in the final thematic framework and created the final thematic map which shows in Fig. 5. And in the final step we prepared a report for the analysis.

Phase 4 updating the proposed model: Based on the results we got from the validation we updated the Proposed UX Model.

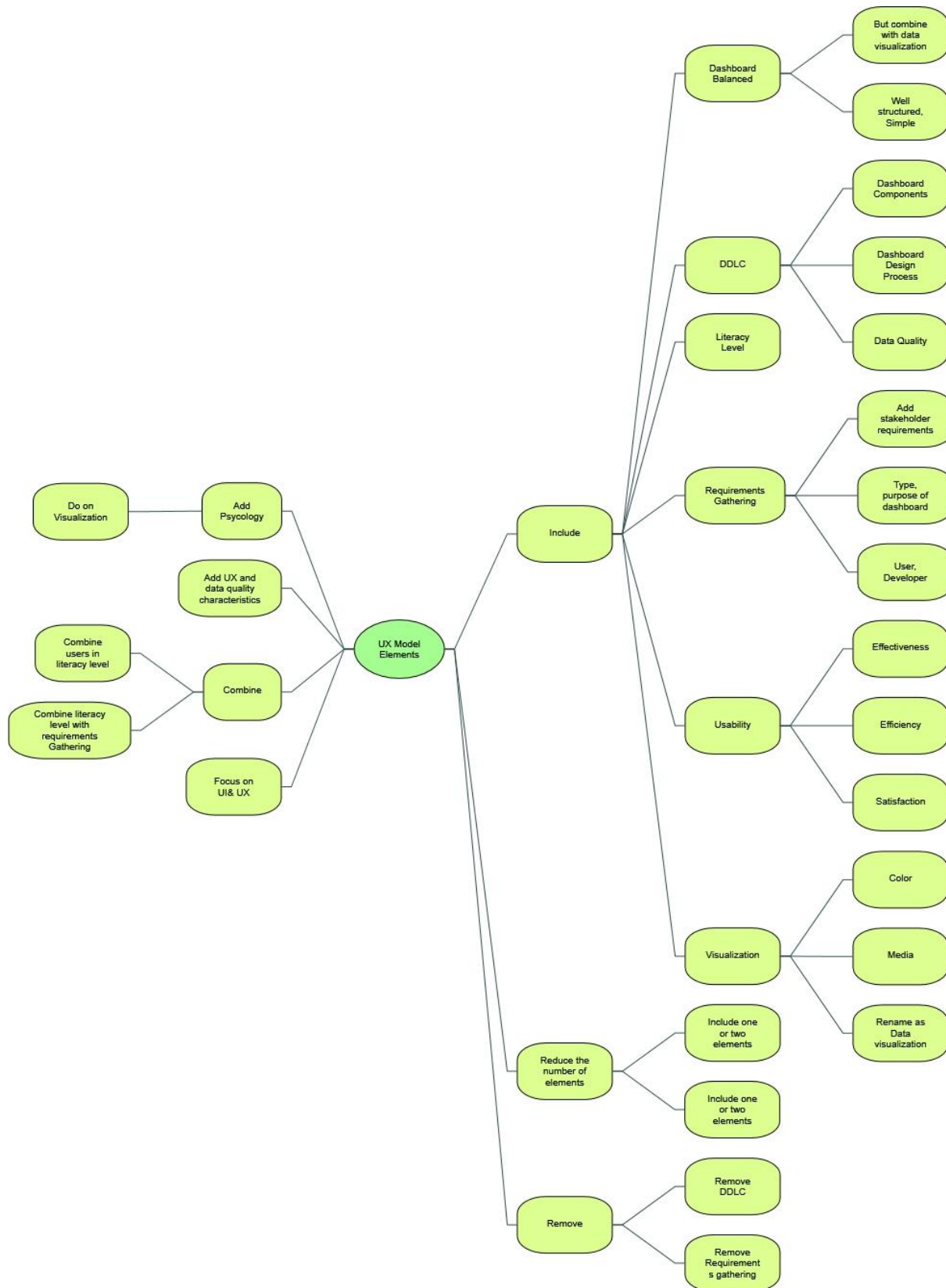


Fig. 3: Initial thematic map



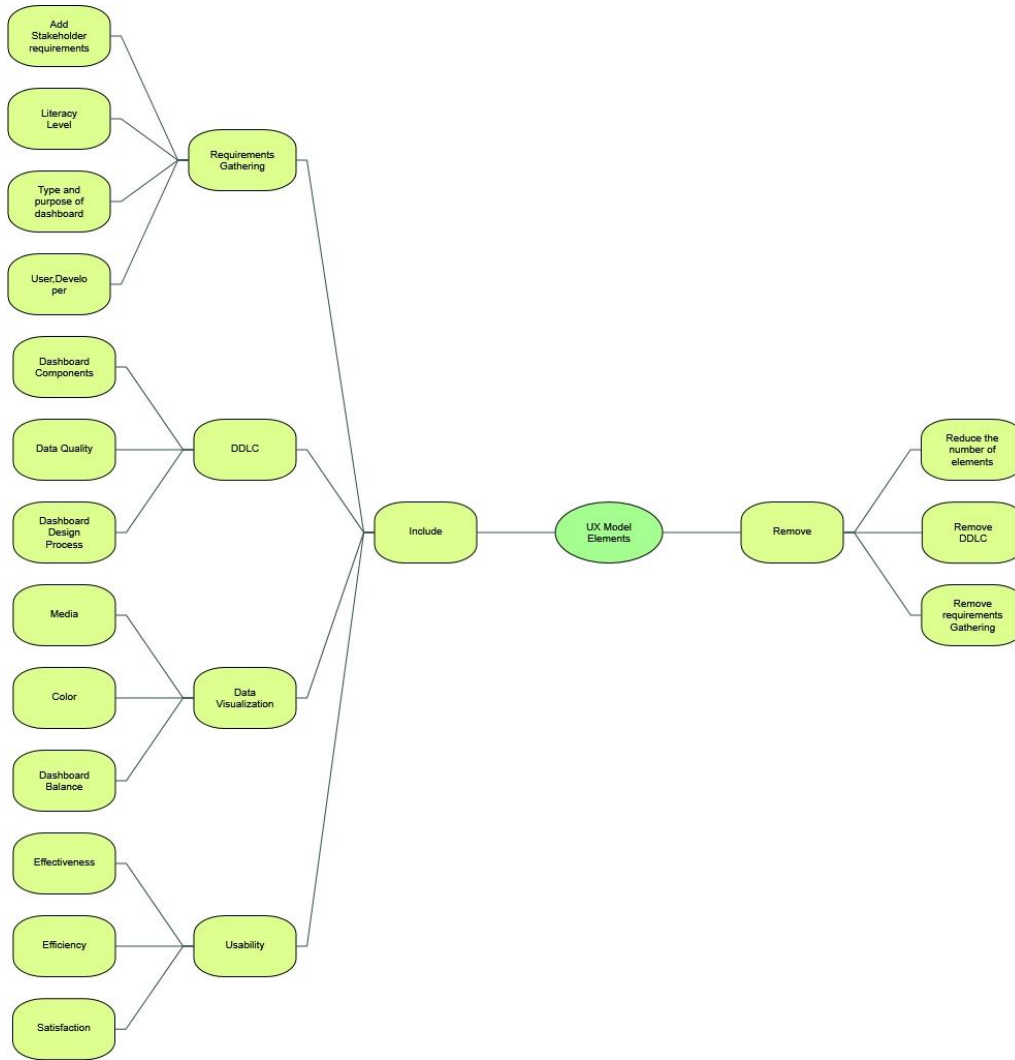


Fig. 4: Revised thematic map

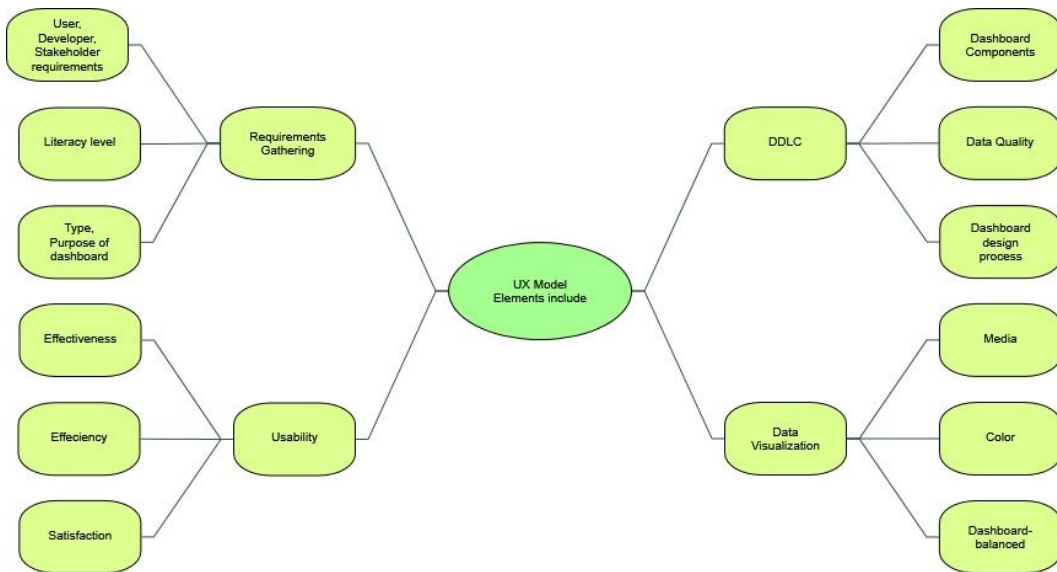


Fig. 5: Final thematic map

## Results and Discussion

In the current section, we present the proposed model, model validation, and updated model.

### A Conceptual UX Model for Designing and Developing the BI Dashboards

The proposed UX Model for BI dashboards was developed based on the literature review, with its elements sourced from existing frameworks and models. This model incorporates both UX and BI dashboard components essential for creating user-friendly BI dashboards and it serves as a guide for developers from requirements gathering to decision-making. The proposed UX Model includes six key elements, as shown in Fig. 6.

#### Requirements Gathering

During the initial stage of developing a dashboard, it is crucial to gather both user and developer requirements. Users should identify all the essential requirements, such

as the desired data fields, source systems, data visualization preferences, and specific time frames for data viewing. Meanwhile, developers have their own set of requirements, such as the need for a trained BI team with high-level abilities in data integration, presentation, analysis, and technical skills for deploying and maintaining the BI infrastructure (Peters *et al.*, 2016). In addition, the BI team should have expertise in diverse business areas such as marketing, logistics, and management. They should also have strong communication skills to effectively engage with business stakeholders (Magdalena *et al.*, 2019). Collecting requirements from both users and developers assists in comprehending the essential needs and the dashboard can be designed based on the provided specifications. This guarantees that no extra data is included and the dashboard appears straightforward, and comprehensible, and supports users in making strategic business decisions. By fulfilling the requirements of both users and developers, the usability of BI dashboards can be considerably increased.

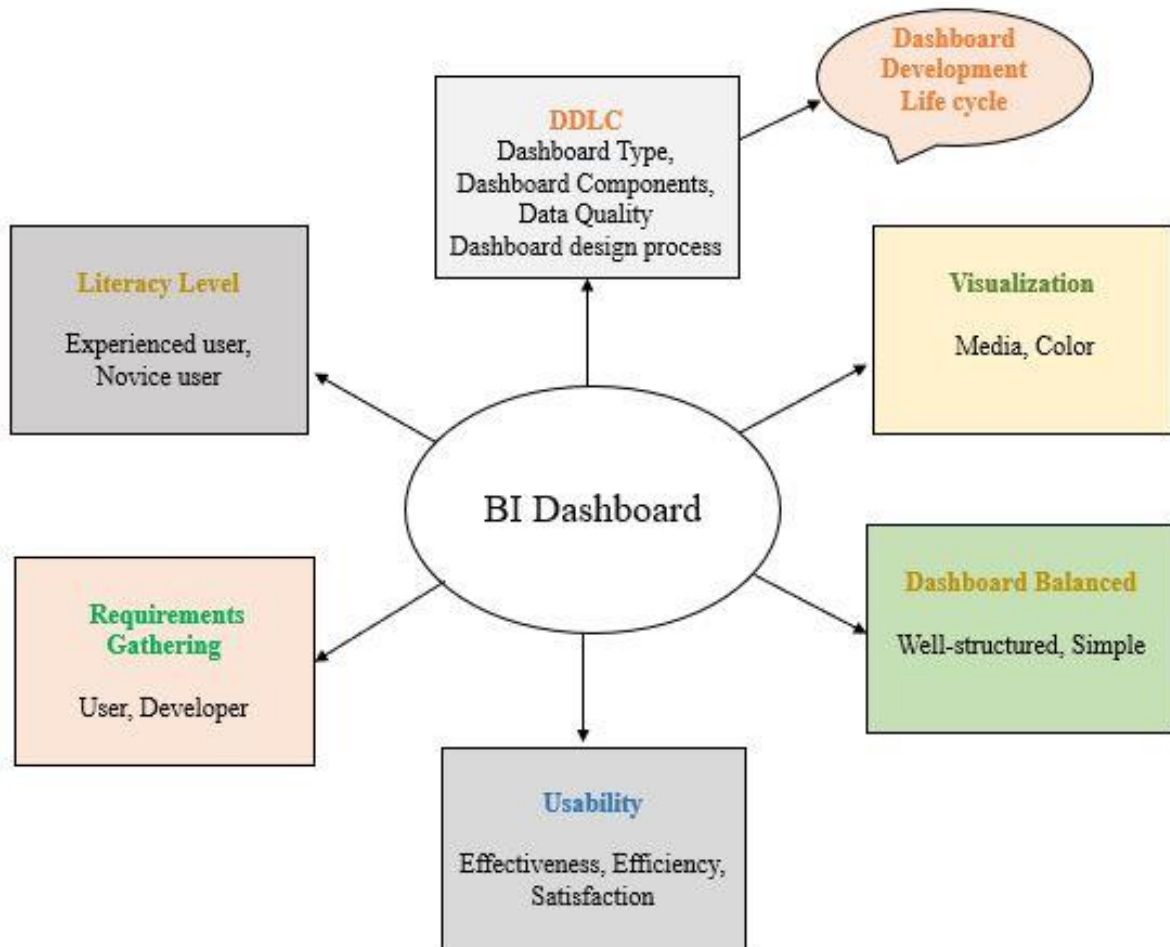


Fig. 6: Proposed UX model



### *Literacy Level*

Creating a usable is crucial and it should be developed according to the user's level of expertise. The user experience is a vital factor in the usability of the dashboard, as users who are familiar with BI dashboards can easily understand the data presented in the dashboard and manage complex dashboards more effectively (Yigitbasioglu and Velcu, 2012). When designing a dashboard for a user who is not familiar with BI dashboards, their level of expertise must be taken into account (Eriksson and Ferwerda, 2021; Yigitbasioglu and Velcu, 2012). Developing a dashboard without considering the user's proficiency level can result in the user finding the dashboard complex and difficult to understand, which will negatively impact its usability. Therefore, it is crucial to either provide adequate education and training to the user or design the dashboard based on their level of expertise to ensure that it is user-friendly and easy to understand.

### *Dashboard Development Life Cycle (DDLCC)*

The Dashboard Development Life Cycle (DDLCC) is a crucial element in the development of BI dashboards. It includes identifying the specific type of dashboard needed, selecting the appropriate BI components, and ensuring that data quality is maintained at every stage of the development process.

To create an effective dashboard, it is important to first identify who will be using it and the purpose behind its use. This will determine the type of data needed and the scope of the Business Intelligence (BI). BI dashboards are categorized into strategic, operational, tactical, and analytical (Pappas and Whitman, 2011) so before developing the dashboard, at the beginning itself developer need to know which type of dashboard they are going to develop and for whom. While creating a BI dashboard, there are several BI elements and tools that can aid business users in effectively managing and analyzing data to make informed decisions. These components may include data sources, data warehouses, data mining, data exploration, ETL processes, OLAP applications, balanced scorecards, data visualizations, KPIs, query tools, reporting tools, programming languages, and a variety of other processes. (Azeroual and Theel, 2019; Babu, 2012; Burnay *et al.*, 2020; Chiasera *et al.*, 2018; Eriksson and Ferwerda, 2021; Mulik *et al.*, 2014; Muppidi *et al.*, 2022). Widely used BI software platforms such as SpagoBI, Qlik Sense, Tableau, Power BI and JasperSoft are accessible for generating customized dashboards, data visualization, and ad hoc reporting Gowthami and Kumar (2017).

The creation of the dashboard is heavily influenced by the data (Bevan, 2008; Calzon, 2022; Souibgui *et al.*, 2019) so effective data quality is critical to the success of BI because poor data quality has the potential to impact business decisions made throughout the organization and

decrease growth (Smuts *et al.*, 2015). To create the dashboard, it is essential to adhere to a suitable development process that involves data extraction, storage, and visualization, aided by ETL, data marts, data warehouses, dashboards, and reports. In the end, the primary goal of BI is to provide high-quality information for managerial decision-making (Orlovskiy and Kopp, 2020; Souibgui *et al.*, 2019).

### *Visualization*

The way data is presented in a BI dashboard can significantly impact the user's experience. The appearance and overall impression of the dashboard are highly dependent on the visualization aspect. It is essential to choose the suitable media when displaying data (Orlovskiy and Kopp, 2020; Scholtz *et al.*, 2018; Schulze and Krömker, 2010) and color (Burnay *et al.*, 2020). The media used should be suitable for the type of data being presented, including graphs, charts, dials, sliders, line charts, bar graphs, gauges, etc. Selecting a media that is not suitable for the type of data can confuse business users and divert their attention to unimportant matters (Orlovskiy and Kopp, 2020). Color also plays an important role in the dashboard's aesthetics. The visually appealing representation of dashboard components can increase a user's interest in viewing the dashboard. Proper use of color can highlight significant data elements. However, incorporating too many bright colors can confuse the user (Scholtz *et al.*, 2018).

### *Dashboard Balanced*

In order to make sure that the dashboard meets the needs of the users, it is recommended that the dashboard be designed to be straightforward and only show the essential parameters necessary for the user. Showing excessive data that is not necessary may negatively impact the user's ability to comprehend the information. Moreover, it is crucial to have a well-organized and structured dashboard to present information (Burnay *et al.*, 2020; Jooste *et al.*, 2014).

### *Usability*

The developer should be able to attain various usability factors, including efficiency, user satisfaction, effectiveness, ease of use, and ease of learning (Bouchana and Idrissi, 2015; Eriksson and Ferwerda, 2021; Jooste *et al.*, 2014). Efficiency refers to the dashboard being well-organized and easily accessible to users, which reduces the cost of accessing information (Burnay *et al.*, 2020). Effectiveness relates to the dashboard's ability to meet user goals easily and be simple to learn.

The three primary factors that influence the effectiveness of a BI system are Conformance to requirements, accuracy of output information, and

contribution to organizational efficiency (Bouchana and Idrissi, 2015). User satisfaction is crucial and the dashboard should provide the required information to meet user needs and increase the usage of BI systems. Content, format, timeliness, accuracy, and ease of use, are important aspects of user satisfaction (Albalushi *et al.*, 2022; Bevan *et al.*, 2015; Bouchana and Idrissi, 2015).

### *Validating the UX Model*

To validate the UX Model we conducted a Focus Group Discussion (FGD) with 5 domain experts, in which two of the experts (A and B) from the industry who are working on the BI dashboard, two experts (C and D) from academics who have experience on UX and the other expert (E) is from the industry who has knowledge on both UX and BI dashboard. This is conducted mainly to know the opinion of the experts on the proposed UX Model i.e., which elements are necessary for the dashboard development and which are not required for the dashboard development. During FGD we explained each element of the proposed model, i.e., how we considered those elements and how our proposed model can guide BI dashboard development. While conducting FGD we got suggestions from the experts. In this section, the results of FGD are presented. The conclusions from the analysis of FGD comments are presented along with each element. For analyzing those comments, we used the qualitative data analysis software NVivo 12 by following the thematic analysis method (one of the qualitative data analysis methods) (Dawadi, 2021).

### *Requirements Gathering*

Expert E mentions that "requirements gathering" is an important element for dashboard development where, by gathering the requirements initially developers will have a complete view of what to present in the dashboard, this is in accordance with (Schulze and Krömker, 2010) by gathering those human needs are key factors of any product use and quality perception.

Expert C also mentions that the dashboard is just one single interface to display all the data so one should be careful on what to present in the dashboard. This is in accordance with (Yigitbasioglu and Velcu, 2012) who state dashboard should provide only user-required information because including too many features and feedback can have a detrimental effect on decision-making.

Expert A mentions that it will be good if we can gather stakeholder requirements, which is in accordance with (Hansoti, 2010; Scholtz *et al.*, 2018) In an organization, the involvement of different stakeholders is crucial for success since they possess a comprehensive

understanding of the organization, which allows for benefits such as making faster, more accurate and dependable decisions.

### *Literacy Level*

Experts B and E mentioned that considering the user's level of experience is crucial for the development of a BI dashboard because developing the BI dashboard without knowing the user's level of expertise and adding more features to the dashboard will make the user feel more complex. This is in accordance with (Yigitbasioglu and Velcu, 2012) who state that user knowledge of the BI dashboard has an impact on decision-making (Eriksson and Ferwerda, 2021) educating the user is crucial as the end-user's knowledge has an impact on their experience while interacting with the dashboards.

Expert A suggested that literacy level also can be included as a sub-element in requirements gathering, where it can be considered during gathering the user requirements.

### *Dashboard Development Life Cycle (DDLC)*

Expert B, E mentioned that DDLC is important, where the sub-elements included in this are also important i.e., dashboard purpose, dashboard type, and data quality are also important, where data quality plays a key role in the dashboard development. This is in accordance with (Pappas and Whitman, 2011; Yigitbasioglu and Velcu, 2012) which state that to make dashboard visuals effective, we need to understand who is going to use them and for what purpose. Scholtz *et al.* (2018) state that before developing the BI dashboard needs to evaluate the data quality to create a dashboard design, where data quality plays a significant role in dashboard development, selecting wrong data can affect the decision-making. Orlovskiy and Kopp (2020); Scholtz *et al.* (2018) also mentioned that, for the development of a dashboard it is necessary to follow a suitable development process and incorporate the necessary BI components.

### *Visualization*

Experts mention that visualizations have more impact on UX, and experts C, D, and E also mention that while selecting the visualization we need to choose proper media (charts/graphs/sliders/ gauges) which is suitable for the nature of the data. Expert B, C, D, and E mention that color also will affect the user level of interaction, so need to choose the proper color while developing the BI dashboard. This is in accordance with (Orlovskiy and Kopp, 2020), that visualization charts should fit the best nature of data displayed on the dashboards because choosing of wrong visualization may mislead the dashboard audience into focusing on

the wrong things. Scholtz *et al.* (2018) also state that visualization should require minimal effect to impart the user, (Burnay *et al.*, 2020) also states that dashboard should be presented in a visually appealing way that can increase user interest in viewing the dashboards, where color is an important aspect that should be used effectively to highlight different aspects of the data. Expert A suggested renaming visualization with data visualization.

### Dashboard Balanced

Expert E mentions that the dashboard should present user-relevant information because adding more features to the dashboard makes the user feel more complex. It is in accordance with (Burnay *et al.*, 2020; Scholtz *et al.*, 2018) who state that the dashboard should display only user-required data, instead of providing excessive data which is not essential for the user. Because providing excessive data can keep a load on human cognition. (Scholtz *et al.*, 2018) state that data in the dashboard must be organized and well-structured, aiding the user in easily identifying the indicators that require attention. (Burnay *et al.*, 2020) also states that the dashboard should be straightforward and present only a limited number of parameters that are necessary for the user. Expert A suggested merging dashboard balance with data visualization by mentioning that dashboard balance comes under data visualization were, it shows how the data is presented.

### Usability

Expert E mentions that effectiveness and efficiency, user satisfaction are the important metrics to evaluate the usability of BI dashboards. Experts A, B, C, D, and E also mention that measuring usability is important for BI dashboards. This is in accordance with Quiñones *et al.* (2018) usability attributes that were proposed by the ISO standard are effectiveness, efficiency, and user satisfaction. (Smuts *et al.*, 2015) also state that end-user satisfaction is a crucial aspect of usability. Experts A, B, and E mention that the developed dashboard should be easy to understand and should present only user-required data.

Comments given by the experts are analyzed by applying the thematic analysis method (qualitative data analysis method) by using NVivo 12 software. The methodology applied for conducting the thematic analysis is presented in the methodology session as shown in Fig. 2. While conducting the thematic analysis we generated thematic maps using the nodes. After generating the revised thematic map (Fig. 4), we reviewed all the nodes and comments given by the experts and we generated the matrix coding query.

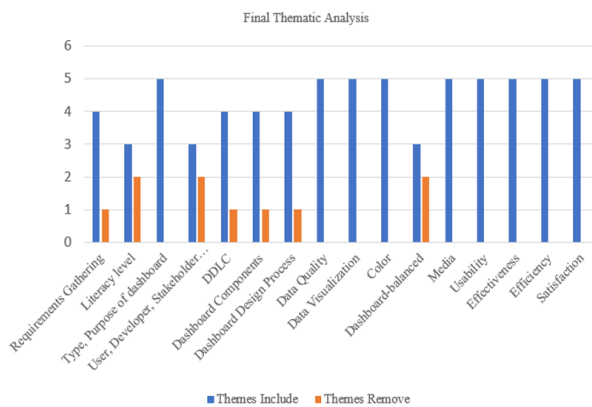
Below Table 2 is the matrix coding query which shows the nodes included in the revised framework. The whole table shows which elements are supported by the experts and which elements are not supported by the experts. In that '1' is for supporting the element and '0' is for not supporting the element. Based on Table 1 final thematic framework was generated.

**Table 2:** Revised matrix coding query

Nodes	Expert A	Expert B	Expert C	Expert D	Expert E
Requirements gathering	1	1	0	1	1
Stakeholder requirements	1	1	0	0	1
Literacy level	1	1	0	0	1
Type, purpose of dashboard	1	1	1	1	1
User, developer	1	1	0	0	1
Literacy level	1	1	0	0	1
DDLC	1	1	0	1	1
Dashboard components	1	1	1	0	1
Dashboard design process	1	1	1	0	1
Data quality	1	1	1	1	1
Data visualization	1	1	1	1	1
Color	1	1	1	1	1
Dashboard-balanced	1	1	0	0	1
Media	1	1	1	1	1
Usability	1	1	1	1	1
Effectiveness	1	1	1	1	1
Efficiency	1	1	1	1	1
Satisfaction	1	1	1	1	1
Remove DDLC	0	0	1	0	0
Remove requirements gathering	0	0	1	0	0

**Table 3:** Final matrix coding query

Nodes	Themes	
	Include	Remove
Requirements gathering	4	1
Literacy level	3	2
Type, Purpose of dashboard	5	0
User/Developer/ Stakeholder requirements	3	2
DDLC	4	1
Dashboard components	4	1
Dashboard design process	4	1
Data quality	5	0
Data visualization	5	0
Color	5	0
Dashboard-balanced	3	2
Media	5	0
Usability	5	0
Effectiveness	5	0
Efficiency	5	0
Satisfaction	5	0



**Fig. 7:** Final thematic analysis

Table 3 and Fig. 7 show the results of our final thematic analysis. In Table 2 Nodes are the elements that we get after performing the revised thematic analysis and to get this final analysis result. In the final step, we have taken two themes that are Include (Elements suggested by the experts to continue in the proposed model) and Remove (elements suggested by the experts to remove from the proposed model) to finalize which elements in the proposed UX model need to be included and which elements need to remove based on the expert suggestions.

Finally, it is clear that 4 experts suggested to include, 1 expert suggested removing the element "requirements gathering", "DDLC", "dashboard components", and "dashboard design process", 3 experts suggested including and 2 experts suggested removing "literacy level", "gather requirements from user, developer, stakeholders", "dashboard balanced", all 5 experts

suggested to include the element "type and purpose of the dashboard", "data quality", "data visualization", "color", "media", "usability", "effectiveness", "efficiency", "satisfaction" in the proposed UX Model. From all those analysis results we consider the majority of the elements which are suggested by the experts to include in, remove from the proposed model, and update the proposed model.

### Updated UX Model

After conducting FGD and analyzing those comments by applying the thematic analysis method we updated the proposed UX Model based on the final thematic analysis results. Based on the suggestions given by the experts some elements are removed, and some elements are merged and updated in the proposed model. From the above result, it is clear that the updated UX model includes the elements: "Requirements gathering- 'gathering user, developer, stakeholder requirements', 'user literacy level', 'type and purpose of dashboard'", "DDLC 'BI dashboard components', 'data quality', 'dashboard design process'", "data visualization- 'media', 'color', 'dashboard balanced'", "usability- 'efficiency', 'effectiveness', 'satisfaction'".

The updated UX Model is shown in Fig. 8 which is similar to Fig. 6 but in the updated model we reduced to four main elements, as expert A suggested we merged the elements of literacy level and type and purpose of the dashboards with Requirements gathering and we merged dashboard balanced with data visualization. The proposed user experience (UX) model will assist developers in creating effective Business Intelligence (BI) dashboards that support users in making better decisions.

In the proposed model, the Requirement gathering phase is to gather the initial user requirements like the type and purpose of the BI dashboard (what is the type of dashboard and purpose of the BI dashboard), user literacy level, developer requirements like software, BI team and who has good knowledge on all the domains. After gathering all the requirements, the next step is to develop the BI dashboard by considering all the BI dashboard components by following appropriate dashboard development processes like data extraction, Data Transformation, Data loading from both internal and external data sources, and maintaining the data quality. While developing the BI dashboard needs to choose an appropriate visualization type that is suitable for the nature of the data, visualizations need to be arranged in an organized way, and need to choose proper colors while developing the BI dashboard. The developed dashboard needs to achieve usability factors. Where the proposed model will provide distinct recommendations and instructions for each phase of the dashboard development process, commencing from the initial stage of collecting requirements up to decision-making.

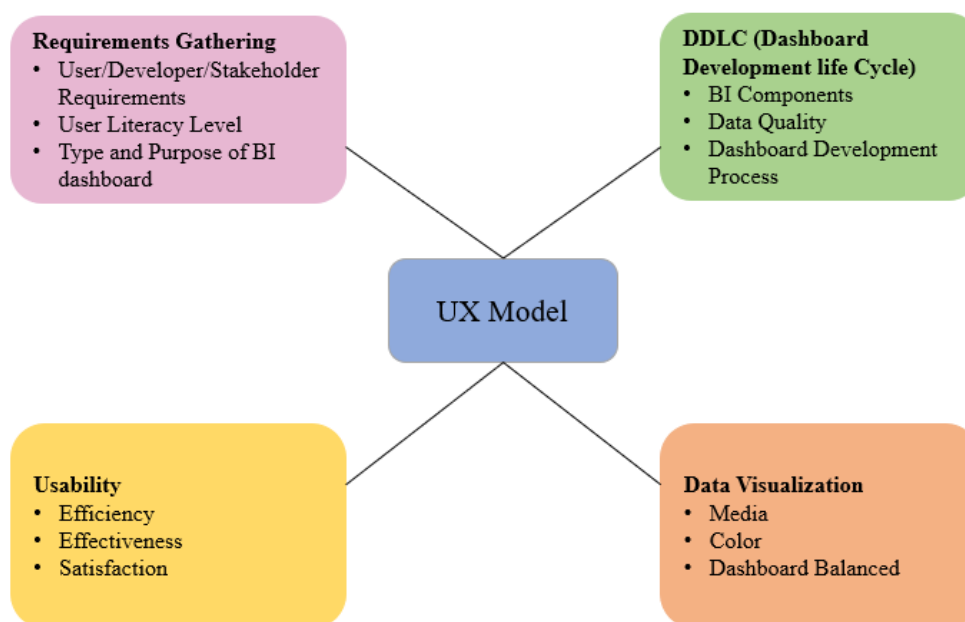


Fig. 8: Updated UX model

## Conclusion

The primary aim of this study is to create a new user experience (UX) model for designing and developing Business Intelligence (BI) dashboards, where the model was proposed based on the literature study. The proposed model was validated by conducting a Focus Group Discussion. After conducting FGD the comments received by the experts are analyzed by applying the thematic analysis method, by using qualitative data analysis software NVivo 12. Based on the thematic analysis result we updated the proposed model. The updated model includes the main elements "requirements gathering", "DDLDC", "data visualization", and "usability". The proposed model can serve as a comprehensive guide for developing a BI dashboard, starting from the initial phase of gathering requirements up until the final stage of decision-making. Implementing this model will enable developers to create a user-friendly dashboard that meets all the user's requirements, resulting in increased usability. However, the focus group discussion involved a specific group of experts with a limited sample size, which could affect the representativeness and diversity of perspectives captured in the analysis, limiting the robustness and applicability of the proposed model. The extent to which the proposed model can be applied to different BI dashboard projects or organizations might be subject to external validity concerns. Where specific context and requirements of each project may vary and thus the applicability of the model in different scenarios should be further explored.

## Future Research

In future research, the UX Model will be applied for the development of any domain-related BI dashboard by applying each and every element for the dashboard development. After developing the BI dashboard, we will conduct the functionality test and will evaluate the results.

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## Author's Contributions

**Apoorva Muppidi:** Research Idea, data funded, analysis, proposed model, manuscript drafted.

**Ahmad Sobri Hashim:** Research Idea, guided on proposing model, guided on drafting the manuscript, reviewed the manuscript.

**Mohd Hilmi Hasan:** Provides insight on fundamental data analytics visualization.

**Aminu Aminu Muazu:** Guiding in the drafted manuscript, reviewed the manuscript.

## Ethics

All authors approved the manuscript and declared no ethical issues as well as no conflict of interest. This manuscript is original and reports unpublished data.

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