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Design and Development of a Patient-Centered E-Health System to Improve Patient Understanding at Discharge

Tonia San Nicolas-Rocca
San Jose State University, tonia.sannicolas-rocca@sjsu.edu

Benjamin Schooley
Integrated Information Technology Program, University of South Carolina

Seong-Jong Joo
Hasan School of Business, Colorado State University—Pueblo

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Abstract:

E-health systems are often designed without considering user-centered design principles. Past research on the topic of patient-centered e-health (PCEH) has lacked focus on the design and development of a PCEH artifact and the process for its development. In this study, information systems design theory (ISDT) is applied to design, develop, and evaluate an e-health system based on PCEH principles. The goal of the artifact in this study is to improve patient understanding of diagnoses, procedures, medications, and post-discharge instructions and empower patients with the information needed pre- and post-discharge to make informed healthcare decisions. The artifact justification, meta-requirements, meta-design, development, and evaluation are presented in multiple iterations—beginning with a simple picture book, and ending with a Web-based, mobile, multimedia system. Findings indicate that a PCEH approach can be useful for achieving multiple design goals. The artifact illustrates achievement of an important *organizational* quality improvement goal for the case study organization involved, a key *physician* goal to improve patient-physician engagement, and an important *patient* goal—to improve understanding about patient-specific diagnoses and health conditions prior to discharge from a hospital visit and initiation of home health care.

Keywords: patient-centered e-health; information systems design theory; media richness theory; media synchronicity theory; health literacy; mobile patient education system

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I. INTRODUCTION

Patient-centered e-health (PCEH) is an interdisciplinary domain of study focusing on the application of IT to improve patient health [Eysenbach, 2001; Resnicow et al., 2010; Wilson, 2009]. PCEH applications are made possible by the convergence of healthcare and Internet technologies and place emphasis on the patient as a core user or beneficiary of an e-health system [Arsand and Demiris, 2008; Oh, Rizo, Enkin and Jadad, 2005; Wilson, 2009; Wilson and Lankton, 2004]. Important characteristics of e-health applications have included empowerment of consumers and patients in making healthcare decisions, encouragement of new relationships between patients and health professionals where decisions are made in a shared manner, and education of physicians and patients through online sources, enabling communication between healthcare providers and patients [Alpay, Henkemans, Otten, Rovekamp and Dumay, 2010; Alpay, van der Boog and Dumaij, 2011; Eysenbach, 2001; Hoyo-Barbolla, Kukafka, Arredondo and Ortega, 2006; Seckin, 2011].

While e-health applications have become more commonplace, they are often designed without consideration of user-centered design principles [Arsand and Demiris, 2008; Johnson, Johnson and Zhang, 2005]. IT artifacts are often developed based upon organizational or business goals, which may have been constructed with the intention to benefit patients, but are designed without directly understanding patient needs and requirements [Wilson, Wang and Sheetz, 2014]. The risk in this approach is that patients reject the artifact, or use of the artifact by intermediaries, even if the designers' intentions were well meaning and the goals of the IT artifact are unrealized [Jamar et al., 1998; Payton and Brennan, 1999; Winkelman, 2004]. Wilson's [2009] expanded description of PCEH themes provides a set of guidelines whereby the design of IT artifacts may help avoid these common pitfalls. His three themes are:

- 2Patient-focus: PCEH applications are developed primarily based on needs and perspectives of patients.
- Patient-activity: PCEH application designs assume that patients can participate meaningfully in providing and consuming information about, and of interest to, them.
- Patient-empowerment: PCEH applications assume that patients want to, and are able to, control far-ranging aspects of their health care via a PCEH application.

While much of the past research on patient-centered e-health has focused on the efficacy of e-health programs and systems, there is a need for more research on why, how, or for whom e-health systems work [Resnicow et al., 2010] and how they are to be designed and assessed [Leroy, 2011; Wilson, 2009]. The goal of the research described herein was to investigate, design, and develop a PCEH application, taking into account Wilson's (2009) PCEH themes. The specific goal of the PCEH application was to improve patient understanding prior to discharge from a hospital visit. The artifact designed represents an important *organizational* goal for the case study organization involved, a key *physician* goal to improve patient-physician engagement, and an important *patient* goal—to improve understanding about patient-specific diagnoses and health conditions prior to discharge from a hospital visit and initiation of home health care. These motivations are described later in this article.

The structure of this article is as follows. First, we review the literature on patient discharge, patient understanding, and IT as an enabler of PCEH. We then describe the methodology used and explain the process used by the research team to design and develop artifacts to improve patient understanding. Evaluations of each artifact are presented. Finally, we discuss the implications, limitations, and future research directions.

II. LITERATURE REVIEW

Discharge Instructions

Patient discharge instructions generally include advice regarding the ongoing management of the clinical condition, medications, complications, and required follow-up [Hulka, Cassel, Kupper and Burdette, 1976]. There are three tasks a healthcare provider must complete effectively during patient discharge in order to improve patient understanding [Samuels-Kalow, Stack and Porter, 2012]. The healthcare provider must communicate the discharge instructions, verify patient comprehension of discharge instructions, and adapt teaching to areas of confusion or misunderstanding to ensure patient safety in the home environment.

Successful communication of discharge information is critical as non-compliance can lead to safety risks for patients after discharge. Theoretic risks include inappropriate home care, including incorrect medication use, and failure to

return for concerning symptoms or follow-up as directed [Samuels-Kalow, Stack and Porter, 2012]. These implications not only affect the health of the individual, but also the healthcare system, as patients with poor comprehension are at increased risk for adverse events and increased healthcare use [Chugh, Williams, Grigsby and Coleman, 2009].

Patient Understanding

A number of factors have been reported that lead to patient non-compliance of discharge instructions. Patients have reported that verbal instructions from physicians and/or medical staff are not provided in simple language [McCarthy et al., 2012], or patients' spoken language [Manson, 1988], and therefore are difficult to understand. In addition, patients' mean reading level is at or below seventh grade [Clark et al., 2005; Spandorfer, Karras, Hughes and Caputo,1995]. In contrast, printed discharge instructions have been written at the 11th grade level [Spandorfer, Karras, Hughes and Caputo, 1995] or at college level [Chacon, Kissoon and Rich, 1994]. This is a significant problem considering the discharge process is a relatively short period of time, approximately seventy-six seconds [Rhodes, Vieth, He, Miller and Howes, 2004]. Patients may feel rushed during the short exchange and not ask relevant questions to ensure understanding of their discharge instructions.

Limited health literacy has also contributed to patients' inability to comprehend discharge instructions. Health literacy includes the cognitive and functional skills needed by a person to make health-related decisions [Institute of Medicine, 2004; Paasche-Orlow, Parker, Gazmararian, Nielsen-Bohlman and Rudd, 2005]. It is estimated that 26 percent of the population has limited health literacy [Paasche-Orlow et al., 2005]. This high prevalence of poor health literacy complicates the discharge process because many patients are not able to fully comprehend written resources [Samuels-Kalow, Stack and Porter, 2012].

Many strategies have been used to improve patient understanding and satisfaction with discharge instructions. These strategies include verbal and written instructions [McCarthy et al., 2012], using patients' language of choice [Patel, Kennebeck, Caviness and Macias, 2009], computerized prompts and programs [Denville, 1990; Graumlich, Novotny, Nace and Aldag, 2009; Lewis, 1996; Strecher et al., 1994], checklists [Sims, Jacob, Mills, Fett and Novak, 2006], graphic symbols [Moriyama, Harnisch and Matsubara, 1994], discharge providers [Guttman et al., 2004; Jack et al.,2009], pictographs [Zeng-Treitler, Kim and Hunter, 2008], and videos [Choi, Ahn, Lee and Jung, 2009; Leiner, Handal and Williams, 2004; Meade, McKinney and Barnas, 1994].

Information Systems as an Enabler

The use of information systems can empower patients with the ability to make their own healthcare decisions. These information systems include email [Gustafson et al., 1993; D'Alessandro and Dosa, 2001], video conferencing software, informational websites that are accessible over the Internet, personal health records, telemedicine applications, electronic health records, and online health videos [Alpay et al., 2010; Atienza, Hesse, Gustafson and Croyle, 2010].

Video-based programs are among the most successful strategies to improve communication with patients [Choi et al., 2009; Leiner et al., 2004; Meade et al., 1994]. Use of videos has shown a consistent increase in short-term knowledge, and has outperformed plain written materials [Choi et al., 2009], lectures, and individual counseling [Gagliano, 1988]. Video educational materials can be as versatile as any television or movie production and can include movement, music, sound, voice-over, or dialogues [Leiner et al., 2004]. This varied combination gives a finished video program a significant advantage over print media because it can keep the attention of the viewer for longer periods of time [Leiner et al., 2004].

The use of mobile discharge instruction videos (MDIVs) offers significant advantages [Choi et al., 2009]. It assures a standard level of education and a consistent core of discharge instruction not subject to the varying abilities or opinions of different educators. In addition, the "rewind," "forward," and "stop-go" functions of mobile video software applications allow patients or their parents/guardians/care takers to watch MDIVs repeatedly, in standardized format, anytime and anywhere. Unlike discharge instructions on paper, there is less possibility of loss or misplacement of discharge instructions on mobile devices. Furthermore, MDIVs could be helpful to patients who possess varying levels of education. While prior studies have introduced videos to patients for the purpose of increasing patient understanding, we have not found a study that investigates the PCEH design of a mobile, multimedia, Web-based education system to improve patient understanding at discharge. This study is aimed at filling this literature gap.

III. METHODOLOGY

This study employed a multi-method research approach. The research process follows the design science research methodology (DSRM) presented by Peffers, Tuunanen, Rothenberger and Chatterjee (2007), which includes six steps: problem identification and motivation, definition of the objectives for a solution, design and development,

demonstration, evaluation, and communication. Following this guidance, the research team: (1) identified challenges with patient education prior to or at the time of discharge, (2) examined existing and alternative methods and tools for addressing patient education, (3) assessed requirements for a solution within the context of patient education at discharge, (4) constructed a prototype system in multiple iterations and feedback cycles with practitioners and consumers, and (5) evaluated the prototype across iterations. Through these iterative research phases, both qualitative and quantitative data were collected and analyzed including patient survey data, interviews and observations, data analysis on patient discharge diagnoses, and group interviews on patient education practices. Details on the methodologies, findings, and design artifacts are described further in the following text. The results of these activities were used to inform and guide a new design iteration together with practitioners from the Pueblo, Colorado, field study location (discussed in the following text).

IV. ISDT FRAMEWORK

The role of systems design and development in this research is to serve as a proof-of-concept for addressing the fundamental research questions and to provide an artifact that can serve as a focus area for expanded and continuing research [Nunamaker, Chen and Purdin, 1990]. We use a design science approach, meaning that the design is based on "an explicitly, organized, rational, and wholly systematic approach to design" [Cross, 1993, 2001]. An information system design theory (ISDT) approach was employed to explore an artifact design for patient education including its functionality and identification of the underlying theoretical drivers for developing a prototype system [Hevner, March, Park and Ram, 2004; Walls, Widmeyer and El Sawy, 1992]. Table 1 shows the ISDT framework used to formulate findings into design elements for the artifact. The framework specifies a design product and a design process.

As shown in Table 1, the ISDT framework was used to guide the meta-requirements, meta-design, kernel theories, and testable design product and process propositions. The justification and need for the meta-requirements are discussed in Section V of this article. In sum, the purpose of the artifact is to aid healthcare workers to improve patient understanding about diagnoses, medications, procedures, and discharge instructions prior to patient discharge. While the meta-requirements remained consistent across design iterations, the meta-design evolved over three phases. The meta-requirements describe the class of goals to which the design theory (kernel theory) applies. The meta-design describes the class of artifacts to meet the meta-requirements [Walls et al., 1992].

We applied several kernel theories for governing the product design and process including media richness theory (MRT) [Daft and Lengel, 1986] and media synchronicity theory (MST) [Dennis, Fuller and Valacich, 2008; Dennis, Valacich, Speier and Morris, 1998]. MRT states that the higher the level of ambiguity and uncertainty in a task, the richer the media needs to be. A second component of MRT is that communication goals are focused on resolving ambiguity and reducing uncertainty. Thus, as information increases, uncertainty and equivocation (where there are multiple interpretations for available information) decrease. Ensuring that patients and healthcare providers clearly understand a given situation from the communications medium used is key to providing quality education prior to patient discharge and home care. As such, MRT was applied to this study to explore the suitability of multimedia information and the qualities needed in the media used to provide quality patient education. Specifically, the appropriateness of the multimedia information, types of media (images and video), and the ability of the media to resolve ambiguity and reduce uncertainty were applied in the design.

Media synchronicity theory (MST) looks beyond media richness to synchronicity as a predictor of communication performance. This theory focuses on the ability of people to work together at the same time with a common focus (synchronicity) when provided with the appropriate media [Dennis et al., 2008; Dennis et al.,1998]. It posits that communication will be enhanced when the synchronicity a given medium can support appropriately matches the synchronicity that a communication process requires. This is critical to health practitioners' ability to effectively communicate to patients, and patients' ability to understand, as they discuss discharge instructions, medications, diagnoses, and diagnostics specific to the individual patient. MST notes there are five intrinsic capabilities of media: (1) transmission velocity (e.g., how fast the messages or information can reach the destination), (2) parallelism (the number of transmissions that can be sent simultaneously), (3) symbol sets (the different ways the message can be encoded), (4) rehearsability (the ability to fine-tune a message), and (5) reprocessability (the ability to retrieve/reprocess a message for better understanding). The theory was applied to this project to understand the extent to which healthcare practitioners can benefit from using visual media and to what extent patient understanding increases as a result. For example, it is important for the artifact described herein to provide reprocessability so that information can be retrieved by patients for increased understanding.

Testable design product and process propositions are illustrated to test whether the meta-design satisfied the meta-requirements findings from qualitative and quantitative evaluation presented in the evaluation section. In this manner, the research team was able to design, analyze, and improve the system in a structured manner that satisfied both design outcomes and the prescriptions and disciplines of this theory-based framework.

Table 1: Information Systems Design Theory Framework [Adapted from Schooley, Feldman and Alnosayan, 2012]	
ISDT component	The proposed mobile, IT-enabled multimedia patient education system
Design product	
Meta-requirements	To improve patient understanding about diagnoses, diagnostic testing, medical procedures, medications, discharge instructions, and health topics prior to patient discharge.
	To improve educational capabilities of healthcare practitioners.
	To improve patient satisfaction with healthcare providers.
Meta-design	System shall allow patients to:
	• Access multimedia information (digital images and videos)
	• View videos using any mobile device or computer
	• View patient education videos anytime and from any location
	• Share videos with others (family and/or healthcare provider)
	System shall allow physicians to:
	• Provide 3D image and video instruction to patients from any Internet-connected device
	• Access educational content relevant to patient's educational needs
	System shall:
	• Provide patient and physician access to videos and 3D images
	• Present relevant content with high degree of reliability
	• Provide access through any Internet-connected device
Kernel theories	Media richness theory
	Media synchronicity theory
Testable design product hypotheses	The education system will be perceived by patients as helpful for understanding and managing their healthcare needs.
	The education system will aid healthcare providers to increase patient understanding.
	Healthcare providers will perceive the system as useful in aiding them with patient education activities.
Design process	
Design method	Requirements elicitation by interviews, questionnaire, and focus group end-users, as well as analyzing discharge data.
	Multiple iterations were used during implementation.
Kernel theories	Agile software development
	Wide Audience Requirements Engineering (WARE) method
	Prototyping
Testable design process hypotheses	Patients will accept and use the education system and multimedia information.
	Healthcare providers will accept and use the education system and multimedia information.

V. DESIGN PRODUCT

The educational artifact was designed, developed, and evaluated in three distinct iterations. While the design product meta-requirements remained consistent over these three phases of work, the meta-design evolved as a result of evaluation findings. Table 2 shows the progression of meta-design goals.

PCEH Design Product Goals

The design of the patient education system was largely driven by PCEH themes. Physicians at the case study hospital had long been involved in promoting patient-centered care, including work with personal health record (PHR) systems. As such, physicians sought to design the artifact described herein based on PCEH concepts. The first of these concepts includes patient-focused e-health, where “patients must be seen as the overriding reason for designing e-health services, the principle source of design requirements, and the key evaluators of e-health success. This is not to say that commercial and organization goals cannot be considered in design of patient-focused e-health, just that these considerations must be secondary” [Wilson, 2009]. Drawing from these principles, this study aimed to design, develop, and test an IT artifact that would significantly enhance patient understanding at discharge and encourage ongoing patient education. Physicians were important to engage in the design process due to the artifact being focused on a common physician-patient engagement [Wilson, 2009]. Organizational goals were also secondary in the design. That is, hospital leadership believed that improving patient understanding could lead to patient compliance with discharge instructions, which could potentially and partially reduce patient readmissions to the hospital as a result of non-compliance.

Table 2: System Meta Design			
Meta-design – Non-functional requirements	Iteration I (photo book)	Iteration II (test video)	Iteration III (expanded set of online videos and 3D images)
Accessibility	Artifact can be accessed by healthcare providers at the time of patient interaction in the medical facility	Same as Iteration I	Artifact can be accessed by healthcare providers at the time of patient interaction in the medical facility, and by patients post-discharge at home via the Internet
Mobility	Artifact can be easily mobilized from one location to the next	Same as Iteration I	Same as Iteration I and II
Availability	Artifact is available for use by medical practitioners when needed	Same as Iteration I	Artifact is available for use by medical practitioners and patients 99.99% of the time
Usability	Artifact is simple to use and requires little to no training for healthcare providers	Same as Iteration I	Artifact is simple to use and requires minimal training for healthcare providers and patients
Content: Topic Breadth	Artifact enables visual education about a range of topics as determined by each individual physician	Artifact enables education about five different specific diagnoses.	Artifact enables education about 80% + of all diagnoses
Content: Comprehend-ability	Artifact provides content that is understood by patients that is engaging and aesthetically pleasing	Artifact provides content that is understood by patients at a standard sixth-grade reading level, and is engaging and aesthetically pleasing	Same as Iteration II
Interoperability	Artifact requires no interoperability	Same as Iteration I	System interoperates with medical facility EHR for recording educational content provided to patient
Portability	The artifact is usable across different internal hospital units	Same as Iteration I	The artifact is usable across different internal hospital units and patient home environments
Personalization	The artifact allows healthcare providers to personalize education based on a standardized set of visual content (images)	The artifact allows healthcare providers to personalize education based on a standardized set of visual content (digital images + video)	The artifact allows healthcare providers to personalize education based on a standardized set of visual content (digital images + video); it also allows patients to openly consume content based on personal needs and preferences
Standardization	The artifact standardizes some educational content in the form of 3D images	The artifact standardizes some educational content in the form of digital 3D images and videos	The artifact standardizes a large proportion of educational content in the form of digital 3D images and videos (100+ videos)

A second important PCEH goal is patient-active e-health. This means to "provide services that allow patients to initiate and conduct all actions that they desire to perform" [Wilson, 2009]. For the artifact described herein to meet this design objective, patients, family members and friends of the patient, and patient care takers alike would need to be able to access the education system when and where desired. Furthermore, such a system that increases patient understanding should be linked with patient instructions and diagnoses as received prior to discharge. As will be discussed further, the latter of these two design requirements has not been fulfilled, but is a design requirement for the current phase of development.

Patient empowerment is a third and final theme described by Wilson [2009]. This can be achieved by providing tools that allow patients to participate and in some cases control aspects of their health care. The primary objective of patient empowered e-health is to "bring as many aspects of patients' existing empowerment online as possible" [Wilson, 2009]. For the artifact described herein, the goal was for patients to be able to access and view the same

content they viewed while in the hospital (pre-discharge) in order to further understand, when and where desired (post-discharge), the health issues, concerns, precautions, and instructions provided to them while in consultation with their healthcare provider.

While the previous themes guided the design of the artifact described herein, the following high level requirements were applied across three design iterations.

System Requirements

As previously noted, high-level system requirements were elicited using multiple data collection and feedback cycles. The first design iteration derived requirements from practitioner observations at Parkview Medical Center and through conducting literature review on the topic of patient understanding and education at discharge. Findings were synthesized and generalized into guiding principles, based on specified kernel theories, to meet the design product meta-requirements as follows:

The system shall allow patients to:

- Access multimedia information (digital images and videos). A core component of the patient education system is for the system to facilitate patient access to images and video content specific to the needs of an individual patient. View videos using any mobile device or computer. The video and image content should be available over the Internet in order to meet the previously described accessibility requirements. This includes allowing for content access in a mobile or stationary environment using standardized Web and Internet technologies. The system should be accessible from any Internet-connected device.
- View patient education videos anytime and from any location. Patients should be able to view educational content at the hospital and in a wide range of post care environments. In order to enhance patient-physician engagement at the hospital, the system should be used prior to discharge to allow for the patient to ask questions and gain clarification from his/her healthcare provider. To increase patient understanding post-discharge, the same educational content should be accessible by the patient.
- Share videos with others (family and/or healthcare provider). Patients should be able to share educational content pertinent to their healthcare needs with other individuals interested in their (patients) health, including caretakers, providers, friends, and family members.

The system shall allow physicians to:

- Provide 3D image and video instruction to patients from any Internet-connected device.
- Access educational content relevant to the patient's educational needs. The educational content should span a wide variety of health topics.

The system shall:

- Provide the patient and physician access to videos and 3D images.
- Present relevant content with a high degree of reliability.
- Provide access through any Internet-connected device.

The artifact was not developed in its entirety in its first iteration. Rather, the system was developed incrementally in order to validate initial assumptions and to allow for several user feedback iterations to ensure the system was developed in accordance with patient, physician, and organizational goals. The incremental artifact meta-design progression is described more specifically in Table 2 in relation to a set of non-functional requirements as elicited across three design iterations. The final high level architecture is also illustrated in Figure 4.

VI. DESIGN PROCESS AND EVALUATION

Research Setting

The research was conducted at Parkview Medical Center (PMC), a non-government, nonprofit hospital in southern Colorado. PMC was founded in 1923 and currently has 1,072 employees and 308 physicians. The hospital is licensed for 350 general acute care beds and twenty long-term beds, and provides a wide range of healthcare services including the region's longest tenured certified Level II Trauma Center and the region's first certified Stroke Center. PMC is a leader in cardiac, women's, emergency, and neurological services as well as behavioral health

programs. The PMC service area includes Pueblo County and fourteen surrounding counties, which represents a population of approximately 350,000 people.

PMC contracts with Southern Colorado Emergency Medicine Associates (SCEMA) for emergency physician and mid-level provider coverage. SCEMA is a corporation, and is physician owned and operated. SCEMA employs thirty physicians, one nurse practitioner, three registered nurses for patient follow-up, and five full-time coders (a coder takes physician charts and "codes" them for billing purposes).

Initial Analysis and Problem Identification

Patient survey response data was analyzed over a six-month period. Surveys consisted of a standardized mail-based instrument distributed to patients one week following hospital discharge. The purpose of the survey was to collect data relating to the patients' satisfaction with their emergency room visit/experience. Between July and December 2011, 986 surveys were collected.[1] Patients were asked questions such as: (1) My doctor(s) showed concern and sensitivity to my needs, (2) My doctor(s) answered questions about my health, and (3) I was given the chance by my doctor(s) to provide input to decisions about my health care. Although most of the survey responses were satisfactory or better, patient understanding scores were considered to be low by PMC administrators and physicians. One question in particular that received a consistently low rating asked if patients felt their emergency room physician explained their treatment in a way they could understand. Patients were asked their level of agreement or disagreement with the aforementioned questions using a five-point Likert scale ranging from "strongly disagree" to "strongly agree." Each available response was given a point value ranging from 0–100, using 25-point increments. Selections included "strongly disagree," "disagree," "neither disagree or agree," "agree," and "strongly agree," and were given point values of 0, 25, 50, 75, and 100, respectively. As depicted in Figure 1, patient understanding was consistently below 89.6 over the six-month pre-intervention period that was analyzed.

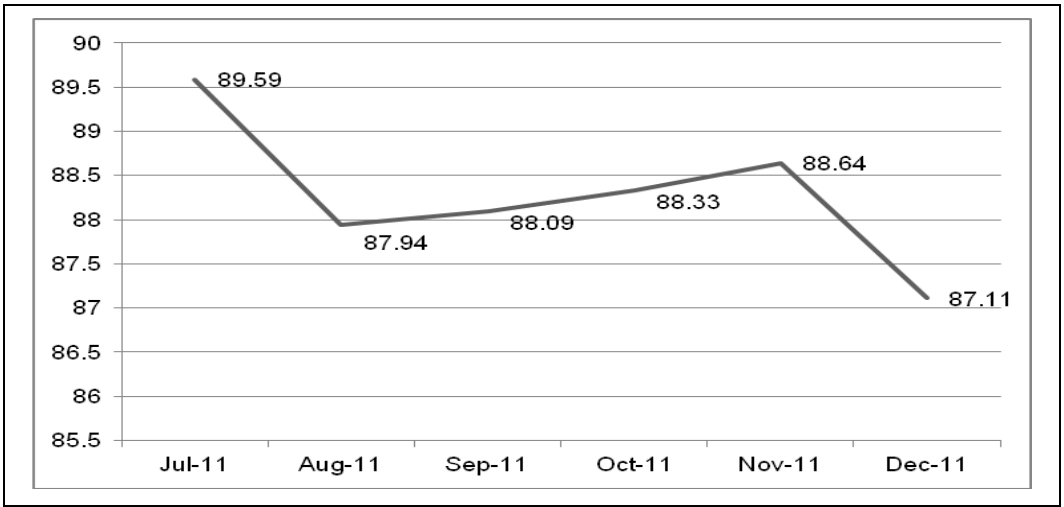

Figure 1. Survey Results of Question, "The Emergency Physician Explained My Treatment in a Way I Can Understand," from July to December 2011

VII. PHASE 1 DESIGN AND DEVELOPMENT: VISUAL AIDS

Product Hypothesis

The results of the initial analysis motivated SCEMA to create a visual aid (hereafter referred to as a photo book) (see Appendix A for illustration) that could be used to educate patients and potentially increase patient understanding. As a process improvement initiative, the photo book included a variety of anatomical parts, and was created based on the ED physicians' knowledge of common diagnoses in the ED and the availability of inexpensive photos that could be used with a licensing agreement. Appendix A provides examples of two of the anatomical images that were included in the photo book. SCEMA stated that using visual aids, such as the photo book, could impact patient understanding. Therefore, our first hypothesis was:

[1] The original survey items were developed by Everett (2012), CEO of Avatar International Inc. The survey was previously being used by the Parkview Medical Center and the researchers had no control over the items' construction or reliability. A description of the research and the references used by Avatar International Inc. are available from the company upon request. No other information on the development of these items is available in the literature.

H1: The levels of patients' understanding on physicians' explanation using the photo book are greater than those levels before using the photo book.

Key requirements and assumptions were made before the visual aids were created. These requirements and assumptions are listed in column 1 of Table 2.

Development

A total of twenty pictures were laminated and placed in an 8.5-x-11-inch spiral notebook. SCEMA members selected these pictures because they could be used to educate patients on over sixty-five common diagnoses. SCEMA felt that most physicians would not use a large volume of images, but would use a small volume that was easy to thumb through and show to patients. Given its size, the spiral notebook could be easily carried on a COW (computer on wheels) and mobile enough for physicians to carry when seeing patients. SCEMA members laminated the pictures so that they were resilient in the ED environment and could be written on to further clarify points when educating patients.

Evaluation

Between January and June 2012, SCEMA members used the visual aids to educate patients. A week following discharge, patients were asked to complete the same pre-intervention mail-based survey administered prior to the implementation of the photo books. A total of 1,043 surveys were analyzed during this six-month post-intervention period, for a total of 2,026 survey responses received over the twelve-month pre- and post-intervention survey periods. Figure 2 shows the survey results to the question, "The emergency physician explained my treatment in a way I could understand." The results in Figure 2 are based on the survey administered from July 2011 and June 2012, before and after the implementation of the photo books. As depicted in Figure 2, use of the photo books by physicians was found to have a positive impact on patient understanding.

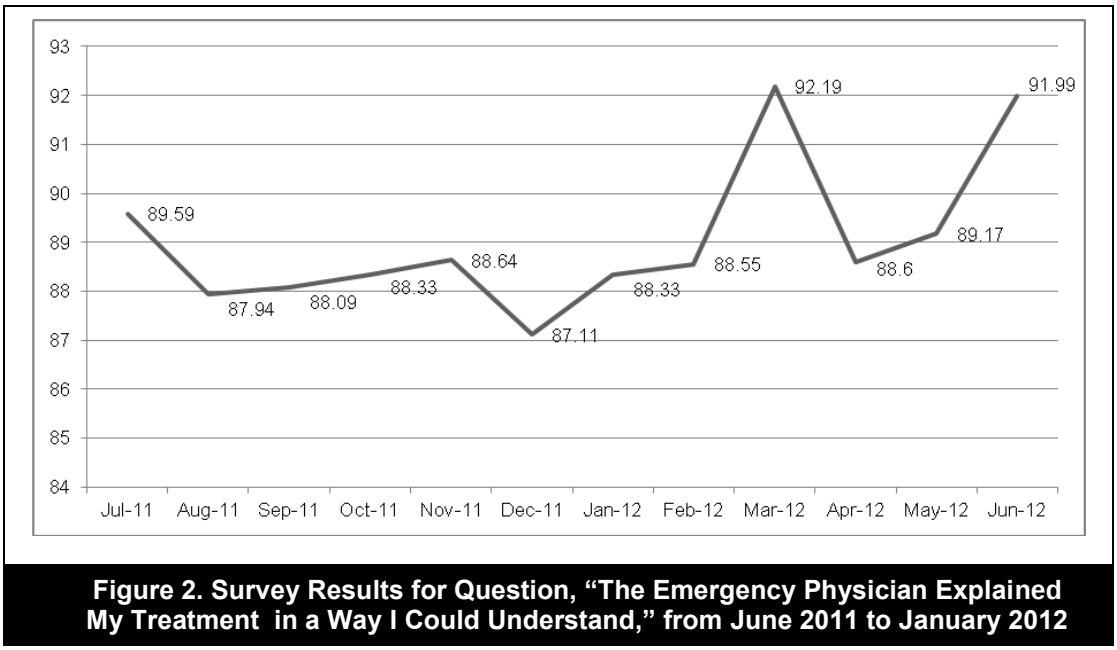

Figure 2. Survey Results for Question, "The Emergency Physician Explained My Treatment in a Way I Could Understand," from June 2011 to January 2012

Data Analysis

Our data consist of the levels of understanding for the six months before and after physicians' use of the photo book, for a total of twelve months. From Figure 2, the average (AVG) score across the entire date range is 89.04. The linear trend, which describes the average rate of change per month, is 0.214 points. Descriptive statistics were used to further understand the data. Table 3 shows descriptive statistics of the data.

Table 3: Descriptive Statistics on the Levels of Understanding

	Sample size (n)	Mean	Standard deviation
Pre-Intervention	6 months	88.283	0.821
Post-Intervention	6 months	89.805	1.793

In Table 3, the mean values are different between two groups or observation periods. However, it was unclear as to whether the difference was significant or due to sampling errors. Thus, we employed a t-test to confirm the difference statistically. Because the groups of patients before and after the intervention were different, we employed an independent t-test for examining the difference of patients' understanding before and after the intervention. Table 4 exhibits the results of the independent t-test.

Table 4: The Result of the Independent T-Test

	T-value	Degree of freedom	Significance (one tail)	Mean difference	Standard error of mean difference
Equal Variances Assumed	-1.890	10	0.044	-1.522	0.80492
Equal Variances Not Assumed	- 1.890	7.008	0.050	-1.522	0.80492

When we assume the equal variances of two groups, the result of the one-tailed independent t-test is significant at $\alpha = 0.05$. However, Levene's test for the equality of variances is significant ($p = 0.020$) at $\alpha = 0.05$. Accordingly, we have to read the p-value for unequal variances, which is 0.05. Since the p-value is the same as the α – value, the interpretation of the p-value can be either significant or not significant. In this case, because the sample size is small ($n = 12$ and adjusted degree of freedom = 7.008), the p-value, which also depends on sample size, could also be small. In fact, if the sample size were larger, such as thirty months or more, results could be more significant than the current analysis. This is highly likely due to the nature of the property of standard error, which is computed with standard deviation divided by the square root of sample size. In sum, we lean on the interpretation of the result as significant and accept our first hypothesis. Based on this interpretation, we conclude that the visual aids increased the degree of patients' understanding of physicians' explanation.

Qualitative Evaluation by Physicians

SCEMA members were asked for comments relating to their use of the photo book. All members were asked if they used the photo book, how useful the photo book was, and to describe any issues or challenges they experienced when using the photo books. The photo books were evaluated positively by SCEMA members. The physicians found the photo books to be useful, helpful in improving patient understanding about treatments and diagnoses, and helpful in providing patients with both a level of standardized education and a personalized education when needed. For example, one physician stated, "The photo books help people understand anatomy and disease processes." Another physician stated, "I find it useful overall." Another, who assumed from the outset of the project that "A picture speaks a thousand words," confirmed the utility of the pictures for communicating relevant issues.

SCEMA members also stated that they don't use the photo book with every patient. For example, one physician stated, "When I do use it, I find it easy to use." This physician went on to say, "The times I don't use it are when it is misplaced or when time is short, or when I know that the discharge paperwork has diagrams, or I think that voice instructions are good enough." Another physician stated, "The main drawback is that I don't always carry it (photo book) to patients' rooms. I have to go back and get it if they (patients) are not understanding the verbal explanation alone."

SCEMA members described improved interactions with patients. One stated, "Not only do they (patients) not know what their kidneys look like or do, they don't even know where they are! Very simple illustrations and pictures, such as 'here is where your appendix is' are still very powerful in helping people understand why or where they are hurting." SCEMA members noted an increased ability to communicate effectively with the patient. One physician stated, "Being able to show something reduced the number of times I had to say something—when speaking to the patient individually or when speaking to the patient as well as his or her family, friends, or caretaker."

The group of SCEMA members who used the photo books discussed a range of other issues as well. Responses included that the photo books were:

- easily accessible by physicians, but not by others,
- available for most interactions with patients. However, it was reported that the books were sometimes misplaced or left on a desk.
- mobile, and could be easily moved from patient to patient. The photo books could be easily carried.
- understandable to patients. The photo books helped patients understand anatomy and disease processes when pertinent to the patient situation.

- resilient to the ED environment. They could be easily cleaned and/or sterilized.
- limited to a few photos. Additional photos would be useful for a wider range of medical issues.
- required physicians to explain the images. Having additional means to explain simple medical issues that prelude or compliment physician explanations may be more efficient and effective than the photo books.

VIII. PHASE II DESIGN AND DEVELOPMENT: TEST VIDEOS

Based on findings from phase I, and understanding that the first phase of design work was largely physician driven, hypotheses were posited that an electronic form of the visual aids would make a more useful artifact to physicians and have a more significant impact on patient understanding. It was believed that a patient-centered e-health system could be derived from the prior phase of findings to make the artifact more portable, mobile, content rich, accessible, personalizable, and usable for patients, their family members, and caregivers. To meet these goals, a prototype Web-based platform was implemented to deliver video content to patients and physicians. Given the observational success of the photo books on patient understanding from physician perspectives, a hypothesis was created as follows:

H2: The levels of patients' understanding on physicians' explanation using videos are greater than those levels before using the videos.

Five test videos were created by a private company called Incendant. Incendant was created by two SCEMA members who partnered with a technical executive to lead the production of the videos. The test videos were created to educate patients on a range of topics including otitis media, abdominal pain, ankle sprain, low back strain, and urinary tract infection. The videos were developed by applying lessons learned from the design and development phase of the photo books and associated health literacy findings (see Appendix B for examples of video screenshots).

Evaluation

The phase II artifact was evaluated in a focus group setting with consumers, physicians, and hospital administrators. There were five total focus groups conducted with four or more participants. Although the focus groups were conducted at different times and places, the test artifact was not augmented until after the final focus group session was completed. The purpose of the focus groups was to determine the perceived value of mobile Internet-enabled video content, including whether the user experience was enjoyable, usable, and understandable to a diverse population. Table 5 shows information relating to the participants in the focus groups.

Table 5: Focus Groups

Focus group	Number of participants	Participant occupation
Focus Group 1	5	University students
Focus Group 2	12	Employed adult consumers Women in their 40s and 50s
Focus Group 3	8	Employed adult consumers
Focus Group 4	4	Senior citizens
Focus Group 5	10	PMC administrators

Focus Group Results

The use of focus groups provided consumer-oriented feedback on the meta-design objectives relative to the testable design product and design process propositions described in Table 1. Following are the findings from the focus group discussions organized by the PCEH themes and media-richness and media synchronicity objectives.

Patient-Focus

Participants discussed the patient-focused aspects of the system. Several discussed how the system is more tailored to their information needs and that the video instruction is more simplified than the instruction they would receive from a busy physician. For example, one participant stated that many people don't know what an EEG is and that including a statement such as, "EEG is a 'painless' procedure," is a helpful yet simple piece of information to have. Participants believed the positive messaging was patient focused, in that the language could help overcome patient fears associated with receiving healthcare procedures. One participant stated, "End the videos on a positive note, not a negative note." Another stated that "prognostics should not only be helpful, but also hopeful."

Focus group participants discussed needed improvements in discharge procedures. One consumer discussed a lack of patient focus in communicating current paper-based discharge instructions. She expressed, "Discharge papers

are a joke—and I'm an educated woman." Participants confirmed the video-based e-health solution was more patient oriented. It was suggested that discharge instructions from the hospital be communicated in simple language, similar to that provided in the videos, and that the videos would provide good reminders on what the patient should do once they leave the hospital.

Patient-Activity

Focus group participants discussed a range of topics related to the system's ability to promote patient activity. For example, participants confirmed their preferences to consume educational video content over the Internet, including, for example, the use of QR codes to trigger online access. Younger participants in particular stated that "paper is a nonstarter" for them—referring to expectations that content be accessible via electronic means.

Similarly, consumers described ways in which they could more easily access information and remember to view information at home than was originally presented to them in the hospital. For example, one participant expressed in positive terms, "A system that just emails the [video] links to the patient. They can access information they need any time after that."

Several participants expressed interest in interactive features to customize the learning experience. For example, one consumer expressed, "The speaker [in the video] is going quite fast—'pause' and more options to stop the video would help." Another participant described the need to add a menu to the beginning of each of the videos, which "would be helpful so the patient can select what part(s) of the video they want to watch." Similarly, another participant stated the need to turn on additional features such as subtitles. She stated, "Subtitles to read what is in the video [would be valuable]." Another participant added the need for "…a menu to pick through the parts of the video."

Participants provided suggestions for furthering patient activity. One participant suggested, "We need an option to send videos to multiple people." Another participant stated that by having family members view the same videos that the patient viewed, "Your family will be comforted by knowing you are doing what you're supposed to and they know what you need to do and how they can help."

Patient-Empowerment

Participants described feelings of empowerment that could result through use of the videos in the hospital. They described how watching a video could provide them with knowledge while still in the hospital setting that could encourage them to ask questions to their physician or nurse that they otherwise may not have asked. One participant explained, "Watching a video isn't stagnant. It makes you think and come up with new questions. Just listening to the doctor, it seems like a lot of it just goes over your head." In a related sense, participants explained that they would like a place to write notes or questions during the video to ask their physician or nurse when finished. Other participants explained that the videos could help them to explain their condition with more confidence due to a higher level of understanding. Many of the participants explained how use of the video could help motivate patients to engage in their own health-related activities, including gaining more knowledge about their situation. For example, one patient stated, "A screen at the end of the videos that has links to related videos, or additional information," would be helpful for easily exploring more related topics. In sum, patients felt that they could accomplish more on their own through an interactive, mobile, portable, Web-based system.

Media Richness

Participants confirmed the value of media to enrich the user experience and help enhance understanding about seemingly complex health issues. Media richness and synchronicity theories were applied to this study to explore the suitability of multimedia information and the qualities needed in the media used to provide quality patient education. As such, and in terms of the videos being engaging, one participant critiqued, "The pictures are good. More pictures should be used, and minimize the amount of time a doctor is viewed." Another participant pointed out the pictures showing iodine running through the body in a CT scan, stating that—without the video—she otherwise would not understand the process. Another participant stated, "Use more pictures. I love the seizure picture about the brain." Participants discussed how the system enables understanding at the appropriate level for the patient. One participant explained, "If the doctor tells me he gave me a narcotic, but my prescription says 'Percocet' then I'm confused. The video can explain what a narcotic is and that Percocet is a narcotic. This helps patients understand at their level."

Participants provided a wide range of suggestions for improving the media presentation content as well. Examples include:

- "Describing the do's and don'ts at the end would be helpful."

- "More bullet points."
- "Italicize questions and use standard fonts for answers."

Media synchronicity theory (MST) was also used to guide this study. Participant responses related to MST are provided in the following text. Responses were found to align with two MST themes: rehearsability and reprocessability.

Rehearsability (The Ability to Fine-Tune a Message)

Participants noted the system's capability to fine-tune instruction due to it: (1) acting as an information intermediary between the doctor and patient, and (2) enabling personalization of a message. The former was previously described by participants. In terms of the latter, participants described how the videos "just related to what I needed, to my situation," but that the videos could also be refined to become, "more personal" than their current form. Another commented on how a patient who uses the system, in consultation with his/her physician, receives a selection of video menu choices that, taken together, is a "personalized set of instructions." Another noted that the system doesn't restrict users from exploring additional topics of interest to the patient, allowing patients to further customize their viewing experience to their particular needs.

Reprocessability (The Ability to Retrieve/Reprocess a Message for Better Understanding)

Participant comments relating to reprocessability can be divided in terms of impacts to practitioners and patients. The second iteration of the artifact provided advantages to practitioners in that they could easily access the same content for a variety of patients. Participant comments included, "Giving the same basic message to anyone who needs it at any time will make the communication a lot better, I think, I mean, it will be like a standard that can just be watched whenever." For patients, however, comments focused on future improvements for the artifact. While a patient could watch the same video multiple times within the hospital facility, there was no mechanism for patients to view the content at home. For example, one participant explained, "When I'm home is really when I'm going to wonder, so what was that thing that I heard? I would need to hear it again."

Testable Design Propositions Revisited

The testable design propositions as outlined in Table 1 at the outset of the project were evaluated in two ways. First, question one was evaluated through analysis of consumer focus group findings. Second, questions two and three were evaluated through a set of focus groups with ED physicians after using the prototype with patients. Physicians provided feedback on the extent to which the video system helped educate patients. Findings are discussed in the following text relative to each design product proposition.

1. The education system will be perceived by patients as helpful for understanding and managing their healthcare needs.

   As previously described, consumers expressed that using the system would help improve patient understanding. One participant, a middle school teacher, expressed, "The value is that all the patients are going to receive things the same way and watch and watch and just get it." Another participant explained, "Everyone learns differently so having the video and doctor to talk to at the same time helps to recall that information later." Several participants discussed the value of accessing content online from a wide range of locations. One participant explained, "Family members who don't live in the area will be able to better understand the situation."

2. Healthcare providers will perceive the system as useful in aiding them with patient education activities.

   Providers believed the simplicity of the video explanations provided for more consistent explanations than they themselves could provide. For example, one nurse expressed, "This does more justice to seizures than I could ever do." Physician participants discussed how the videos helped to keep patients engaged in topics related to their individual health. An emergency physician related his experience using the videos, "The patients are quite focused when watching the videos. They pay much more attention to them than they do to me." Emergency physicians felt that their patients were able to understand the videos. "They [the videos] are quite easy to understand. For both the stroke and pulmonary embolism (PE) [videos] the graphics of the clot going to the brain and lung respectively is easy for patients to understand. I had a patient with a stroke say with slurred speech 'is that what is happening in my brain?' Last night a woman with a PE said 'Is that what is happening in my lung?' They get it quite quickly."

3. The education system will aid healthcare providers to increase patient understanding.

Physicians discussed instances where patients provided observable evidence of understanding through the use of videos. In many circumstances, the physicians felt the videos could explain common health conditions with greater simplicity, promoting stronger focus on the topic from patients. An emergency physician explained, “There is usually one key point in the video in which they look at their significant other...with a recent case of mine you could visually see the parents relax. My assistant was amazed....She said ‘you could see their stress just melt away in an instant.’" Another emergency physician described a separate situation: “I had a stressed out young woman last night who was having a miscarriage....I showed her the video and she was very comforted...that she can get pregnant again and that she did not do anything to cause the miscarriage."

IX. PHASE III DESIGN AND DEVELOPMENT: VIDEOS AND 3D IMAGES

The system prototype, including the five test videos described previously, were refined based on the focus group findings and the evaluations made by the ED physicians. The Web-based system functionality was enhanced, including expanded content to include ninety-five additional videos that were created based on the focus group findings and an expanded set of design requirements. A two-week development process was used for a set of videos that covered diagnostic testing, diagnoses, procedures, medications, and health topics.

Content Expansion

Further emphasis was placed on developing patient-focused video content. To accomplish this, six months of emergency department discharge data was extracted from the hospital electronic health record (EHR) at Parkview Medical Center. A total of 724 different ICD-9 diagnosis codes were found. The diagnoses were organized into sixty live subject groupings. For example, finger, ankle, knee, and wrist sprains were organized into one group called Sprains. A video category was designated for each grouping, with the total number of diagnosis videos covering over 80 percent of patient ICD-9 diagnoses as found in the hospital (EHR). Forty (40) additional video categories were also designated to cover topics on policies (e.g., hospital discharge, readmission), precautions and health dangers (e.g., smoking), medications, procedures, and diagnostics. Video content was produced and is accessible by every department in the hospital on every floor, and for use by patients in post-discharge care environments. Appendix C provides a list of videos available to patients. Figure 3 provides a screenshot of the patient Web portal menu for accessing patient education content.

Key Design Requirements

- Accessibility—the videos can be accessed by healthcare providers at the time of patient interaction in the medical facility, and by patients at home via the Internet.
- Accessibility to a wider audience—the videos should be available to patients and their family, friends, and/or caregivers.
- Availability—the videos must be available regardless of time or location.
- Content: Topic Breadth—the videos enable education about multiple diagnoses, diagnostics, medication, procedures, inpatient discharge, prevention, and planning.
- Content: Comprehend ability—the videos must use language simple enough for patients to understand, or at a standard sixth-grade health literacy level. The videos must be in a language the viewer can understand.
- Internet based—the videos must be accessible to patients through the Internet.
- Enjoyable—the videos must be enjoyable to the viewer.
- Interoperability—the system interoperates with medical facility EHR for recording educational content provided to patients. The videos must be platform independent. The videos should be hardware (PC, MAC, Android, iOS devices, etc.) and software (Windows, MAC OS, iOS, UNIX, Android, etc.) independent.
- Mobility—the videos must be mobilized from one location to the next.
- Personalization—the videos allow healthcare providers to personalize education based on a standardized set of visual content (images + video); also allows patients to openly view content based on personal needs and preferences
- Portability—the videos are usable across different internal hospital units, and the patient home environment.
- Repeatability—the videos must be repeatable. Patients and physicians should be able to view the videos multiple times or as many times as needed.

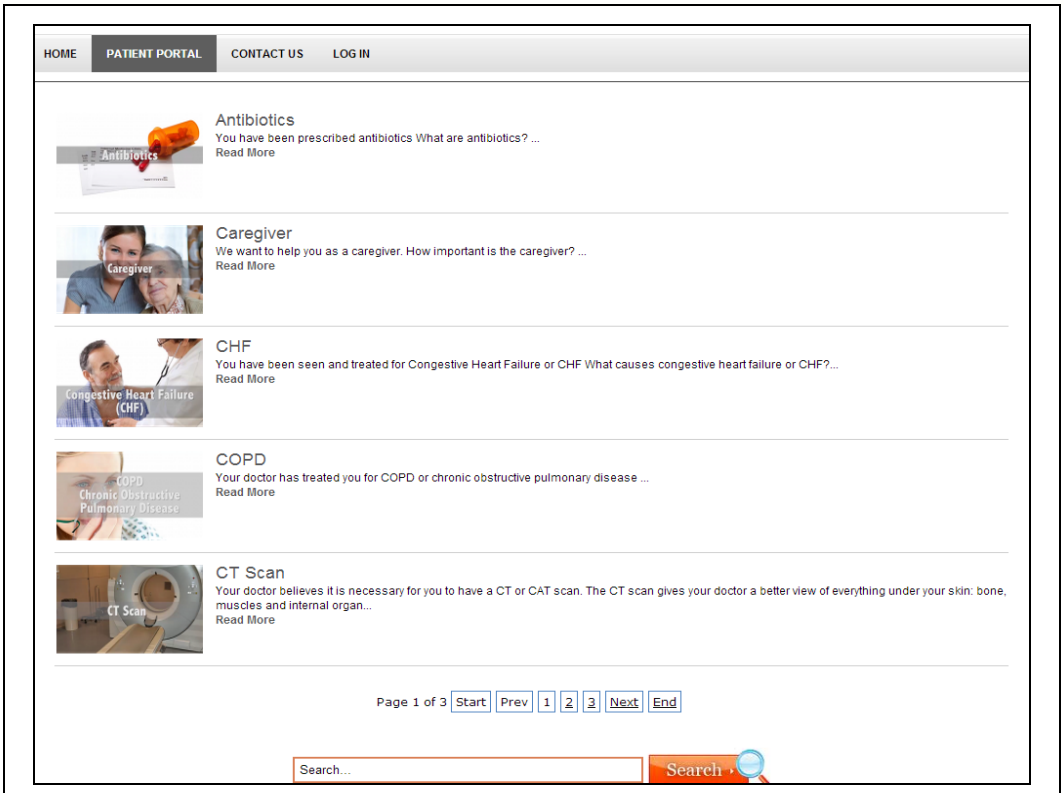

Figure 3. Patient Web Portal Menu to Access Video Content [Incendant, 2012]

- Standardization—the videos standardize a large proportion of educational content in the form of 3D images and videos.
- Usability—the videos are simple to use and require minimal training for healthcare providers and patients.

To accomplish the design requirements noted in the list, the ED physicians made several design choices during the design and development of the videos.

1. Videos could be accessed by physicians and patients in the hospital and in the patients' home.
2. Videos could be accessed by mobile devices, including smart phones, tablets, iPads, and the like, through the use of quick response (QR) codes. QR codes are small, two-dimensional barcodes that can be used to access information on websites.
3. Videos could be viewed on any existing multimedia device found in the hospital.
4. Videos could be used by the physicians in the emergency department or any hospital unit.
5. The system could help alleviate patient and family anxiety by minimizing confusion about the patient's condition and diagnosis.
6. The system could alleviate poor comprehension and attention to treatment plans.
7. The system could help improve home care by replacing confusing discharge papers with simple, graphical instructions.
8. The 3D images and videos could improve patient satisfaction scores which, in turn, would achieve an organizational goal to improve hospital reputation.

Artifact System Architecture Implemented After Third Design Iteration

The artifact described herein is depicted in Figure 4. This patient-centered e-health system, referred to as the 360 Patient Application, is accessible by both healthcare workers and patients, and can be shared with others who are

interested in the patient's health such as caretakers, family members, and healthcare providers. The e-health system provides three primary interface points. The clinician and patient may use the patient application on a tablet PC, mobile device, or other computer to view videos or educational illustrations while in the healthcare facility. Screenshots taken from these devices can be seen in Appendix B. Follow-up email messages may also be sent to the patient or other interested parties. These follow-up messages include links to the Incendant patient portal videos that can be accessed using any Internet-connected device in the healthcare facility or in the home. Additionally, patients may receive follow-up telephone messages where they can listen to patient educational materials that are specific to their diagnosis and be connected to facility personnel. This phone-based education is also available through the 24x7 patient support phone line.

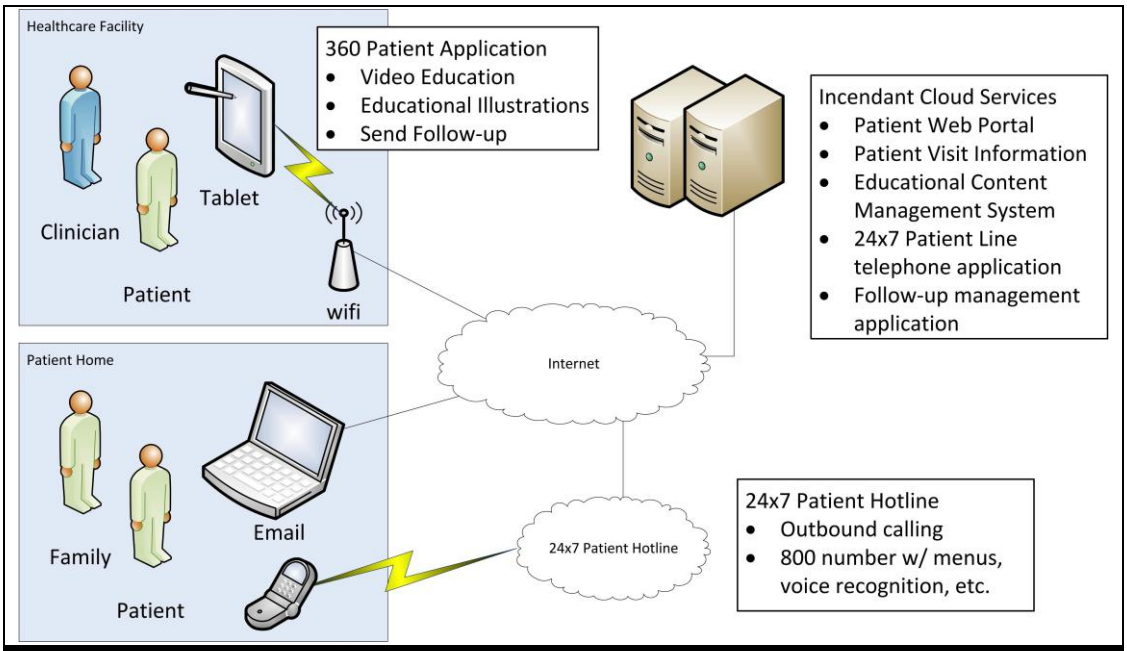

Figure 4. System Architecture [Incendant, 2012]

X. DISCUSSION

Interview findings indicate that there is a need for a mobile, multimedia patient education system as described herein to help aid physicians in patient education, and to empower patients with the information needed at discharge to make informed healthcare decisions. This research provided an opportunity to use an ISDT approach to develop and test a prototype (in PCEH) in this context. Evaluation of this prototype helped to expose design-practice gaps and gave system stakeholders an opportunity to suggest refinements and act as a catalyst to instigate quality improvement at a medical center.

Central to the success of the artifact described herein was the overall, positive feedback from participants on the perceived benefits to patient understanding. Consistent with the literature on PCEH, study participant responses suggest that the designed system exhibits at least some aspects of the following PCEH themes: patient-focus, patient-activity, and patient-empowerment. In terms of design goals, findings also indicate the system meets at least some media richness and media synchronicity conceptual model principles.

The themes and conceptual model described previously were used to organize participant responses to further understand the testable design propositions as described in Table 1. We present the design product testable propositions and then we present the design process testable propositions. Each of the testable propositions are presented in the following text, scored according to how heavily each proposition was commented upon (see Table 6).

The researchers conducted the scoring based on the qualitative data presented above. While Table 6 does not represent a statistical scoring methodology, it nonetheless provides an aggregated or "rolled-up" overview relative to the qualitative responses received, including which propositions were addressed by participants and to what degree. This systematic scoring proved very valuable at this stage as it brought into focus the propositions that need further attention in future iterations as well as the perceived importance of certain elements to the users participating in the prototype evaluation.

Table 6: Testable Proposition Verification	
Design product	
The education system will be perceived by patients as helpful for understanding and managing their healthcare needs	++
The education system will aid healthcare providers to increase patient understanding	+
Healthcare providers will perceive the system as useful in aiding them with patient education activities	+++
Design Process	
Patients will accept and use the education system and multimedia information	++
Healthcare providers will accept and use the education system and multimedia information	++
+ Proposition not well tested ++ Proposition tested, but not strongly +++ Proposition strongly tested	

The testable propositions as shown in terms of verification degree (see Table 6) support the use of ISDT relative to the design product as outlined by Walls, Widmeyer, and El Sawy (1992). The authors acknowledge that this evaluation was conducted on a prototype and in a demonstration environment. Therefore, the use of ISDT and the corresponding kernel theories, methods, and testable propositions will require further validation after a pilot field test when patients and physicians alike are using the system in a real-world environment with a production level system.

As Walls, Widmeyer, and El Sawy (1992) state, "an ISDT can be empirically validated only by constructing an IS based on its precepts and by conducting experiments with that system" (p. 46). Hevner, March, Park, and Ram (2004) further clarify that one way to evaluate design science research is through the socio-technical aspects of the artifact using quantitative surveys or qualitative interviews, and argue that "the goal of design science is all about efficacy and utility" (p. 41). Similarly, Käkölä and Taalas (2008) demonstrate the use of an ISDT with a case study and show that validity is determined if the artifact could be used to explain and generate solutions to identified problems. As such, the utility of the prototype thus far validates the ISDT and use of ISDT for designing a mobile, multimedia-based education system to help improve patient understanding at discharge.

In terms of design process, the artifact began as a paper-based solution and expanded to include a range of features available in many mobile and Web-based applications today. Described herein was a specific solution to improve patient understanding relative to hospital discharge. An important question is whether the artifact became more beneficial to patient understanding with each iteration. As per ISDT, following a rigorous process with multiple iterations and together with end users should have produced a positive answer to that question. However, additional evaluation is required to come to a solid conclusion. This will be discussed further in the next section.

XI. CONCLUSION AND FUTURE DIRECTIONS

This research has illustrated a PCEH design process around a specific hospital quality improvement initiative. In this regard, the e-health challenge described herein includes a common physician-patient engagement. Physicians commonly provide instruction to patients prior to discharge about a range of healthcare issues including discharge instructions, prescriptions, diagnoses, procedures, diagnostics, and related health information. As such, the design of the system described herein has included a user-centered approach focused on more than one set of users. These include: (1) physicians interested in enhancing patient education, and (2) patients/consumers of health information, especially in regards to understanding what healthcare actions need to be accomplished once the patient leaves the hospital. In this regard, the example herein provides support for system design foci to be centered on the needs of the patient according to the guidelines set forth by Wilson (2009). While PCEH themes explain that secondary emphasis should be on organizational goals, it is unclear whether the system described herein would have been developed without the hospital organization, together with physicians, first emphasizing the importance of PCEH in solving an identified organizational challenge. Thus, this research presents an example where PCEH principles integrated into a larger quality improvement project resulted in a system that could provide significant benefits to multiple stakeholders: organizational administration, physicians, and patients.

In terms of research, this article offered an ISDT for improving patient understanding, drawing generally from PCEH and media richness theories. An ISDT is an important contribution as it guides system developers and sets an agenda for academic research. In terms of practice, this article offers guidelines for developers of this type of system.

The design of a PCEH for improving patient understanding is aimed at helping organizations improve patient outcomes as a result of improved understanding. Moreover, such a system provides support to persons in achieving their goals of improved health. Future work should consider deepening the theoretical guidance for a PCEH system, including the evaluation methods used that relate to those theories, to further expand the ISDT presented herein. Patients are the people most impacted by the system. As such, future research should evaluate the use of the IT artifact by physicians and patients within a hospital setting. Patient understanding of the diagnosis and/or post-discharge instructions could be evaluated based on standard patient evaluation instruments such as the one used in phase I of this study. This could effectively associate use of the system with patient understanding scores. Because patient understanding is not the ultimate goal, a second set of studies could analyze the extent to which using the system by patients in pre-discharge and post-discharge environments translates into positive patient outcomes, such as adherence to discharge instructions, improved recovery in home care settings, and whether sustained use of the system results in fewer undesired hospital readmissions.

We believe that new and innovative PCEH approaches could be added as patients become more engaged in the actual use of the system. In this regard, we acknowledge that a limitation of the study is that additional design iterations are required. The authors acknowledge that these early evaluations may not appropriately represent all physicians and patients and that adaptations may be necessary as a production model is used more broadly. The development and evaluation of the system should continue through pilot implementation and testing. Future work will focus on addressing these issues and modifying the design framework with new findings.

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Editor's Note: The following reference list contains hyperlinks to World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the article on the Web can gain direct access to these linked references. Readers are warned, however, that:

1. These links existed as of the date of publication but are not guaranteed to be working thereafter.
2. The contents of Web pages may change over time. Where version information is provided in the References, different versions may not contain the information or the conclusions referenced.
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APPENDIX A: PHOTO BOOK IMAGES

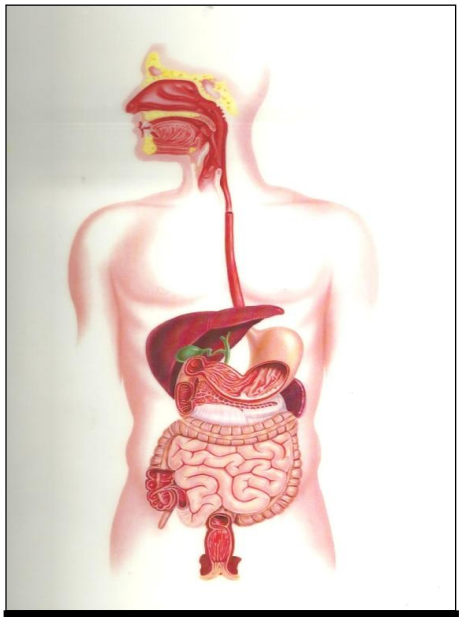


Figure A–1. Digestive System

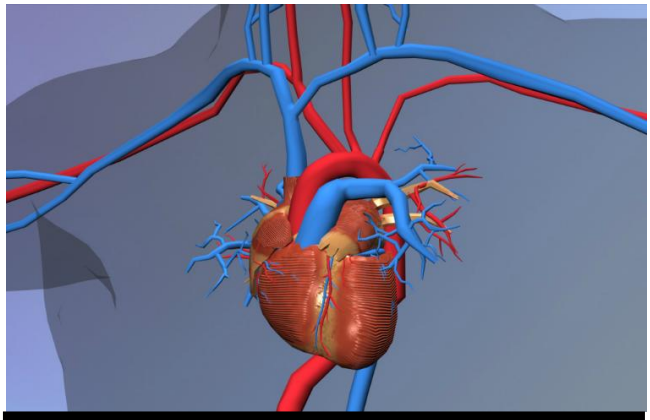
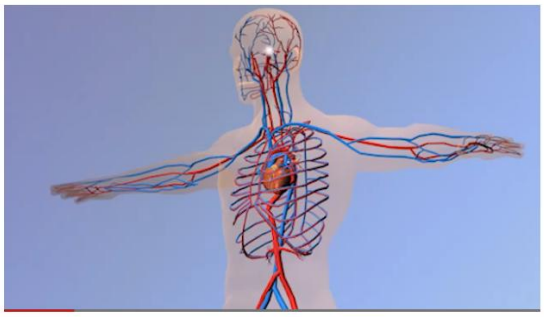


Figure A–2. Anatomy of a Heart Attack

Photos used with permission of Incendant.

APPENDIX B: SCREENSHOTS



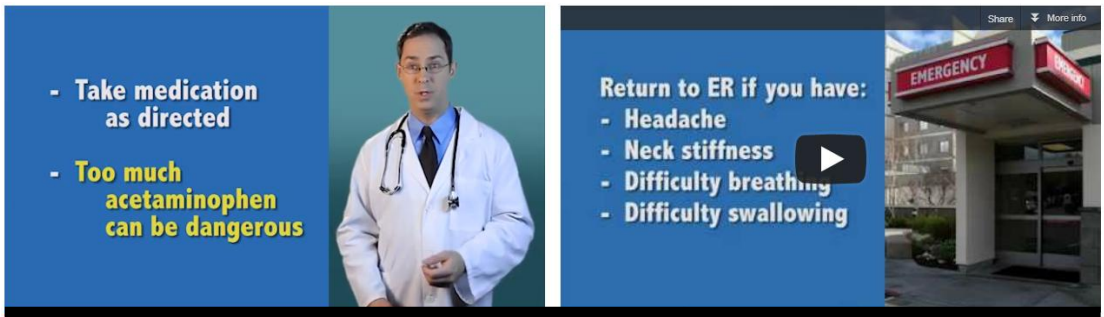


Figure B–1. Fever Video Screen Shots

Screenshot used with permission of Incendant.

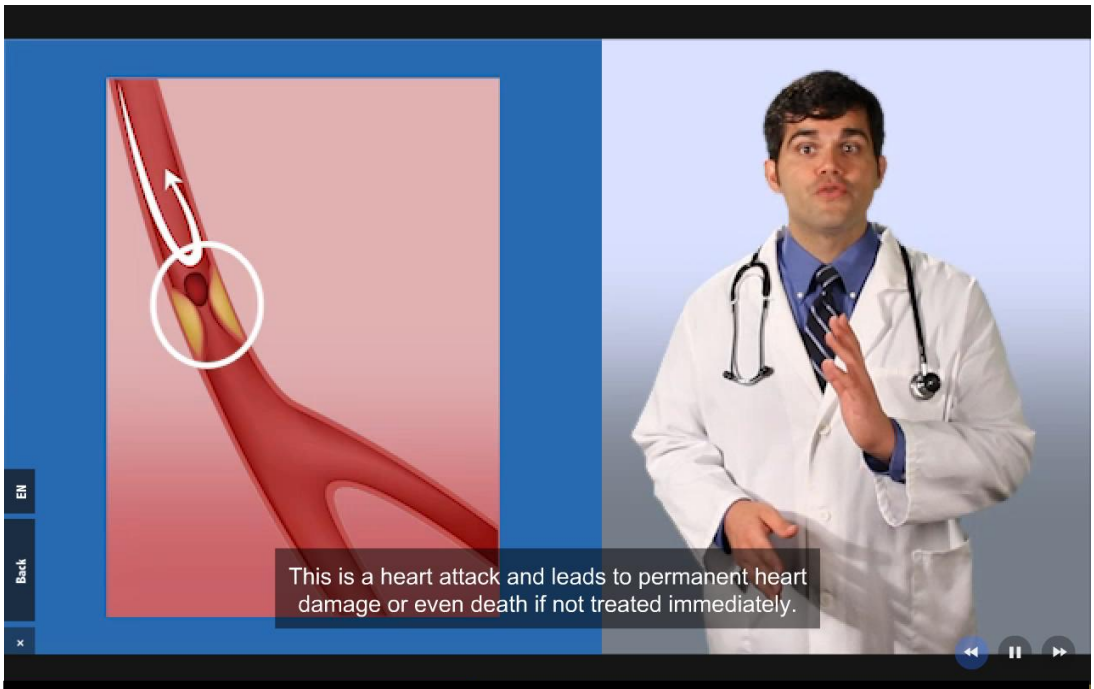


Figure B–2. Heart Attack Video Screenshot

Screenshot used with permission of Incendant.

APPENDIX C: VIDEOS

Table C–1: Videos

Topic	ER	Inpatient
ER Discharge	X	
1. Abdominal Pain	X	X
2. Ankle Sprain	X	
3. Back Strain	X	
4. Otitis Media	X	
5. UTI	X	X
6. Head Injury	X	X
7. Headache	X	
8. Seizure	X	X
9. Pneumonia	X	X
10. Pharyngitis	X	
11. Tooth Infection	X	
12. Bronchitis	X	
13. Cellulitis	X	X
14. Cervical Strain	X	X
15. Croup	X	X
16. Diarrhea	X	X

Table C–1: Videos – Continued		
17. Febrile Seizure	X	
18. Lower Extremity Fracture	X	X
19. Upper Extremity Fracture	X	X
20. Upper Extremity Sprain	X	
21. Lower Extremity Sprain	X	
22. Abscess	X	X
23. Nose Fracture	X	X
24. Contusion	X	
25. Dislocation	X	X
26. Nose Bleed	X	X
27. Sinus Disease	X	
28. Dysfunctional Uterine Bleeding	X	X
29. Pelvic Infections	X	X
30. Pelvic Pain Unknown Cause	X	
31. Threatened Miscarriage	X	X
32. Asthma	X	X
33. Biliary Colic	X	X
34. Chest Pain Unknown Cause	X	X
35. Conjunctivitis	X	X
36. COPD/Emphysema	X	X
37. Corneal Injury	X	
38. Diverticulitis	X	X
39. Dysrhythmia	X	X
40. Renal Colic	X	X
41. Wounds	X	X
42. Viral Illness	X	
43. Vomiting	X	
44. Ulcer Disease	X	
45. Otitis Externa	X	
46. Completed Miscarriage	X	X
47. Constipation	X	X
48. Reflux Esophagitis	X	X
49. Allergic Reaction	X	X
50. Hypertension	X	X
51. Fever	X	X
52. Syncope	X	X
53. Vertigo	X	X
54. Bell's Palsy	X	
55. Hypoglycemia	X	X
56. Hyperglycemia	X	X
57. Substance Abuse	X	X
58. Pain	X	X
59. Dermatitis	X	X
60. Pyelonephritis	X	X
61. Tendonitis	X	
62. Withdrawal	X	X
Procedures		
63. Procedural Sedation	X	X
64. Lumbar Puncture	X	X
65. Incision and Drainage	X	X
66. Paracentesis	X	X
67. Stroke—tPA	X	X
68. Cardioversion		X
69. PTCA	X	X
70. Colonoscopy	X	X
71. Dobutamine Echo		
72. Stress Echo		

Table C–1: Videos – Continued		
73. Angiography		
Diagnostics		
74. CT Scan	X	X
75. MRI	X	X
76. Ultra Sound	X	X
77. Nuclear Medicine		X
Medications		
78. Narcotics	X	X
79. Respiratory Inhalers	X	X
80. Antibiotics	X	X
81. Benzodiazepines	X	X
82. Antipyretics	X	X
83. Antihypertensives	X	X
84. Lipid Medications	X	X
85. Anticoagulants		X
86. Antiplatelets	X	X
Other		
87. Advance Directives	X	X
88. Smoking Cessation		X
89. Safety	X	X
90. Respiratory Failure/Ventilator		
Inpatient Discharge		
91. TIA		X
92. Heart Attack		X
93. CHF		X
94. PE		X
95. DVT		X
96. Angina (for ACS)		X
97. Sepsis		X
98. CVA		X
99. Post op Wound Care		X
100. Home Care:		
Emergency Care Plan		

ABOUT THE AUTHORS

Tonia San Nicolas-Rocca is an Assistant Professor in the School of Library and Information Science at San Jose State University. She holds a PhD in Information Systems and Technology from Claremont Graduate University. Her research interests include information systems security, health information systems, and knowledge management. Dr. San Nicolas-Rocca has published her work in peer-reviewed research journals and conference proceedings.

Benjamin Schooley is an Assistant Professor in the integrated Information Technology Program and Adjunct Associate Professor in the School of Public Health, University of South Carolina (USC). Dr. Schooley conducts applied research on the design, development, and field testing of information technology within a range of healthcare settings. His work in mobile applications for emergency medical services (EMS) has been supported by the National Science Foundation and Federal Highway Administration. His research on distributed, Web-based applications for people with chronic conditions and disabilities has been supported by the Centers for Medicaid and Medicare Services, Department of Labor, and California Wellness Foundation. Dr. Schooley has published his work in over fifty peer-reviewed research journals, conference proceedings, and book chapters.

Seong-Jong Joo is an Associate Professor of Production and Operations Management at the Hasan School of Business, Colorado State University—Pueblo in Pueblo, Colorado. He teaches undergraduate and graduate courses in Operations and Supply Chain Management. He is interested in studies on sourcing/purchasing, supply chain collaboration, inventory management, and corporate performance measurement.

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