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An Integrated Usability Evaluation Framework For The Design And Development Of Health Information Systems

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Abstract: **Usability is often ignored; many software developers focus on the functionalities and give little thought to the usability. This hinders the users and also damages the reputation of developers and the software. Such systems fail in adoption, scale up, and at times score very low when evaluated for usability. Users are not satisfied, systems are created ad hoc, and often abandoned, thus resulting in a waste of human and economic resources. Users many times describe the systems as complex, not intuitive and requiring a lot of training for successful use. Computerised systems usability concerns has evolved since the early 1980 during the advent of personal computers and to date a number of usability evaluation frameworks exist, however none of them is sufficient in providing health information system evaluation explicitly, they each evaluate different aspects of HIS pertinent to human, organizational and technological factors. The existing frameworks differ in terms of generality and specificity, timing based on the system development phases, thus there exists a gap of an integrated evaluation framework that can merge critical usability constructs together. From the gaps identified this study seeks to investigate and analyze the existing usability evaluation frameworks during the design and development of health information systems and develop an integrated usability evaluation framework for health information systems that would help all stakeholders perform systems evaluation during the design and development of information systems. The integrated usability framework developed shall be reviewed for adoption for the design and development of health information systems in the future. This study is also important to future researchers of health information systems, as it will add to the body of knowledge of usability concept in the design and development of health information systems.**

Keyword: **Usability, Evaluation, Framework, Health information systems.**

1. INTRODUCTION

Usability has been defined in various ways and typically encompasses a set of evaluation methods to understand user experiences for the purpose of creating more desirable, usable, and useful products. Healthcare leaders are increasingly expressing dissatisfaction with their clinical information systems, and often cite cost and difficulty of use as contributing factors (Gregg, 2014). The Healthcare Information and Management Systems Society (HIMSS) health information systems Usability Task Force report cited that usability was perhaps the most important factor that hindered the widespread adoption of HISs prior to the signing of the Health Information Technology for Economic and Clinical Health (HITECH) Act in 2009 (Belden, Grayson, & Barnes, 2009). Since then, organizations have worked quickly to get these clinical systems in place to take advantage of the incentive dollars offered through the Centers for Medicare and Medicaid Services (CMS) Meaningful Use incentive program (ONC, 2013). Adoption has been swift since 2009, yet enhancements to usability have been slow. Usability is usually properly addressed in projects where its a clearly illustrated area of interest, and it as much as it would be necessary to output highly usable software. Usability is not considered and addressed in software development as often as would be necessary to output highly usable software (Xavier, 2014). It is properly addressed only in projects where there is an explicit interest in usability, and the quality of the system-user interaction is perceived as critical by the software development organization (Xavier, 2014). In this kind of projects, usability experts drive the development, using mostly usability-related techniques in the phases previous to coding (Xavier, 2014).

The challenges that we face regarding usability in healthcare IT are several. First, there is no standard and accepted definition of usability in the healthcare IT industry. Several are offered that are very good, but none seem to be the gold standard from which we all work. Nielson (1995) defined usability as "a quality attribute that assesses how easy the user interfaces are to use." Further, Zhang and Walji (2011) noted that usability "…refers to how useful, usable, and satisfying a system is for the intended users to accomplish goals by performing certain sequences of tasks". Second, we have the issue of individual perspectives and paradigms. What may make perfect sense on a display screen to one person may not be as clear to another. Reasons for this are several and may be due to the person's level of exposure to technology, their age and education, and perhaps gender. The bottom line is that healthcare is complex, HISs are complex, and attempting to visually display the nonlinear work of caring for patients is a huge challenge. However, several core concepts that are evidence-based can help lay a strong foundation for those informaticians working in the area of system design.

2. METHODS

The study reviewed a number of existing literature ie i) systems development models with regards to usability, this provided an insights of how usability is factored in the systems development models, ii) the researcher also analysed the health information systems usability evaluation studies, these reviewed under earthed the deficiencies of usability in the design and development stages, iii) the information systems usability ISO evaluation standards were also reviewed to identify which ones were focused on design and development of information systems. These standards were integrated into the developed framework, iv) the researcher reviewed the usability evaluation models examining what each of the models focuses on. This was critical the development of the integrated usability evaluation framework, v) finally the researcher also reviewed the underpinning theories that were critical in usability evaluation. *Usability Aspects*: Usability is measured by evaluating the interaction between user, tool, and task in a specified environment (Yen, 2010). These measures of interaction are called usability aspects. Various researchers have identified several usability aspects for system design and evaluation with the goal of providing a usable tool for users (Table 2.3). Some aspects are broader concepts (e.g., effectiveness, efficiency, etc.); some can be embedded as sub-concepts (e.g., flexibility to efficiency).

2.1 Systems Development Models with regards to Usability

Insufficient or lack of user involvement in software development affect both the product quality and also results in user dissatisfaction (Butt & Ahmad, 2012). Traditionally user involvement takes place in two stages, ie when collecting requirement and at a later stage of the development in order to validate and verify their requirements (Butt & Ahmad, 2012). This section tries to examine the most popular software development models carefully to identify whether they incorporate elements of usability.

Classic Model: In a classic software model like the V-model coding starts once the requirement gathering from users is completed, implementation of codes takes place in small increments and iteration (Butt & Ahmad, 2012). The client is supplied with small release after the development cycle (Butt & Ahmad, 2012). During the requirement analysis phase the development team writes user stories to describe user need and roles (Butt & Ahmad, 2012). The people interviewed also need not to be the real users, thus the product fails due to lack of coordination with real users and fails to collect real user data (Butt & Ahmad, 2012). This models thus fails to incorporate usability testing at its stages.

Water fall Model: In waterfall model user involvement is only at the requirement gathering and design phase. It's not good for rapid change in requirement and large projects (Butt & Ahmad, 2012). This model only fit users or stakeholders who have clear vision about the project (Butt & Ahmad, 2012).

Spiral Model: Spiral model integrates the characteristics of waterfall and prototyping mode (Butt & Ahmad, 2012). It's good for large projects and also very costly, a lot of high expertise is required to handle risks and uncertainties in the project (Butt & Ahmad, 2012).

Agile Model: Agile development model focuses about iteration and incremental process, on initial requirement gathering, so any missing requirement will cover in the next phase of an iteration (Butt & Ahmad, 2012). However this model does not consider user interface, but if it does it will fail to quality user centered design (Butt & Ahmad, 2012). From the above discussions of the models above, there are problems that come up, that make the software fail, these include, development process is not flexible, lack of User involvement, lack of focus on User Interface unable to handle rapid change in Requirements, and lack of Software Usability (Butt & Ahmad, 2012).

2.2 An analysis of Health Information Systems Usability Evaluation Studies

This section reviewed health information systems evaluation studies highlighting some of the findings. Health informatics evaluation is still at its infancy and what constitutes 'good' HIS is still unclear. It seems desirable to have a broadly accepted, detail evaluation framework that could guide researcher to undertake evaluation studies. Similarly, HIS evaluation should start at the conception, thus this study proposes to evaluate usability during the design and development of the Health information systems.

TABLE 1: Analysis of Health Information Systems Usability Evaluation studies (Omoro, 2020)

Author(s)	Title/Objective of Study	Item(s) of study	Usability evaluation Method(s) used	Product Lifecycle management Phase(s)
Berglind Smaradottir, Santiago Martinez 2011,	Usability Evaluation of a Collaborative Health Information System (*Lessons from a User-centered Design Process)*	Effectiveness, efficiency and satisfaction	1)Test in usability laboratory with end-users, 2) Individual questionnaire and, 3) Group interview. A mixed methods research approach was used including observations, interviews and a questionnaire.	Implementation and post-implementation
Prithima Reddy Mosaly, Lukasz Mazur, Lawrence B. Marks, 2016	Usability Evaluation of Electronic Health Record System (EHRs) using Subjective and Objective Measures	Effectiveness of Usability evaluation Methods	(1) Subjectively using subject's informal feedback and usability expert's heuristics, (2) workload measures using eye tracking, (3) behavior measures using clicks and navigation windows, and (4) performance measures using actual time on task and predictive time based on CogTool	Post- implementation
Noelia Vicente Oliveros, Teresa Gramage Caro, Covadonga Pérez Menéndez-Conde, 2017	A continuous usability evaluation of an electronic medication administration record application	Usability problems and their severity.	Heuristic evaluation complemented by usability testing	Development
Rajesh Vedanthan, Evan Blank, 2014.	Usability and feasibility of a tablet-basedDecision-Support and Integrated Record-keeping(DESIRE) tool in the nurse management ofhypertension in rural western Kenya	Usability and feasibility testing	Think aloud, and focus group discussion	Post- implementation
Emily Beth Devine, Chia-Ju Lee, 2014	Usability evaluation of pharmacogenomics clinical decision support aids and clinical knowledge resources in a computerized provider order entry system: A mixed methods approach	Heuristic evaluation and satisfaction	Mixed method approach	Post- implementation

William Brown III, Po-Yin Yen, 2013	Assessment of the Health IT Usability Evaluation Model (Health-ITUEM) for evaluating mobile health (mHealth) technology	Error prevention, Completeness, Memorability, Information needs, Flexibility/Customizability, Learnability, Performance speed, Competency	Focus group discussions	Post- implementation
Arielle M. Fisher, Timothy M. Mtonga, 2018	User-centered design and usability testing of RxMAGIC: a prescription management and general inventory control system for free clinic dispensaries	Usefulness, interaction challenges	Interviews	design, develop, and deploy

2.3 Usability Evaluation Standards

One of the main purposes of international standards is to impose consistency, compatibility, and safety (Bevan, 2009). Usability depends on the context of use, design environment, resources constraints, importance of usability etc (Bevan, 2009). In this section the researcher reviewed the five international standards that are concerned with defining and evaluating usability of information technology and interactive system. This was followed identifying the most applicable standard for this research. Even though there are a number of usability evaluations standards, the following provide guidelines of information technology and interactive systems (Rajanen, 2014); ISO/IEC 9126 – 1, ISO/IEC 14598 – 1, ISO 9241 – 11, ISO 13407, and ISO 18529 (Rajanen, 2014). These standards provide guidelines and general principles for planning and executing evaluation during product/system development cycle (Rajanen, 2014). We studied these standards because they are intended to provide guidelines and general principles for planning and conducting evaluation during product/system development life-cycle.

TABLE 2: Scopes of ISO/IEC 9126-1, ISO/IEC 14598-1, ISO 9241-11, ISO 13407, ISO 18529 (Adopted from (Rajanen, 2014))

Standard	*Entity*	*Stakeholders*	*Phase in life-cycle*
ISO/IEC 9126-1 ISO/IEC 14598-1	Software product	Designers, developers, evaluators, maintainers, acquirers	Requirements, development, use, evaluation, support, maintenance, quality assurance, audit of software, acquisition
ISO 9241-11	Software, hardware or service product in interactive systems	Designer, developer , evaluator, acquirer	Design, development, evaluation, procurement
ISO 13407	Computer-based interactive system	Project managers, All parties involved in human-centred system development	Throughout the system development life-cycle
ISO 18529	Life-cycle process of computer-based interactive system, software and hardware	Those involved in design, use and assessment of life-cycle processes	Design, development, use and assessment of life-cycle process of system, software and hardware

Usability is defined by ISO 9241-11 as the extent to which a product can be used by specified users to achieve specified goals with *effectiveness*, *efficiency* and *satisfaction* in a specified context of use. Most of the early efforts in standards for usability was focused in providing guidelines for use interface design, both hardware and software, in the ISO 9241 series (Earthy, 2009). The exhaustive ISO 9241 guidelines include the presentation of information (ISO 9241-12), design of user guidance (ISO 9241-13), menus (ISO 9241-14), command languages (ISO 9241-15), direct manipulation (ISO 9241-16), and forms (ISO 9241-17) (Bevan, 2009).

2.4 Information Security Standards

ISO/IEC 27002

ISO/IEC 27002 is an information security standard published by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) as ISO/IEC 17799:2005 and subsequently renumbered ISO/IEC 27002:2005 in July 2007, bringing it into line with the other ISO/IEC 27000-series standards. It is entitled Information technology - Security techniques - Code of practice for information security management (Tofan, 2011). This current standard has been revised from first published by ISO/IEC in 2000, which was a word-for- word copy of the British Standard (BS) 7799-1:1999 (Tofan, 2011). Its purpose is to set out a structured set of literally hundreds of information security controls, the use of which will help to achieve conformity with 27001 (Tofan, 2011). However, it is not an compulsory list: organizations are free to implement controls not specifically listed, so long as they are effective and conform to the requirements outlined in 27001 (Tofan, 2011). ISO/IEC 27002 provides best practice recommendations on information security management for use by those who are responsible for initiating, implementing or maintaining Information Security Management Systems (ISMS). Information security is defined within the standard in the context of the C-I-A triad: the preservation of **confidentiality** (ensuring that information is accessible only to those authorised to have access), **integrity** (safeguarding the accuracy and completeness of information and processing methods) and **availability** (ensuring that authorised users have access to information and associated assets when required). ISO/IEC 27002 contains best practices and security controls in the following areas of information security management: security policy, organization of information security, asset management, human resources security, physical and environmental security, communications and operations management, (Access control, Information systems acquisition), development and maintenance, information security incident management, business continuity management, compliance (Tofan, 2011).

2.5 Health Information System related evaluation framework

The evaluation frameworks complement each other in that they each evaluate different aspects of HIS pertinent to human, organizational and technological factors. As illustrated in table 2.5 below, these frameworks differ in terms of generality and specificity, timing based on the system development phases and the aspects that have been assessed in the model. In addition, these frameworks do not provide explicit evaluation categories to the evaluator, thus specific measures within the dimensions of each aspect can be defined to facilitate HIS evaluation. The proposed PhD research study seeks to combine different evaluation aspects into a proposed framework, through building on the strengths and weakness of the existing frameworks.

Table 3: An Analysis of health information systems evaluation frameworks and studies (Omoro, 2020)

Study/Usability Evaluation Frameworks/Authors	Domain/Evaluation aspects	Strengths	Weaknesses
TURF: Toward a unified framework of EHR usability. (Zhang, 2011)	Systems implementation	TURF defined usability around the representation effect on: useful, usable, and satisfying, and listed a set of representative measures for each of these three dimensions. Also demonstrated how TURF can be used as a method to redesign products to improve their usability.	Did not include discussion on how to develop usability guidelines and standards.
Towards a Framework for Health Information Systems Evaluation (Mohd & Maryati, 2006) *HOT-fit framework (Human, Organization and Technology-fit)*	Systems implementation, System Quality, Information Quality, Service Quality, System Use, User Satisfaction, Organizational Structure, Organizational Environment and Net Benefits.	HOT-fit addresses the essential components of IS, namely human, organization and technology and the fit between them.	
Information Systems (IS) Success model (DeLone and McLean, 2004)	Systems implementation	These measures are included in these six system dimensions: *System Quality* (the measures of the information processing system itself), *Information Quality* (the measures of IS output), *Service Quality* (the measures of	It does not include organizational factors that are pertinent to IS evaluation. Van der Meidjen et al discovered that a number of measures such as user involvement during system development and

		technical support or service), *Information Use* (recipient consumption of the output of IS), *User Satisfaction* (recipient response to the use of the output of IS) and *Net Benefits* (the overall IS impact).	organizational culture do not match any of the dimensions of the framework
4Cs (Kaplan, 1997)	Systems implementation	Developed from the Social Interactionist Theory, which stands for Communication (interaction within department), Care (medical care delivery), Control (control in the organization), and Context (clinical setting)	
CHEATS (Shaw, 2002)	Systems implementation, Clinical, Human and organizational, Educational, Administrative, Technical and Social	CHEATS is a generic framework for evaluating IT in healthcare that has six evaluation aspects: clinical, human and organizational, educational, administrative, technical and social. CHEATS attempts to provide a more comprehensive evaluation and some more specific measures, especially in the clinical aspect.	However, the dimensions within some of the aspects, such as technical, human and organizational could benefit from further development
Total Evaluation and Acceptance Methodology (TEAM) (Grant, et al., 2002)	Management level	It has 2 dimensions: Role, Time (evaluation phase) and Structure (strategic, tactical, operational management level). The 3D structure of this model illustrates	The selection of evaluation measures that match the management level can be challenging as the same measures can be categorized into more than one management level. As a whole, this framework is quite broad for a specific type of IS evaluation.
IT Adoption Model (ITAM) (Dixon, 1999)	Systems implementation,	Was constructed to study the individual user perspective and potential IT adoption. From the individual user perspective, this framework includes comprehensive evaluation criteria and relationships among them	This framework is clearly insufficient for a wider scope of evaluation, which involves the organizational aspect
A Framework for Usability Evaluation in EHR Procurement (TYLLINEN, 2018)	Systems procurement. Looked at usability attributes, evaluation methods and measures.	Emphasizes the detailed planning of usability evaluations. There were five key factors in developing and using the framework: Defining (1) the key user groups and use contexts; (2) the central tasks and goals; and (3) the usability objectives, attributes and their importance for the user groups. (4) Applying suitable methods to evaluate these attributes reliably, efficiently and extensively; and (5) quantifying the results for selection purposes.	The results and data gathering methods are not presented.
A framework for evaluating electronic health record vendor user-centered design and	Systems implementation. Looked at UCD process, summative testing	The framework utilizes existing vendor safety-enhanced design SED reports, as required for certification by the Office	One of the limitations of the framework is that it is based on the reported UCD process, summative

usability testing processes (Raj M Ratwani, 2016)	methodology, and summative testing results.	of the National Coordinator for Health Information Technology (ONC), to systematically examine vendor UCD and summative testing processes. By identifying the SED certification requirements and aligning them with standards that are recognized in the human factors literature, the framework provides a method to quickly understand and compare vendor usability processes based on ly available CHPL reports.	testing methodology, and summative testing results as provided in the SED certification reports that are self-reported by each vendor. The scores reflect the UCD and testing processes based on these reports and do not reflect the usability of the actual vendor EHR product.
Framework for Evaluating the Usability of Mobile Educational Applications for Children (Tahir, 2014)	Usability characteristics, goals (interface design criteria), questions, usability metrics (objective and subjective) and two evaluation instruments (task list and satisfaction questionnaire	Provides a comprehensive structure for evaluating the usability. At the base level it presents the usability characteristics and the UI design criteria for educational apps for children and how these are related	Due to rapid changes in mobile technology and a large number of educational apps being developed may cause the interface design criteria (goals) and metrics presented in this paper to be updated in future in order to match the needs of changing technology. This study didn't also check the effectiveness of this framework with different devices and operating systems.
Development of a Usability Evaluation Framework for the flight deck (Banks, 2018)		Provides a structured approach to flight deck design that may help reduce the risk of system failure from usability-related issues.	
Development Framework for the Evaluation of Usability in E-Government: A Case Study of E-Finance Government of Malang (Lestari, 2017)	Systems implementation. effectiveness, efficiency, and user satisfaction	The framework assessed 3 aspects of usability ie effectiveness, efficiency, and user satisfaction	Did not look at the design and development stages of the system
A user-centered framework for redesigning health care interfaces (Johnson C. M., 2005)	System redesigning phase	Comparison between the original and redesigned interfaces showed improvements in system usefulness, information quality, and interface quality	Only used at the redesign stage
Assessment of the Health IT Usability Evaluation Model (Health-ITUEM) for evaluating mobile health (mHealth) technology (William, 2013)	Systems implementation, Error prevention, Completeness, Memorability, Information needs, Flexibility/Customizability, Learnability, Performance speed, Competency, Other outcomes	This study demonstrated the flexibility, robustness, and limitations of this model. Health-ITUEM framework advances the science of mHealth technology evaluation and supports the effective use of these tools.	Did not look at the design and development stages of the system

2.6 Theoretical Underpinnings

Theories are formulated to explain, predict, and understand phenomena and, in many cases, to challenge and extend existing knowledge within the limits of critical bounding assumptions. The theoretical framework is the structure that can hold or support a theory of a research study. The theoretical framework introduces and describes the theory that explains why the research problem under study exists. In this research the main theory is the engagement theory. Alongside the engagement theory are other four theories were reviewed and utilized. Throughout the design and development phase of the health information systems engagement theory was utilized, while during the evaluation and testing phases selected user satisfaction theories, learnability theory, efficiency theory, Socio-Technical Systems (STS) theory and the Technology Acceptance Model 2(TAM2) were used.

Table 4: Theoretical analysis matrix (Omoro, 2020)

Constructs	User Satisfaction Theories				Design and Development Phases		
	Expectancy Disconfirmation Theory	Efficiency Theory	Learnability Theory	TAM2	Socio-Technical Systems Theory	Engagement Theory	Integrated constructs for the Proposed conceptual Framework
Learnability			✓				✓
Efficiency		✓					✓
Memorability							✓
Safety/Errors							✓
Satisfaction	✓						✓
Ease of Use				✓			✓
Participation						✓	✓
Involvement						✓	✓
Tasks					✓		✓
People					✓		✓
Technology					✓		✓
Structure					✓		✓

2.7 User Engagement Theory

The theoretical framework is grounded on the engagement theory and user satisfaction theories. Engagement theory's basic concept was used in student-learning context to mean that all student activities involve active cognitive processes such as creating, problem-solving, reasoning, decision-making, and evaluation (Kearsley & Shneiderman, 1998). In addition, students are intrinsically motivated to learn due to the meaningful nature of the learning environment and activities. Engagement theory is based upon the idea of creating successful collaborative teams that work on ambitious projects that are meaningful to someone outside the classroom. In this thesis this is used to imply that health information systems developers must meaningful engage the users through interaction, this could occur with or without technology: - thus this theory is utilized to demonstrate the engagement aspects during the design and development of health information system between the design and development team and the users. Engagement theory leads to constructive products which through user satisfaction theories demonstrates clear defined health information systems usability outcomes in the healthcare delivery.

2.7.1 Socio - Technical Systems Theory

Socio-technical (STS) systems theory was initially coined by Eric Trist and Fred Emery, consultants in Tavistock Institute in London, in 1960. The initial problem was that business were not achieving high level of productivity with the investments in technological systems. (Ada, Sharman, & Gupta, 2009). Thus it was argued that organizations need be approached as socio-technical systems, to increase productivity (Scheneberger & Wade, 2008b). The theory basically discusses that organizational systems are composed of social and technical systems, which are independent and interactive (Ada, Sharman, & Gupta, 2009). The social system component of the theory is concerned with the people, their attributes and the interactions between people in the organization. (Ada, Sharman, & Gupta, 2009). Technical system component of theory deals with the processes, tasks, technology that is required to transform the input into outputs (Bostromand &

Ileinen, 1977). In this study this theory is used in the area of information security, to include establishing and maintaining the systems.

2.7.2 User Satisfaction Theories

The place of users or customers' satisfaction in software products development and the influence this holds in the quality of such products cannot be over emphasized (Mkpojiogu & Hashim, 2016). It's important to identify user requirements and satisfaction levels even before the product is designed (Mkpojiogu & Hashim, 2016). This is to avoid unnecessary rework and redesign, later product delivery, extra costs, effort, personnel and finance (Mkpojiogu & Hashim, 2016). Product quality is determined by customer satisfaction (Hartoyo & Simanjuntak, 2017). Thus, issues on user or customer satisfaction are worth considering (Mkpojiogu & Hashim, 2016). Knowing the extent of user or customers satisfaction is not enough, it is useful to also know the importance of the product requirements or features from the point of view of the user-customer stakeholder (Mkpojiogu & Hashim, 2016). This information provides a double boost for the designs that succinctly delight users or customers and that also enhances the perceived quality of such products (Mkpojiogu & Hashim, 2016). Software companies stand to gain when their customers are satisfied and delighted, but loss when their customers are dissatisfied as they will lose their patronage and loyalty (Rust and Oliver 2000).

2.7.2.1 Expectancy-Disconfirmation Theory

Expectation theory (also commonly known as Expectancy-Disconfirmation Theory) is the most widely accepted theory concerning customer satisfaction processes. The theory holds that satisfaction/dissatisfaction results from a customer's comparison of performance (of a product or service) with predetermined standards of performance (Yüksel & Yüksel, 2008). The expectation level then becomes a standard against which the product is gauged (Yüksel & Yüksel, 2008). Once the product/service has been used, outcomes are measured against expectations (Yüksel & Yüksel, 2008). If the outcome matches the expectation *confirmation* occurs. *Disconfirmation* occurs where there is a difference between expectations and outcomes (Yüksel & Yüksel, 2008). A customer is either satisfied or dissatisfied as a result of positive or negative difference between expectations and perceptions (Yüksel & Yüksel, 2008). Thus, when service performance is better than what the customer had initially expected, there is a positive disconfirmation between expectations and performance which results in satisfaction, while when service performance is as expected, there is a confirmation between expectations and perceptions which results in satisfaction (Yüksel & Yüksel, 2008). In contrast, when service performance is not as good as what the customer expected, there is a negative disconfirmation between expectations and perceptions which causes dissatisfaction (Yüksel & Yüksel, 2008).

2.7.4 Efficiency Theory

Efficiency describes the extent to which resources such as time, space and energy are well used to the intended task. (Yampolskiy, 2011). In complexity theory it's a property of algorithm for solving problems which require solutions (Yampolskiy, 2011). In this thesis context efficiency theory is used to describe the time and energy taken by the users of the health information system. Efficiency is also used to mean shorter representation of redundant data sharing (Yampolskiy, 2011).

2.7.5 Learnability Theory

Learnability theory is a body of mathematical and computational results concerning questions such as: when is learning possible? What prior information is required to support learning? What computational or other resources are required for learning to be possible? It is therefore complementary both to the computational project of building machine learning systems and to the scientific project of understanding learning in people and animals through observation and experiment (Fulop & Chater, 2013). Learnability theory includes work within a variety of theoretical frameworks, including, for example, identification in the limit, and Bayesian learning, which idealize learning in different ways (Fulop & Chater, 2013). Learnability theory addresses one of the foundational questions in cognitive science: to what extent can knowledge be derived from experience (Fulop & Chater, 2013). In this thesis this theory is used to demonstrate the learnability components of the health information system by the users.

2.7.6 The Technology Acceptance Model2 (TAM2)

TAM is an adoption of theory of reasoned action (TRA) (Davis, 1985). TAM theorizes that user's perceptions of usefulness and ease of use are significant determinants of technology acceptance or adoption (Halawi & McCarthy, 2006). TAM has been expanded by adding two additional variables into the model ie perceived quality (QUAL) and anticipated

enjoyment of the using the system (FUN) (Davis, 1985). TAM2 has also been employed to measure technology acceptance across several different cultures (Halawi & McCarthy, 2006). TAM2 clearly investigates and tackles the role of the end-user when new technology is initiated. It also facilitates the examination of additional and external forces (Halawi & McCarthy, 2006). In the thesis this theory is used to describe the anticipated enjoyment by the users when using the health information systems under study.

3. PROPOSED USABILITY EVALUATION FRAMEWORK

The proposed usability evaluation framework represents schematic flow of activities during an evaluation of health information during the design and development stages. This is categorized into structure, Process, and outcome. See figure below.

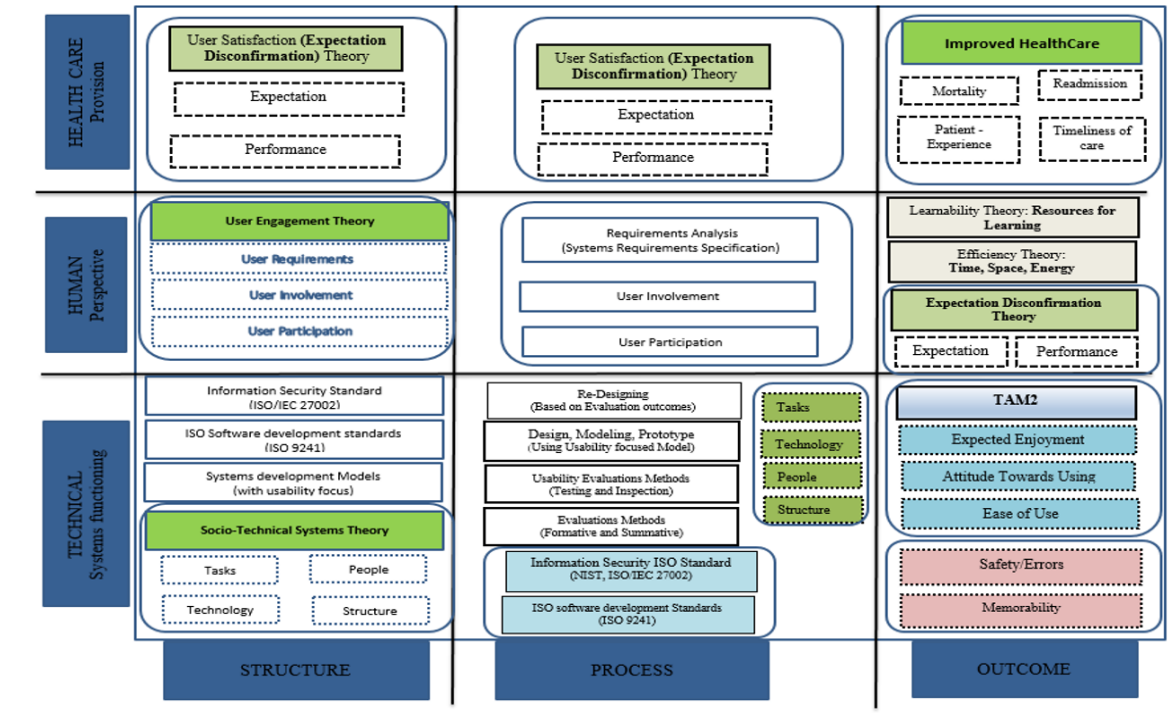

Fig 10. Proposed Usability Evaluation framework

4. CONCLUSIONS AND RECOMMENDATIONS

The research study has drawn on substantial body of data to develop the integrated usability evaluation framework for the design and development of health information systems that will be utilized by all stakeholders. Going forward, a key challenge is likely to be the ongoing engagement of all the stakeholders in a system development project to capture the dynamics, processes, and interrelationships involved in technological change; the large number of these dimensions and their complexity; and the usability of evaluation tool by those delivering care, which is linked to their potential to have impact. The researcher also encourages prospective application of the developed integrated framework.

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