Designing Community of Practice Systems: a Value Sensitive Approach

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Abstract—**This paper presents a process for designing an online Community of Practice (CoP) system for nurses. First, we used Value Sensitive Design by identifying the four features: benefits, harms, future trend, and pervasiveness of the CoP system to stakeholders. Next, we created two personas that represent direct stakeholders. We then incorporated the four features and personas into value scenarios. Based on the needs and barriers of potential users described in the scenarios, we created a paper prototype and evaluated its usability using three approaches: heuristic evaluation (HE), Wizard-of-Oz, and surveys. Our findings from the HE and Wizard-of-Oz methods demonstrated design flaws, as well as users' needs and barriers in interacting with the prototype. To sum up, this paper demonstrates a design process using personas and Value Sensitive Design. We also show an evaluation process using multiple usability testing methods that could be potentially used in the early stage of development.**

Keywords—*Design study; user-centered design; personas; value sensitive design; heuristic evaluation; Wizard-of-Oz; community of practice; online community of practice; virtual community of practice*

I. INTRODUCTION

The healthcare field is rapidly evolving and new medical knowledge is being produced at a very fast speed. One of the challenges to the Biomedical and Health Informatics field is how to integrate existing and new medical knowledge into practice. Experienced physicians use about two million pieces of information to manage their patients [4]. When seeing patients, physicians obtain most information from their memory, but, unfortunately, some of them are out of date or inaccurate [4]. Physicians cannot practice high-quality medicine without constantly updating their clinical knowledge to help them manage patients. In primary care as an example, each General Practitioner encounters more than 500 clinical topics in any year, so the information need is very broad. Healthcare providers may not have enough time during the routine work to look up in the literature for specific pieces of information by themselves when needed. However, talking to online colleagues might give them faster results. In other words, communication among the members may bring benefits to the levels of individuals (members) and to the community as a whole.

The online Communities of Practice (CoP), also known as a virtual community of practice, is developed and maintained using the Internet [5, 7]. CoPs are defined as "groups of people who share a concern, a set of problems, and a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" [12]. It is a learning tool hosted online and is established in a way that members (e.g., healthcare providers of a specific specialty like nursing, Family Medicine, Surgeons, etc.) can share tips, advice, knowledge, news, and literature. Members also have the capacity to raise concerns, problems, look for solutions, and seek best practices. These kinds of activities would benefit the members of the community by increasing the members' knowledge and encourage the culture of exchanging knowledge to add values to the domain of the practice. Further, CoPs allow their members to access to both tacit and explicit knowledge.

Tacit knowledge is the stored knowledge in everyone's' subconscious mind. It includes personal knowledge, physical skills, perception skills, emotions, values and actions which make it difficult to codify; however, it is difficult to document and formalize tacit knowledge. On the other hand, explicit knowledge can be recorded in a structural way such as guidelines, databases, graphs, and books [6]. Even though explicit knowledge is available in different format such as guidelines, healthcare providers would still need to take into account tacit knowledge as a source for common medical recommendations. Exploring those two types of knowledge is important to health providers because they could expand their horizons of thinking and not limit themselves to one way of thinking.

In the rest of the paper, we review related work to our study. We then describe Value Sensitive Design (VSD) with conceptual investigations, personas, and scenarios. We then present how we developed a prototype based on the persona and scenarios. We conclude with demonstrating our findings from the evaluation of the prototype.

II. RELATED WORK

A. Online Community of Practice

Community of Practice (CoP) is the process of social learning that happens when members in community with a shared common interest in a subject or problem collaborate to

share ideas and opinions in order to find solutions and develop innovations. The Community of Practice definition applies to every day's activities, as most people are involved in CoP at school, work, and home. Roles vary in CoP, some roles are at the center of CoP in terms of importance, while other roles are at the margin. Some CoPs do have names, some do not; some CoPs are formal and some are informal; some are well organized and some are not well organized at all. However, in a CoP system, it is likely members share their concerns or passions with other members for activities and learn from each other. The CoP systems can have a universal membership, but they are not bound by location or by participants. The CoP has different levels of participation among members. In this paper, we will focus on two types of members: senior and junior student nurses.

Prior work evaluated the effectiveness and usability of the CoPs. Meins et al. used surveys to test whether participation in CoPs improves community healthcare providers' knowledge of pain management strategies and the level of confidence in their ability for offering pain management [8]. Mather et al. used an online survey to determine the usability of a virtual CoP for clinical supervisors (e.g., senior nurse leaders) [7]. The survey participants (i.e., clinical supervisors) reported that a visual CoP would be useful for better communication about clinical supervision, but they were not sure about sharing knowledge to the public mobile learning resources. In another study, Roberts et al. used a mixed method study (i.e., surveys and interviews) to identify the enablers and barriers to school health therapists' participation in CoPs [11]. However, little is known about the usability of the prototypes of the CoP systems designed for multiple stakeholders (e.g., senior and junior student nurses).

B. Value Sensitive Design

VSD is known as an established approach for reflecting human values throughout the design process [3]. VSD was used to develop value scenarios [1, 13]. Value scenarios are defined as the integrated version of envisioning criteria (i.e., stakeholders, time, values, and pervasiveness) with scenario-based design approach [9]. The criteria in value scenarios help designers identify potential problem domains and find solutions.

Czeskis et al. developed and used value scenarios for identifying technical challenges and revealing the hidden human values for mobile phone safety [1]. In another study, stakeholders (homeless young people, service providers, police officers, and community members) created scenarios to elicit their thoughts about mobile device uses for their better safety of homeless young people [13]. However, to our knowledge, no studies used VSD to design CoP systems, in our study, we will identify benefits, harms, trends, pervasiveness of the CoP system through VSD and incorporate them into value scenarios.

III. CONCEPTUAL INVESTIGATIONS

We defined a design problem and created personas (see Fig. 1). We then created value scenarios through Value Sensitive Design [3]. We aimed to use the personas and use scenarios for creating a paper prototype of CoP systems.

A. Benefits of the CoP system to Stakeholders

CoPs have specific targeted users (stakeholders) when designed. We identified three possible groups of stakeholders who can use or benefit from a CoP: direct stakeholders, indirect stakeholders, and non-targeted users. Direct stakeholders are the targeted users who interact directly with CoP systems, while indirect stakeholders and non-targeted users are the users who do not interact directly with the systems, see Table I. CoPs are designed to benefit specific users (direct stakeholders), but indirect stakeholders and non-targeted users also can benefit from CoPs.

There are potential benefits per each stakeholder group. First, direct stakeholders are expected to have access to evidence, arena for solving problems, sense of belonging, reduced time for information search, skill building, practice outcomes, increased quality of care, quick answers to the questions, encouraging users to try new approaches (evidence-based), and access to clinical expertise, gain confidence, know alternative procedures, make better decision, build trust, get tips on giving bad news to families or patients, difficult conversations with colleagues or physicians. Second, non-targeted users may have an observation of the types of question posted by users. In particular, junior students may have easy access to useful information for academic purposes. Industry people may be interested in products and practices, while physicians may gain an improved understanding of issues facing nurses. Lastly, indirect stakeholders would be able to improve quality and increase understanding of patient's needs and values. Quality managers and health care administrators may have opportunities to improve process and workflow, and payers and the insurance profession may appreciate reduced harm and liability due to the application of evidence-based practice.

A. Harms of the CoP system to Stakeholders

There are potential harms per each stakeholder group. Potential harms for direct stakeholders are as follows: false information, weak evidence, mismatching of evidence to situations, repetition/annoyance, waste of time, too much information, complexity and investment to learn the system. Further, regarding non-targeted users, employers and
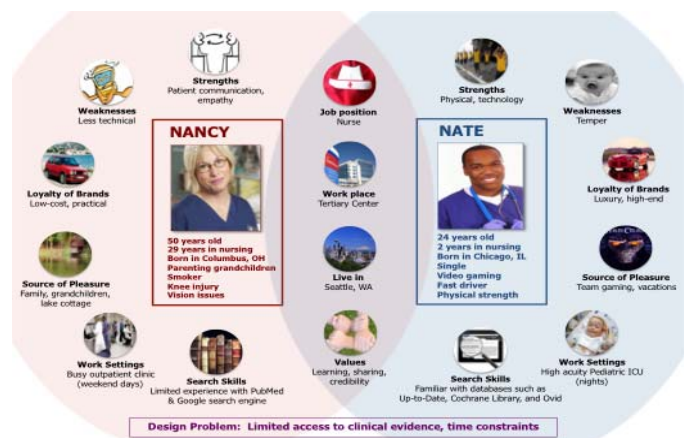

Fig.1 Personas

TABLE I.   INSTANCES OF EACH STAKEHOLDER GROUP

Category	Stakeholders
Direct stakeholders	nurses, senior and junior student nurses
Indirect stakeholders	patients and families, health care administrators, quality managers, other clinical disciplines, payers/insurance
Non-targeted users	employers, industry, physicians

TABLE II.   REFLECT ON FUTURE TRENDS OF THE CoP SYSTEMS

Category	Future Trends
How people do their work	CoP system could be integrated as a tool with access from the EMR. It will provide direct links to individual policies/procedures, as well as access to literature. As a result of the CoP, users will receive succinct summaries with strength of recommendations
How people make and maintain friendships and family relationships	Members of the CoP could feel more connected to each other by sharing their knowledge and experiences with other members. Communications, share common concerns, belonging to community, contribution to others or community, people relate to those similar to themselves, may feel validated to hear others with similar issues Feel a sense of responsibility to share their knowledge and experiences
Physical health and wellbeing	CoP system could provide voice-activated access option - no need to use keyboard or other device, similar to Siri on iPhone or voice commands for making calls CoP system will provide an option for users with poor vision, auditory output that reads aloud from the screen with an option to record for future reference.
Individuals who cannot afford the technology	CoP system could be available in many employment settings: hospitals, clinics, and academic libraries. Facilities pay annual fees which provide access to their employees. Free access is available in certain cases, for example newly graduated students and small hospitals.
Norms and social expectations	All practice is evidence-based: the CoP system supports this through consistently evaluating literature and strength of recommendation. Learning from others in different settings Sharing similar challenges, goals, and practices Solving problems Trust-based system

bad evaluation to the nurses based on the shared topics or in nursing care after viewing questions, and junior students may over use the system for insignificant questions. For indirect stakeholders, the potential harms could be unmet expectations and values, poor quality of care for example receiving the inaccurate procedures, and receiving the inaccurate information, receiving incomplete information.

A. Future trends of the CoP system

There are five categories of future trends: how people do their work, how people make and maintain friendships and family relationships, physical health and wellbeing, individuals who cannot afford the technology, and norms and social expectations. Table II shows an example for each category of trends.

B. Pervasiveness of the CoP system

First, we considered the needs of direct stakeholders. As the system grows to larger number of users, the processes for searching, categorizing, quickly identifying topics and conversation threads will become more important. We will need ways to minimize redundancy, to keep new information and requests fresh, and to moderate information/activity. We will expect a greater depth and richness of interaction reflecting diversity of users' practices. It is anticipated that work-life may be affected by growth of the system. Daily interactions among stakeholders could be replaced by online conversations in CoP. Our system may offer a network of additional communication channels for nurses. This will allow nurses of another method for communicating with many other members of their community rather than the current limitation of speaking one to one. Ideally, the values of sharing, learning and credibility will diffuse from the CoP into clinical areas and promote community building among nurses in every aspect of their work.

Second, we considered the needs of indirect stakeholders. Indirect stakeholders will not have any access for "direct interaction". However, our system will generate reports of user activity: type of questions, clinical concerns, and quality indicators. In addition, the system will provide mechanism for an automated generic summary of articles (SOA) available by request within a fee structure. As the system grows, the indirect stakeholders may begin to expect higher standards for use of evidence, reflected as better patient outcomes, optimal practice patterns, and enhanced quality of care.

Third, we identified implications of widespread use. As the system might be widely used in several places, we would need

to think about the efficiency of the system. To maintain the values of the community, we will plan for a dedicated server and backup server to deliver uninterrupted access, timely and expert moderated information. Growth of CoP may bring about a relative culture shift among stakeholders and those affected by the work of our stakeholders, including patients, families, and individual health care recipients. Standards and quality indicators will be well known and widely accepted as the "way we deliver care", evidence will be transferable and translated to practice quickly with a shared mentality for optimizing care. Reflect on Future Trends of the CoP systems satisfaction measures for providers and receivers of healthcare will be vastly improved.

Lastly, we considered widespread geographic locations. Our online community will not be limited to one geographic location which benefits direct stakeholders by supporting varied practices. Our direct stakeholders are nurses across the world, thus ensuring active members at all times of day and night. We will consider how to provide the services in languages other than English. We anticipate that the translational capacities will improve over time, we will not build a translation service into the system, rather we will

implement one to the extent possible (such as Google Translate). Our users will be advised of limited availability for translation in the early phases with enhancements available over time after rigorous testing to assure credible translations of medical evidence.

IV. SCENARIO DEVELOPMENT

A. Personas

As part of our scenario-based design approach, we created two personas with ten attributes (see Fig. 1). Four entities, such as job position, work place, places, and values were the same although we aimed to create two distinct personas to make them representative of real-life situations. The remaining six entities were: strength, weakness, loyalty of brands, source of pleasure, work settings, and search skills. These entities were used to specify the characteristics of each persona.

B. Scenario A

1) Scenario

Nancy (50 years old) works as a pediatric nurse in well baby clinic. She is used to receiving babies in the examination room where she measures vital signs including: temperature, heart rate, blood pressure as well as their growth and documents them on the paper chart.

Today, due to the shortage of the nurses because of the summer vacations, the charge nurse assigned Nancy with a different task, which is vaccination. Before the clinic opened, she dusted off the pediatric reference book to refresh her memory of vaccination schedules, medication interactions, and delivery techniques. When she received the 11th baby, she prepared him for vaccine by exposing the area, cleaning with alcohol swab then inserting the right dose of the right vaccine in the syringe. After she gave the baby the vaccine, he cried loudly then he started to have some difficulty in breathing and he turned to be somewhat pale. Nancy put oxygen on the baby and calls the other clinic down the hall for back up. The second nurse who responded explains that she has seen this before and that the baby will recover in a few minutes. The charge nurse is worried and no physician is around. How can Nancy share this experience with the community? Since she is already logged into the institution EMR, she can easily find the link to the community of practice (CoP). She now logs into welcome page for the CoP. She finds an icon for sharing and begins the process to describe her experience for others in her community. She engages with the system to initiate a post about how the infant responded to the vaccination and her supportive measures. She knows that other nurses might face similar situations when administering vaccinations to infants and knows that they can learn from her experience. In addition, she noticed that in the clinic, there are many young nurses who may not have much experience. Nancy is pleased to find several responses from other CoP members when she next logs into the system.

2) Discussion

One of Nancy's key values was sharing knowledge with others. This scenario represents how Nancy shared her experience with other nurses using the CoP system. She was able to accomplish the task successfully, even though she was not a tech-savvy person. Further, based on working experience, this scenario demonstrates that her key value was empathy because she was aware of the situations where other nurses might have difficulty. This motivated her to support young nurses who have less experience than her. However, as this scenario does not describe about how she interacted with the CoP to gain knowledge from other nurses clearly, there still exist t*he key value tension between empathy and technical skills for sharing in this scenario to have CoP as a learning tool.*

C. Scenario B

1) Scenario

Nate works in the Pediatric Intensive Care Unit (PICU) where he likes to care for the sickest of critically ill patients. In the PICU he has a routine of following up with all patients. At the beginning of the shift he would do a head-to-toe assessment, equipment and safety checks, document his assessment and draw up a work list. He reassesses head-to-toe every two hours, and documents vital signs, ins and outs and ventilator settings hourly. In between he does basic nursing care and treats any urgent concerns like hypotension, pain management, agitation, and does some teaching with the families when they are present.

Today, the relief charge nurse assigned Nate to a newly intubated patient. He knew that monitoring ventilation was a primary goal for this patient. In collaboration with the respiratory therapist, he adjusted all settings including Peak Inspiratory Pressure (PIP), Positive End Expiratory Pressure (PEEP) and Ventilation Rate (VR) as the guideline (and unit protocol) recommends. The patient started to have high CO_2 readings, but not critical. This is Nate's first case with such a presentation. None of the senior nurses or the physicians were around. Nate paged the resident and when the covering fellow called back she told him that she would be there in 10 minutes. While Nate was waiting, he picked up his smartphone and started looking up literature on a web browser. He found three different recommendations and was wondering which one to follow. What can he do now?

Nate made a phone call to one of his colleagues that graduated with him. They had a conversation about the three differing recommendations hoping that his friend could help him identify the best practice. Neither had a good way to evaluate the recommendations. He then decided to use a different approach. He clicked on an icon for the CoP (on his smartphone), hoping for more satisfactory help. He accessed the advanced search option. He then typed a couple of questions related to the clinical situation. He submitted his questions and immediately got results. To his delight, he went back to patient care with a summary of articles with a clear ranking of strength of evidence. After his shift ended, Nate thinks about the CoP as a resource and learning tool for his clinical practice. He invites his friend to join the community and shares with her the summary of articles.

2) Discussion

Nate's key value was initiative on learning from somebody. This scenario shows how Nate was able to get the answers to his questions related to the clinical situation using the CoP system. Although he was not an expert in the PICU, this scenario showed that he was good at using innovative technologies, such as interacting with the CoP using his smartphone and utilizing the advanced search option for identifying search results efficiently. In particular, as he invited his friend, this scenario showed how new members could join existing a CoP system and have it as a learning tool.

V. PROTOTYPE DEVELOPMENT

We created a paper prototype (see Fig. 2.) that reflects the needs and barriers of the potential users of the CoP system using the persona and scenarios described in the previous section. Key features in the prototype includes logging on to the system, displaying information on a dashboard, searching for literature, and posting text to the system.

VI. EVALUATION

Our overarching goal for this evaluation was to gain deep perspective of how potential users (direct stakeholders) interacted with our system. In particular; our intent was to assure that the system was useable, friendly, meet expectation, and serve special needs of our users. The benefits of involving potential users in the evaluation process are twofold. First, it helps the designers to increase their understanding of user's requirements and needs for the system. Second, users may be more ready to accept the completed system. That said, we intended to accomplish the following specific goals: a) identifying and consider many interface issues for the users, b) identifying possible needed functions in the design, c) identifying missing elements, d) getting recommendations to strengthen the design effectiveness, e) getting more insights into the existing functions of the design, f) expanding the designers' knowledge of the domain, g) collecting quantitative measures of feedback on potential uses of the CoP system. We used three methods for evaluating the usability of the CoP system: Heuristic evaluation [10] for a), b), and c), the Wizard-of-Oz technique [2] for d), e), and f), and survey for g).

A. Heuristic Evaluation method

Using heuristic evaluation is beneficial because usability problems can be found by a small number of evaluators with relatively inexpensive costs [10]. We invited an evaluator who has experience with in the field of human-computer interaction design for at least five years and asked the expert to fill out the checklist (see Fig. 3) using the Nielsen's ten original usability heuristics [10]. Prior to the evaluation, the evaluator received an overview of the system and minimal instructions describing how to interact with our paper prototype. We then provided the evaluator with our system prototype and the checklist. We asked the evaluator to provide comments on the heuristic and give a scale from 0 to 10 where 0 is the least and 10 is the most to improve the design.
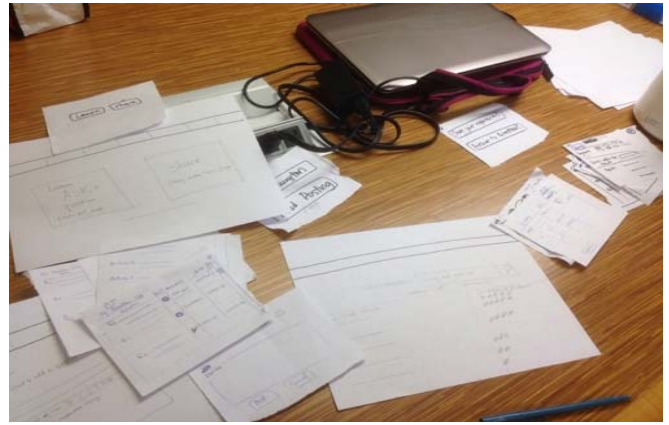

Fig. 2. Paper prototype

B. Wizard-of-Oz method

We used the Wizard-of-Oz method [2] to evaluate the usability of our prototype with direct stakeholders. This method is particularly valuable when testing unimplemented prototypes in the early stage of the development [2]. We recruited two participants who are Registered Nurses (RN) and could potentially use the CoP system. Prior to the evaluation, we set up a room as shown in Fig. 4 and assigned a role to each author.

For instance, one author was assigned to be a wizard who will drive the prototype in response to each participant's actions (clicking or voice activating) in real time, while the other authors were assigned to an observer and recorder who are in charge of taking notes of the behaviors and actions of each participant. Authors participated in reviewing the recorded video afterward together. During the evaluation, each participant was asked to interact with our prototype in order to accomplish the two tasks: searching for literature from database and sharing one's experience with others by posting text about the experience. We provided each participant with instructions about overall study procedure. Each participant then started interacting with the prototype. For each action of the participant, such as clicking a button and typing text, the wizard manipulated the prototype to respond to the action. For

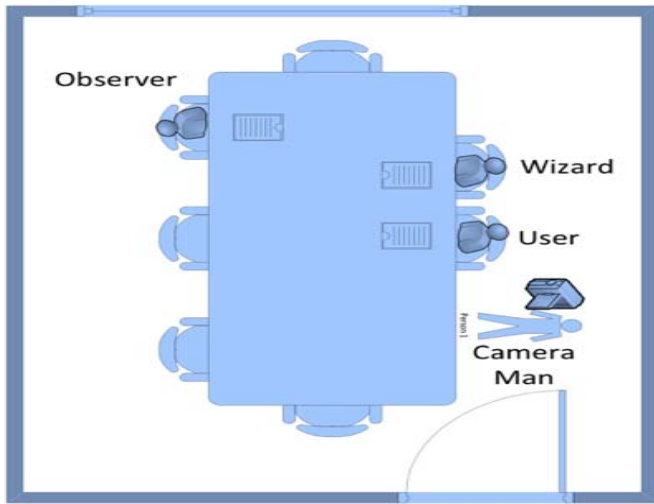Fig. 3. Heuristic evaluation form

Fig. 4. The setup of the Usability testing room for the Wizard-of-Oz method

instance, if the participant clicked on the "Next" button, the wizard put the paper that represents the next screen on the existing prototype.

C. Survey

We conducted surveys to understand the perceptions and potential uses of the CoP system, which were not captured by Heuristic Evaluation and Wizard-of-Oz methods. After reaching out to nursing students and posting adds in the nursing faculty we only got five respondents participated in a web-based survey.

VII. RESULTS

First, from the heuristic evaluation, the evaluator in the study reported that the following three principles received higher than the point 5 (see Fig. 5.): recognition rather than recall, aesthetic and minimalist design, and help and documentation. However, the following four principles received less than the point 5: user control and freedom, consistency and standards, flexibility and efficiency of use, and help users recognize, diagnose, recover from errors.

Second, from the Wizard-of-Oz usability testing, we found that two participants mentioned comments on the following five themes: hesitant to join community, topics of interest, literature and strength of evidence, answer questions of others, and ask questions. Table III demonstrates challenges and preferences in interacting with our prototype.

Lastly, as illustrated in Fig. 6, all the participants strongly agreed that shared knowledge can help other members and help advance the knowledge of the community as a whole. Participants thought that the designs represent an area of common interest for nurses and gave them a sense of belonging. Further, participants agreed that the designs were helpful in building relationships and networking with others. Also, they agreed that the designs benefit their daily work from the relationships established. Participants also agreed that the designs reduced communication barriers among members with a user-friendly communication platform. In terms of the potential uses of the designs, 4 out of 5 participants agreed that

the designs will help them in the future to achieve better results, as well as building, sharing and learning into their work life.
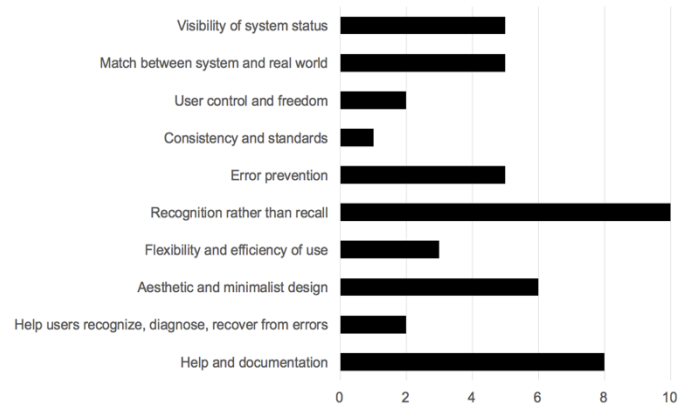

Fig. 5. Heuristic evaluation results (scale 0 to 10 where 0 is the least and 10 is the most)

TABLE III: USER EXPERIENCE FROM WIZARD-OF-OZ EVALUATION

| Themes	Participant 1	Participant 2
Hesitant to join community	Worry about cost	Credibility of site, unclear how to join
Topics of interest	Recommend dropdown list	Request default to modify interests during use
Literature and strength of evidence	Read each, delete, then go back and save	What is advantage of CoP? Why not us other search engine?
Answer questions of others	Prefer answer the author, not list of question	Request immediate access to the next posting
Ask questions	Prefer to read others' questions first	Prefer reading about topics first, alto want to know "who" before posting
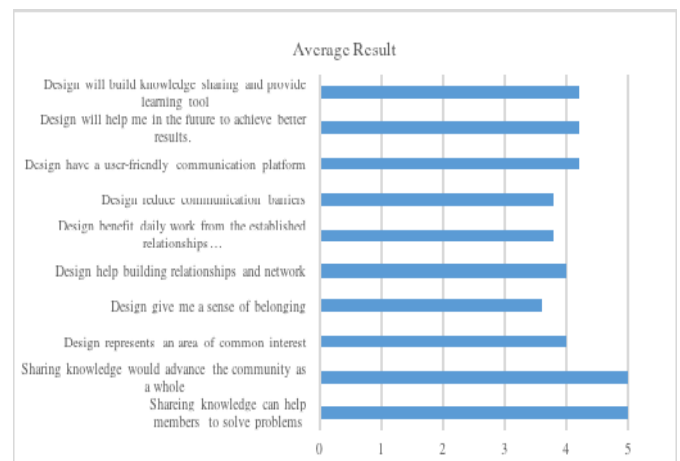
Fig. 6. Survey average results from direct stakeholders (scale 0 to 5 where 0 is the least and 5 is the most)

VIII. Conclusion

The main contribution for this work is that we showed how the VSD approach involving multiple stakeholders can be used for creating a CoP system. Further, we demonstrated that use of VSD can be used to identify the needs and barriers of the stakeholders at the early stage of the design process. In particular; we created a paper prototype based on VSD and evaluated the usability of the prototype using the known three methods: heuristic evaluation, Wizard-of-Oz, and surveys. From the heuristic evaluation, we identified initial issues related to the user interface of the prototype. Using the Wizard-of-Oz method, we observed how participants interacted with our prototype and found the five common themes in terms of interaction with the prototype. We then gained feedback on the themes. In addition, we collected a small number of responses from the web-based survey and found the perceptions of the participants in regard to shared knowledge, belongings, and potential uses of the prototype.

One of the limitations of this work was that we did not involve indirect stakeholders (i.e., patients and families, health care administrators, quality managers, other clinical disciplines, payers/insurance) for evaluating the usability of the CoP prototype, though they were identified in VSD process. In particular; our study showed that VSD can be used in the early stage of development of the CoP system. For instance, VSD was used for understanding how direct stakeholders would interact with potential CoP systems based on stakeholders' values. In addition, value scenarios were used as materials to generate ideas about which features should be included in a paper prototype of the CoP systems. To give a stronger result from the survey we need a bigger number of participants.

Further research into creating and evaluating functional prototypes of CoPs based on the findings from this study is required to determine the acceptability, feasibility, and effectiveness of the system in real-life scenarios. It would be also worthwhile to determine the satisfaction and attitudes of both direct and indirect stakeholders with the prototype.

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