Human Involvement in Designing an Information Quality Assessment Technique – Demonstrated in a Healthcare Setting –

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Abstract. Information quality (IQ) has gained increasing importance in the last decade, yet results of assessing and improving IQ in practice are still rare. In this paper we employ a human-centered design approach and illustrate how human involvement in designing an IQ assessment technique can improve the resulting IQ assessment technique. We demonstrate the engagement with practitioners, users, and researchers during the design stages of the assessment technique. Using an emergency medical care (EMS) case our human-centered design approach is scoped to a healthcare setting. The design approach resulted in an improved assessment technique that assists increasing the quality of information exchanges. Our results showed the importance and impacts of human involvement during a design process.

Keywords: Information Quality, Design Science, Human-Centered Design, Information Exchange.

1 Introduction

Information quality (IQ) has become a critical concern of organizations and an active area of Management Information Systems research. The growth of technologies and the direct access of information have increased the need for, and awareness of, high-quality information in organizations [1-5]. Many have indicated that there is a relation between the quality of information and success of organizations. Poor IQ costs billions in society and economic impact [2, 3]. The challenges facing the IQ community within healthcare domain are immense as the tools and methods which collect, process, and use the healthcare-related information are in a constant state of flux. An effective quality based information system for healthcare considered far from sufficient, for example, it is reported between 44,000 and 98,000 [6].

Organizations have increasingly invested in tools and methods to improve IQ, even so, they often still find themselves stymied in their efforts [7]. In the search for IQ improvement approaches, limited attention has turned to the expertise of practitioners. At the same time, users and practitioners have long been acknowledged as important contributions to the success of innovative products and services [8, 9]. The ability of

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practitioners to be such effective innovators has been ascribed to a combination of adequate technological expertise and superior knowledge of the user domain so-called use experience [10]. In addition, a general consensus has been reached in relation to the definition for IQ, sometimes used synonymously with data quality (DQ), as being information/data that is "fit for use" [3]. The definition strongly implied that user and practitioner involvement should be considered in IQ assessment.

Having known the importance of human involvement in the design of IQ approaches, most Information Quality (IQ) assessment approaches yet lack human engagement in the early stages of development. The purpose of this paper is, therefore, to propose a human-centered IQ assessment technique design, demonstrated in healthcare emergency medical service (EMS) setting.

Healthcare is known as a service involving various disciplines and its information management has long been a complicated issue. Indeed, as the EMS example shows, it is particularly a time and information critical service; however IQ is often not adequately addressed. Our previous research showed that IQ studies mostly focus low data level and lack business process view on an enterprise level [11]. By engaging practitioners in EMS field we have noticed similar limitations in IQ exercises in practice as well, especially in the quality aspect of information exchange. This observation corresponds to the findings in IQ literatures. The need of the IQ assurance approach arose because they experienced the symptoms of poor information control over routine tasks involving a mix of manual and automated processing concerning the delivery of patient care and patient handoffs (i.e. poor document control, poor data tracking, loss of unacceptable number of information etc.). To design an effective IQ assessment approach, our research focused to engage with practitioners in order to capture their expertise. Results reveal positive feedback towards the proposed conceptual level IQ assessment technique for information exchange.

The rest of the paper is organized as follows: Section 2 provides information of related work and the design approach. Section 3 presents the IQ challenges in EMS practice. Human-centered design approach for an IQ assessment technique development is demonstrated in section 4. Finally, this paper is concluded in section 5.

2 Information Quality Challenges in Emergency Medical Service

IQ is a well-established concept, and it has gained increasing attention during the last years in different fields with different foci. However, there is still a critical need for a methodology that assess how well organizations exercise and ensure IQ in today's dynamic environment. It is a challenging task particularly in the healthcare sector, where they deal with large quantities of vital life saving information. Practitioners in healthcare are facing increasing complexities, especially in the EMS setting that information is timely critical and handled across multiple organizations yet IQ is limitedly emphasized. Investment and improvement projects have been introduced in EMS setting but resulting in unsatisfying outcome [12]. The reason often is that the

impractical design and implementation causes user resistance. Therefore, a human-centered design for IQ assessment technique is necessary.

2.1 Information Quality

In today's information era, the quality of accessed and stored information plays a huge role for an organization's operational efficiency. Information quality is commonly defined in the literature as "fit for use" [13], which implies that IQ is relative, as information considered appropriate for one use may not possess sufficient attributes for another use. The information users determine whether the quality of information is sufficient and satisfying. In this sense, involvement with users and practitioners for an effective IQ assessment technique development is essential.

IQ is described as a multi-dimensional concept including accuracy, completeness, timeliness etc. [3, 14] with varying attributed characteristics depending on an individual's philosophical and system interaction point of view. Shanks and Corbitt [15] contend that IQ should be assessed within the context of its generation, while [16] add that it needs to be assessed according to its intended use. Literature has proposed IQ assessment methodologies to address the importance of contexts [17-19]. Healthcare context has been addressed as one of the most challenging in IQ studies [20, 21]. On a daily basis, the media reports on the impact of poor IQ in the healthcare sector [22]. Information is generated, exchanged, and stored with involvement of various processes, actors, and locations etc. that are essential to understanding IQ. The traditional approach to ensure quality predominantly focuses in the technical aspects of quality paying little attentions the human side. This leads to unsatisfying results when the proposed programs being implemented in practice. To bridge the gap, we deploy a human-centered design process to develop an IQ assessment technique, demonstrated in healthcare domain.

2.2 Case Scenario: IQ Practice in EMS Setting

EMS is regarded one of the most essential and critical services in healthcare setting. It is a continuum of care that can be measured and mainly assessed on three units: Dispatch center, ambulance center, and emergency department (ED) [23]. In an emergency response, a large amount of information is created, transferred, and stored across organizations. Information exchange across organizations is an essential routine and the quality has direct impacts on the patient care outcome. Schooley and Horan [24] outline that EMS are time-critical information services – the medical necessity to deliver emergency services as rapidly as possible coupled with the dependence of these services upon timely information from multiple organizations. The information-critical element refers to the fact that this service is highly dependent upon information – from the nature and location of the incident, to the medical needs of the patient that should be attended to at the awaiting hospital [25, 26]. Our previous work stressed that quality information such as accurate information, complete information etc. should be addressed in EMS setting [27].

Healthcare governance is entitled to manage and ensure the quality of the information and information systems that is satisfying and efficient in use. EMS is

complicated service that information exchange and sharing is challenging to manage. Information managers are faced with their emerging role in establishing quality management standards for information collection and application in the day-to-day delivery of health care. IQ assessment tools and methods have been introduced to healthcare organizations, for example, the Record Matching method based tool ChiceMaker was successfully implemented in New York City Department of Health and Mental Hygiene [28], and UK nation-wise developing a framework for healthcare information management that integrate patients data [29]. However, most practices are not applicable to the dynamic EMS setting, especially for the information exchange across organizations.

It is found that IQ of information exchange assurance in EMS setting is important yet studies are lacking. We, therefore, in this paper involve practitioners to design a suitable solution to address such limitations. The following phases are undertaken: Phase One – generate ideas by observing the limitations under current IQ assessment in EMS setting. Phase Two – explore a suitable approach to address the limitations. Phase Three – design an appropriate assessment technique by gathering the information from the previous two phases.

3 Human-Centered Design Approach

This section gives an overview of our theoretical development, which is grounded in IQ studies and human-centered design literature. It reveals the need for a new approach regarding the quality of information exchange assessment and improvement.

3.1 Motivation for Human Centered Design

The idea of human involvement is a widely accepted principle in the development of usable devices or systems [30]. A user or practitioner becomes involved when they consider an output for him/her to be of important or significant. This involvement leads to a more consistent behavior and higher satisfaction towards the output [31]. The benefits include the improvement brought to the quality, as it is built with more accurate information in practice. This results in greater acceptance as well as increased user participation [32].

Alam [33] investigated human involvement in new service development, and their findings support the importance of four key elements mentioned in literature:

- *Objective/purpose of involvement* – to develop successful approaches that improve the existing ones to solve the upfront problems.
- *Stage of involvement* - most important stages of the development process involving practitioners/users are idea generation, service/system/methodology/device design, and testing/pilot run.
- *Intensity of involvement* - the most preferred levels of involvement were extensive consultation and information and feedback.
- *Modes of involvement* – face-to-face interviews, user visits and meetings, observation and feedback, and focus group discussion are most common modes.

In this paper, we adopt those four elements to guide our development process with human involvement.

User involvement is perceived to be higher in the earlier stages of development, for example, analysis and design rather than the later implementation stages [30]. Fears that lack of human involvement in the design process, could lead to an illogical user interaction from the practice point of view exist [34]. Various IQ assurance methodologies and approaches have been proposed in IQ literature to ensure the quality of information for organizations [2, 3, 35-39]. However, human engagement at early design stages is not adequately addressed.

3.2 Human-Centered Design Science Approach

It is important to consider which methods are suitable and most beneficial for any particular point in the artifact development. We choose Design Science Research Methodology (DSRM). Design research involves the analysis of the use and performance of designed artifacts to understand, explain and very frequently to improve on the behavior of aspects of information systems. The design science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts, including constructs, models, methods, and instantiations [40, 41]. In this paper, the artifact is presented as a method – an IQ assessment technique.

Ostrowski and Helfert [42] state that the act of designing new innovative artifacts does not occur in isolation, it is a process of constant engagement with practitioners. Construction of artifacts is a living process engaging practitioners from the field. The bilateral construction of an artifact falls within the scope of engaged scholarship [43]. In response to the modes of practitioner involvement mentioned in section 2.1, we select relevant methods: observation and feedback, interviews, focus group, user visits and meetings.

Observation and Feedback – Indirect approaches of observation, for example, ethnography or contextual inquiry is beneficial in a busy healthcare environment. Ethnography observes the user in their natural environment, and then interviews separately the involved personnel to get feedback and further insight to their observations. Contextual Inquiry is a more intrusive technique however, and in a busy healthcare environment it can be inappropriate to ask questions as tasks are being performed.

Interviews – can also take a variety of forms, and are adopted according to the type and purpose of analysis they contribute towards. Semi structured interviews are undertaken with separate experts. They allow for the rich exchange of insight with the participants [44].

Focus groups – a research technique, which collects data through the interaction of a group, under the researcher's defined topic [44]. Here, people share similar views and discuss these views to reach a consensus on the issue. We selected related information manager and director from healthcare organizations.

User visits and meetings – the users are invited to several meetings of the development team. The give input on different aspects of the design and development process.

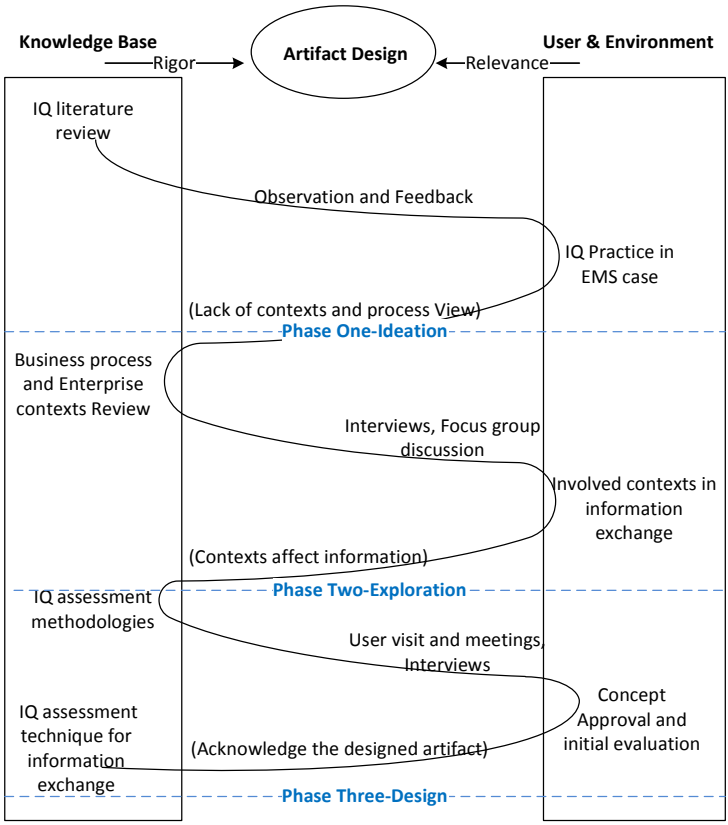

Fig. 1. An IQ assessment technique design by engaging practitioners

Under DSRM, we consistently and continuously engage practitioners and users, while the combination of literature facilitates the understanding of the construction. Fig. 1 presents the process of engaging practitioners in the artifact design with the modes of involvement at different phases.

- Phase One – Ideation: Limitations of IQ assessment approaches found in literature and EMS case. Through observation and feedback we can generate the ideas to solve the problems.
- Phase Two – Exploration: Explore ways to bridge the gap. Interviews and focus group discussion modes are carried out in seek of deeper and precise insights from users and practitioners.
- Phase Three – Design: Propose a technique that addresses the limitations through Interview and User visits and meetings to engage practitioners for the design and feedback.

4 Human Engagement in Developing an IQ Assessment Technique

4.1 Phase One – Ideation

As mentioned in section 3, traditional IQ research focus on static low-data level, based on statistic calculation. Higher business level is not adequately addressed, particularly for dynamic information exchanges. Such limitations are found in practice as well. We conduct field examinations with the EMS unit in Ireland and we view EMS as one enterprise that consists of several organizations. The need of the investigation arose because they experienced problems and challenges in information control over routine tasks.

4.1.1 Field Investigation

Dublin County's EMS is one of the largest emergency response units in Ireland. Currently they have encountered many challenges in assuring IQ in practice. Health Information and Quality Authority (HIQA) is an independent authority that is responsible for quality and performance across EMS organizations including 9-9-9 Control Room, fire services, ambulance services, and health care facilities. Within this role the HIQA strives to find ways to use information to integrate service performance. The EMS system in Dublin has distinguished itself as an early system integrator, pushing data about emergency incidents from computer-aided dispatch (CAD) systems to emergency responders, and a priority dispatch system has been integrated into the CAD system, which connects the Control Room and dispatch centres. However, even with all the IT investment, they still find themselves stymied in their efforts to effectively use the information in the dynamic service environment. One of the central challenges that HIQA faces is to regulate and assure the quality of the information exchange and information flow across EMS organizations. Although Prehospital Emergency Care Council (PHECC) is established for prehospital information system management, challenges to manage information exchange with hospital personnel are still up front. In essence, the authorities mandate certain levels of quality information exchange, compliance with designated emergency response times, health care provision protocols. Considering the information critical characteristic, the authority explores ways to assess and evaluate the quality of information to ensure the quality of the services delivered. However, the current IQ exercises are focused on static digital data that is entered and stored in the computers within each individual organization. For example, within the control room and ambulance stations that information is exchanged through CAD, and IQ assessment is based on the stored information in CAD. Information exchanged between the ambulance crew and hospital is not integrated or assessed at all, especially for the written or verbal information.

4.1.2 Idea Generation: IQ Assessment on an Enterprise Business Level

We observed that the emergency response involving multiple organizations collecting and sharing information processes related to the incident, the patient care, and service performance. For the purpose of this study, we focus on information exchanges across

organizations during an emergency incident. Information flow, which is closely connected to the business (EMS delivery) processes. Information accumulates and changes in a dynamic manner as the service progresses across a series of system components and actors. Information itself is presented in different forms such as electronic, paper, and voice, facilitated with two-way radios, application interfaces, and written patient care records etc. From EMS case observation, it clearly presents that information exchange is a process-focused concept where information is connects to location, actor, and purpose etc. enterprise contexts on a business level. Although the exchanged information is linked to processes, the IQ assessment in practice does not consider business processes. In addition, quality of the exchanged information is affected by the contexts that facilitated information exchange across organizations, yet the IQ assessment stays in low data level that business level is not address.

The low-data level does not capture the requisite semantics to accurately communicate information across business processes. As a result, most of the IQ issues exist at the process and organizational boundaries. The top (or business) level is the focal point with the highest probability for discrepancy [11, 45].

Therefore, the idea to develop a novel approach for information exchange is generated: IQ assessment on a business level – connecting information to enterprise contexts by deploying business process concepts.

4.2 Phase Two – Exploration

From phase one, the direction for the IQ assessment technique design is generated. To connect information to other enterprise contexts, it is necessary to explore its feasibility and appropriateness. This section provides theoretical and practical foundations to support our assessment design.

4.2.1 Theoretical Development: Business Process and Enterprise Contexts

A business process is "a set of logically related tasks performed to achieve a defined business outcome" [46]. Business processes play the function of integrating the enterprise, where an aggregation of enterprise contexts that are composed of people, information, and technologies, performing functions agreed purposes, and responding to events [47]. Business process models (BPM) are described as graphic-oriented representations of sequences of activities, typically showing event, actions, and links in those sequences from end to end [48]. Business process model is particularly well suited to cross-functional perspective, classifying activities and identifies important elements in understanding the information exchange [49]. Based on these characteristics of BPM and the observed connections of information exchange to business processes, the academic panel agreed to select BMP as an approach to bring IQ assessment to a business level.

Based on semantics, pragmatics, and the activity theory, and some “contextual” approaches, Leppänen [50] distinguished the context domains of purpose, actor, action, object, facility, location, and time. Schooley and Horan [51] identified the most important three dimensions to analyze interorganizational services. It is founded that the operational dimension of contextual factors for information sharing are

business processes, technological resources, information across organizational boundaries, and **organizational goals and participants.** It is positively corresponded to our findings on 45 articles in information system and management literature of business process and enterprise contexts. As shown in Fig.2 that **business process, technology, information**, and **organization** are the mostly mentioned factors affect an enterprise performance

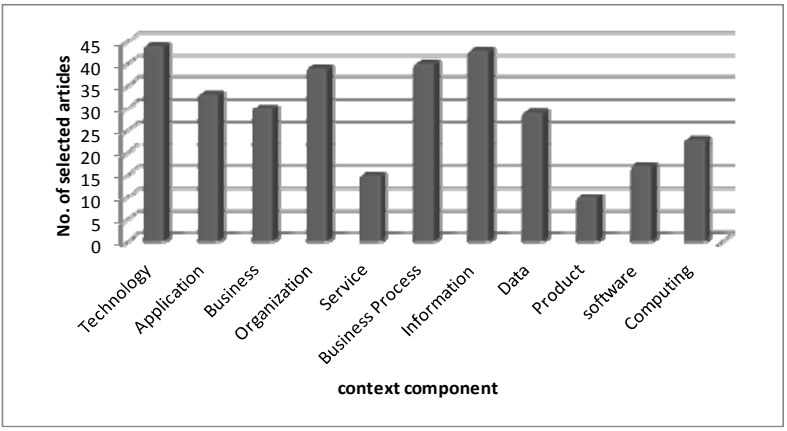

Fig. 2. Most important context factors for information exchange in an enterprise

Under these findings, the proposed IQ assessment technique starts with BPM, through which the context factors of **technology, process, and organization** can be captured and analyzed in relation to the quality of exchanged **information**.

4.2.2 IQ and Enterprise Contexts in Practice

Involvement with practitioners through interviews and focus group discussions allow us to get insight from their experience on how these contexts affect IQ in EMS practice. In addition, users and practitioners can provide either positive or negative feedback about the context approach for IQ by deploying BPM. We summarized the interview and discussion results as below.

Technology View: The Dublin EMS Agency has made significant efforts to collect and utilize incident data to manage service. The efforts have always been made on the separate and disparate information systems that support EMS. It was noticed that very little information is aggregated and shared across all organizations. What happens on the pre-hospital side is often not well known to those who operate within the hospital side. Pre-hospital patient information was recorded in one system/location, and hospital patient information was recorded in another. It has been a problem of inconsistent, inaccurate, or incomplete patient records that occurred when the information was entered from the pre-hospital Patient Care Records (PCR) to the hospital patient records (HPR), which cause the patient medical history error and inefficient health care delivery.

Processes View: Standardized EMS delivery process is lacking, and attention on design and redesign emergency response processes from end-to-end perspective does not exist. We noticed that the efforts to ensure the data collection and transmission either automatically or manually. There are two processes that appeared most unnatural and problematic: one is that the non-standardized and unstructured communication process about the patient and the incident on way to hospital and in the emergency department (ED). That is where the information found incomplete, time consuming, and incorrect. Another process is re-entering the patient and treatment information based on the written PCR from the ambulance crew. High chances of inconsistent and inaccurate records occur during this manual process.

Organization View: The organizational participants discussed challenges to improving the flow of information. One issue was how a large proportion of incident information is transmitted via voice or hand-written communications and not captured in the system. The authority states that the EMS Agency attempts to address this matter with information technology such as mobile PCR system integrated to the hospitals. However, it has been noticed that hospital staff rarely use the system, and they continue to rely on the traditional methods of receiving incoming patient reports-voice "snapshot" from the paramedics in combination with paper reports. The original purpose behind the system was to advance patient information to the physician prior to patient arrival, but neither the paramedics nor the hospital staff adapts the system due to various reasons.

The practitioners and users agreed that those three enterprise context factors affect the quality of exchanged information, and also showed positive feedback towards BPM approach for IQ assessment.

From the ideation and exploration phases we are able to generate the most practical solutions to improve their current IQ exercise. This means that the following design phase is well supported in practice, as well as rich knowledge foundation. Table 1 summarizes the human involvement contributions towards the design process.

Table 1. Summary of first two phases in developing the IQ assessment technique

Phase	User Involvement/ Contribution
Ideation	Identify IQ Problems and challenges in practice.
Exploration	Seek for realistic and user satisfying solution approaches.

4.3 Phase Three – Design

As analyzed above, the purpose is to design an IQ assessment technique that connects to the contexts on an enterprise business level, based on this EMS case. The concept of business process approach is established in theory and practice during the first two phases. The challenge left is how to link static IQ assessment to the captured contexts of technology, process, and organization in dynamic BPM.

The most important enterprise contexts are identified, and for this research purpose, we consider following characteristics: 1) Organization which includes the organizational participates and rules to perform the processes, 2) Information including the information types and information format, 3) Technology that facilitates the tasks, and 4) Process

includes the steps and procedures executed. The context information captured in BPM can be classified of who (organization), what (information type/format), when (process), how (technology). This allows IQ measurement based on the specified enterprise contexts.

Academic and practitioner researchers have produced several generic IQ frameworks [2, 52-54]. Typically, these use a small number of components or dimensions of IQ to group a larger number of IQ criteria or characteristics. IQ dimensions are "a set of IQ attributes that represent a single aspect or construct of IQ" [2]. By identifying different aspects or constructs of IQ it is then possible to either objectively or subjectively measure the quality of information against those aspects or constructs identified. Numerous dimensions including, for example, timeliness, accuracy, coherence, have been identified in the literature. Three functional forms for developing objective data quality metrics [3]. These are 1) simple ratio, 2) minimum or maximum operation and 3) weighted average. Each functional form is appropriate to a specific quality dimension. Pipino etc. [3] also suggest the use of a questionnaire to measure stakeholder perceptions of IQ dimensions lending further substance to this research's initial posit of the importance of an empirical approach.

In this study, we connect the measurable dimensions for information to the contexts that are extracted from BPM, shown in Fig. 3.

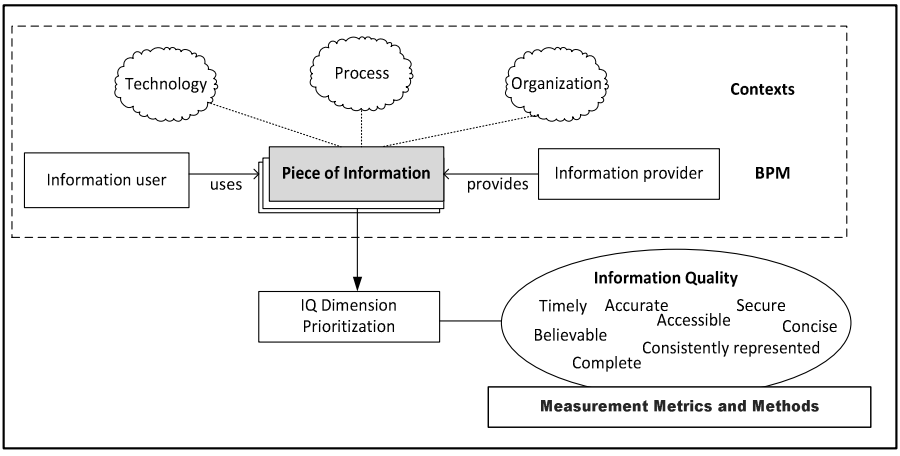

Fig. 3. Overview of the proposed quality assessment technique for exchanged information

In depth discussion formed the IQ assessment technique for information exchange, presented in Fig. 4. The designed technique adopted **Business Process Models** where rich enterprise context can be captured; designed an **Information Profile** where the information content is organized accordingly; and constructed an **IQ Analysis Framework** where IQ measurement and improvement is developed based on previous information. Business process model defines the exchanged information within an enterprise context because it overarches organization and application systems that interact with each other [47]. The Business Process Model then allows to assess statically the "right piece of information from the right source and in the right

format is at the right place at the right time" [13], which will be structured in the information profile in form of what, when, who, and how under the dynamic information exchange processes. And finally the IQ Analyzing provides concrete IQ measurement and assessment methods and metrics for the exchanged information.

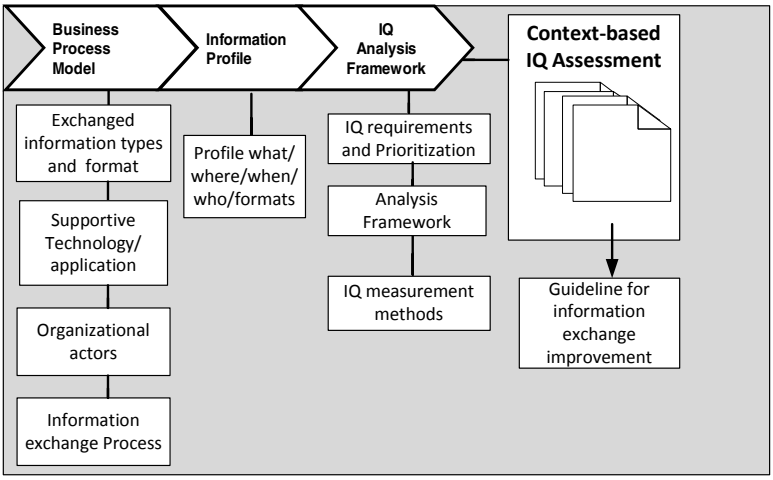

Fig. 4. Overview of the proposed quality assessment technique for exchanged information

4.3.1 Feedback on the Benefits of a Human-Centered Design Approach

The background analysis of information quality, business process and enterprise context, and the EMS case led us to identify several features that are important for understanding the quality assessment for information exchange. In order to gain the insights from academic researchers and practitioner, we visited related personnel – from the Technical University of Dortmund in Germany, Instituto Superior Técnico in Portugal, Dublin City University in Ireland, HIQA, Irish Prehospital Care Council and two hospitals – to discuss the designed IQ assessment technique.

95% of the participants agreed and provided positive views of this novel approach: a context based IQ assessment technique within an enterprise business level is valuable, and the need for such approach is largely due to numerous contextual challenges and barrier in information management. In addition, all participants reached to agreement that this design completed the human-centered design Principles [55]:1) *Early focus*. In design of this IQ assessment, early focus on users and tasks is addressed. As designers, we understood the users, their cognitive behavior, attitudes and the characteristics of their tasks; 2) *Active user participation*. We carefully selected users and practitioners emphasizing the most relevant and skills of typical practitioners and users for IQ exercise. This includes work domain experts and actual end-users; 3) *Multidisciplinary design teams*. In design the proposed technique, we closely involved relevant academic researchers and usability designers in the process. 4) *Integrated design*. The work practices, system examination, in person interaction, desk research etc are conducted in parallel.

The benefits of the human-centered design approach through the EMS case demonstration presented in many ways, shown in Table 2:

Table 2. Benefits of a human-centered design approach for IQ assessment technique

Phase	Benefits
Ideation	Users and practitioners provided useful and practical information and feedback on the problems and challenging.
Exploration	Users identified the IQ problems that embedded in the information exchange processes, which provided design approaches and offered a practical view.
Design	Involvement from fields to research, interaction for comments, feedback, suggestions, acceptance, leaning by designers. These lead to a more practical and satisfying outcome.

5 Summary and Concluding Remarks

This paper demonstrates the importance of human involvement in the early stages to develop an IQ assessment technique. The design process is closely engaged with practitioners and users, from ideation of investigating the existing problems in practice to design a novel artifact as a solution. Positive feedback has been received although more evaluation on the design process and results are needed. As for the implementation and testing of the designed artifact, human involvement is also essential.

In addition to examine human involvement in a design process, this study contributes to the design of an IQ assessment within an enterprise business level by involving practitioners, users, and academic researchers in the early stages. Complementary to our research focus of IQ studies, we had close and in depth interactions in field with EMS involved organizations from the very beginning of problem revealing to the problem solving. Overall, a human-centered design approach benefits the utter output:

- Users provided useful information and ideas;
- Users helped define the scope of the approach;
- Users and practitioners were satisfied and accepted the design, and therefore from practical view it will be an improved approach.

Additional contribution is that such design approach not only brought positive impacts in practice, but also in academic research and theories. The field of IQ research is enriched by providing a technique that considers a high level quality of information assurance for dynamic information exchange environment.

Validation will be carried out by continuous human-centered approach to fully apply and evaluate this technique in EMS case, and generalizing to other domains. A prototypical software tool can be developed in the future based on the technique features.

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