PERSONALIZED REQUIREMENTS ELICITATION USING A DOMAIN MODEL

by

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THESIS ABSTRACT

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My interest is in applying a domain model to help elicit personal requirements for the problem of community travel for people with cognitive impairments. The domain model I took advantage of is the ACT model, which is embedded in the tool I designed for defining required prompts for travel. I set up a study to look at the use of the domain model to help travel-planners generate personalized prompts for a traveler. My goal is to better understand the mechanisms of running a human-performance study and to get a first look at how the domain model can be understood by travel-planners. The study shows that most participants prefer the ACT-based tool to free-thinking and writing down prompts. I found out that the tool helps participants define more organized and concise prompts, but not necessarily a higher number of prompts, compared to the free-think approach. The tool captures prompts for some steps that are neglected while free-thinking. However, some steps of the ACT model need to be disambiguated or presented more effectively in the tool.

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CHAPTER I

INTRODUCTION

I am interested in elicitation techniques that generate personal requirements [1]. In application areas such as assistive technology, educational technology, and any other area where individual characteristics have an important role in determining functionality of the application, producing personal requirements becomes crucial. The problem I'm addressing in my thesis is community travel for people with cognitive disabilities.

The PC-RE framework suggested by Sutcliffe et. al. is a method for requirement analysis that accounts for individual and personal goals, and the effect of time and context on personal requirements [1]. The framework rests on a means of assessing an individual user to produce his or her personal requirements. I believe a domain model of community travel can be integrated to this framework as the basis for an assessment process. The domain model I applied is ACT (Activities of Community Transportation) [2]. Section 1.1 contains a description of the PC-RE framework and the ACT model.

My thesis also aims at learning two foundational research methods. The first is the means to present the domain model to the stakeholder group that is most relevant: the care providers that act as the travel-planners for the end-users (people with a cognitive impairment). The travel-planners will be required to understand the domain model to use any subsequent assessment process I derive in my later work. I wish to gain some experience in presenting the model to them. Second, I will need to understand the mechanisms of carrying out a human-performance study. This includes setting up the

study question, getting consent from the human subjects office on campus, running the study and then analyzing the results. I have chosen a thesis problem that I believe helps with both methods.

The following section provides a background of some fundamental concepts. Chapter II describes my thesis study problem. Chapter III addresses related work. Chapter IV discusses the evaluation goal and procedure. Chapter V is about study results. Future work is discussed in chapter VI, followed by the summary.

1.1. Background

The following sections will describe the PC-RE framework and the ACT domain model.

1.2. What Is PC-RE?

PC-RE [1] is a framework for personal and contextual requirements analysis. The motivation for the framework is that considering just general functional or non-functional requirements of a software system is not always enough. Individual characteristics and personal goals, and the effect of time and context on personal requirements should also be considered. The framework, as shown in figure 1, has three layers: general requirements, individual user characteristics, and personal goals. At each layer, requirements vary over location and time.

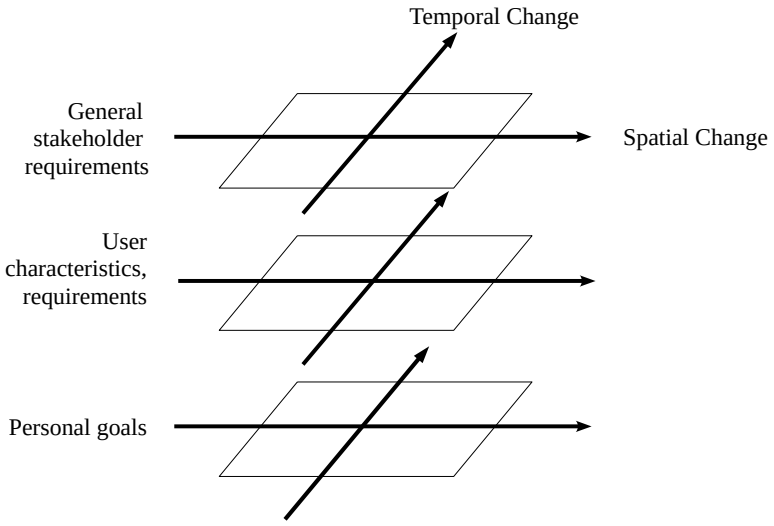


Figure 1. PC-RE framework [1].

The use of PC-RE framework is illustrated with a case study of personal navigation system called GO. This case study addresses personal and mobile requirements to help disabled users make trips on their own, assisted by a mobile PDA guide. Requirements for the GO navigation support application are organized according to the PC-RE framework as shown in Table 1.

Table 1. Requirements for the GO navigation support application [1].

Requirements layer and goals	**Functional requirements**	**Temporal change**	**Spatial context**
Group: enhance independent mobility	Schedule reminder, route instructions, route map, bus transport guide	Learning effects: add new routes, select route	Appropriate instructions, map display, re-orientation help
User characteristics: short term memory loss, forgets purpose, location, time and destination	Schedule reminders, route following walking, bus trip instructions, destination reminder	Add new routes, instructions for new modes of transport	On route tracking for appropriate instructions, destination reminders, off route re-orientation
Personal goals: social meeting; recreational trips; trips to job	Fixed route support, reminders for regular trips, new routes	As above. Add new routes	As for user characteristics plus privacy of instructions in public places

1.3. What Is the ACT Model?

ACT (Activities of Community Transportation) [2] is a comprehensive model delineating the requisite steps and skills for community navigation for individuals with cognitive impairments. ACT is designed at the department of communication disorders and sciences at university of Oregon. It is validated based on observations of 395 actual trips by travelers with navigational challenges.

ACT is composed of three components: 1) steps required to access and use public transportation, 2) person-centered skills required for successful community travel, 3) community-centered supports. The third component is not considered in my project, because this component states pre-requisite supports that community should provide. It has nothing to do with defining personal reminders for a traveler. Figure 2 shows the first two components of ACT model that are applicable to my project.

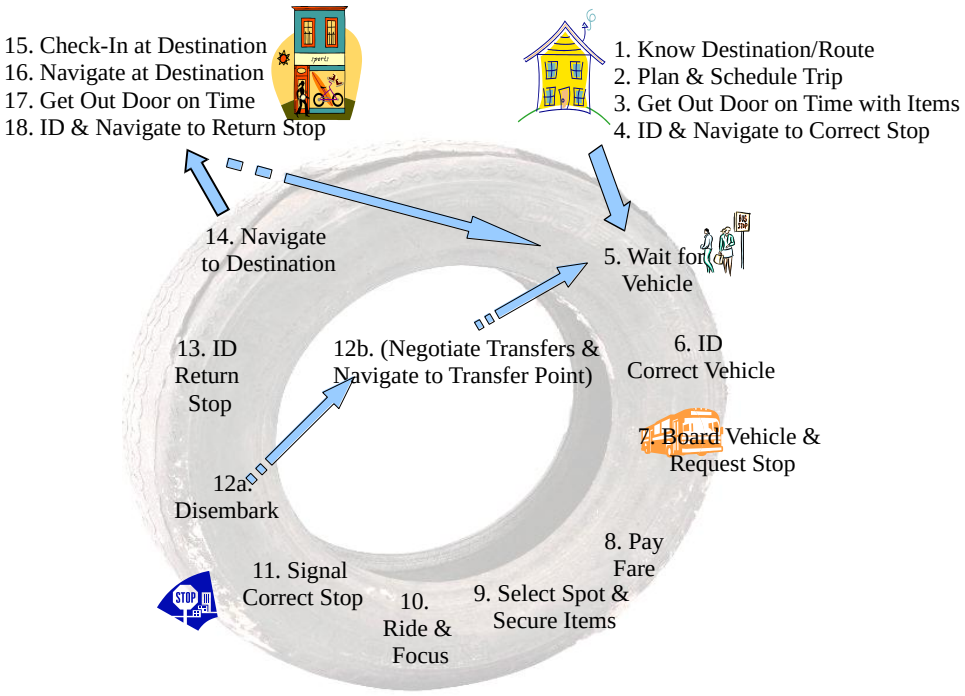
CHAPTER II

MY THESIS STUDY PROBLEM

In the following paragraphs I will describe my proposed method for incorporating the ACT model in personal requirement gathering.

The problem I studied is that of generating prompts and reminders for community travel for people with a cognitive impairment. Assume a person with a cognitive impairment starts travel from home, goes to a destination by bus and walking, navigates at the destination and then returns home. A reminder system developed for the person sends appropriate prompts via a cell phone the person is carrying during the travel. A rehabilitation professional, or clinician, has defined the prompt set in advance. The goal of sending prompts is to help the traveling person overcome his/her disabilities whenever required during the travel. Some example prompts would be “don't forget your wallet”, “bus number x is coming, be ready to board”, “Pull the stop cord and prepare to get off”. We assume that the person and bus are equipped with GPS technology and we always have the current location data of the person and the bus.

Since a clinician or care provider will need to tailor the prompts to each individual, I have developed a computer tool to help generate the personal prompts required. The tool will be based on the ACT model. My research statement is that an ACT-based tool will capture more personalized prompting requirements than techniques that do not employ a domain model.



Person-Centered Supporting Skills		
Physical Mobility/Endurance • Efficiently maneuver indoors • Efficiently maneuver outdoors • Efficiently board/disembark • Maneuver in vehicle (*access seat or handrail, reach stop request cord*) • Safely cross streets	*Social/Behavior* • Appropriate behavior (*respect personal space, regulate emotions, appropriate topics, follow rules, appropriate seat*) • Stranger safety	*Communication* • Express self efficiently (*speech or device*) • Follow spoken directions or instructions • Follow written directions, signs, or signals
Cognition		
• Attention (*stay awake, watch for vehicle or landmarks*) • Memory (*remember destination; follow route steps; keep track of items*) • Initiation (*act on intentions*)	• Spatial skills (*know direction to go*) • Planning (*use travel schedules; dress for weather; organize & bring needed items; have fare ready; think one step ahead*) • Problem-solving (*know what to do for unexpected changes; avoid obstacles)*	• Time management (*keep track of time, know when to leave*) • Fare management (*swipe pass; keep pass current; make correct change*) • Use telephone (*dial & connect*)

Figure 2. The ACT domain model [2].

Section 2.1 described how the ACT model can be integrated to PC-RE framework. Section 2.2 is about the tool I designed for capturing personal requirements for community travel.

2.1. Integrating ACT with PC-RE

The ACT model can be used along with the PC-RE framework and help elicit personal requirements for navigation support system.

The steps piece of ACT clarifies general goals and requirements, hence it corresponds to the PC-RE top layer. ACT enables requirement-engineers to have a clear definition of a “successful travel” or “making a trip”. The ACT steps specify the actions and order they should be taken to accomplish a trip. Without the ACT model, “travel” or “trip” are abstract concepts in the mind.

The skills piece of ACT lists required skills for making a successful trip. It explains the concept of “user characteristics” for traveling by specifying exactly what kinds of skills are involved in a travel. Without ACT skills, some skills might be neglected and some skills that have no role in making a travel might be considered in requirements definition.

When defining personal requirements for an individual, the requirement engineer needs to select a subset of ACT steps and a subset of ACT skills that match the individual's needs.

The integrated ACT and PC-RE is shown in figure 3.

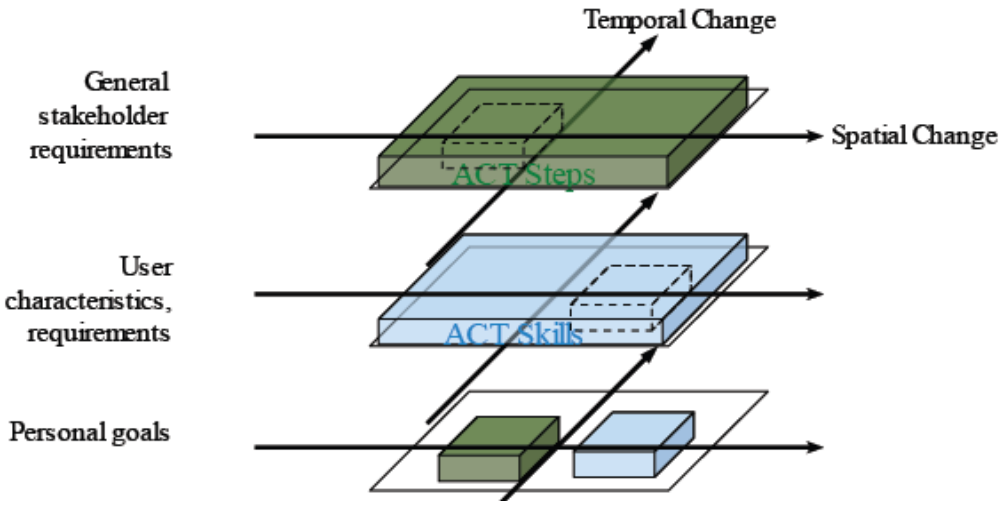


Figure 3. PC-RE with ACT.

So far I have discussed the correspondence between ACT and three layers of PC-RE. In the following paragraphs I will describe how ACT complies with temporal and spatial dimensions of PC-RE.

Requirements of the navigation system are expected to change over time as the users learn to navigate more effectively. In order to comply with this temporal change, the ACT should be evolved over time to cover new routes. Since the ACT is an abstract model, and there is no specific route, bus line, bus stop, or destination in this model, adding new routes or more complex destinations does not make sense. Hence, the ACT does not address the temporal dimension of the PC-RE framework.

Spatial implications of navigation system is dynamic change of instructions according to the subject's location. The ACT provides abstract model of locations the user will visit. Hence, it complies well with spatial dimension of PC-RE.

As the first cut of the study, I focus on the steps part of the ACT model and try to find a way to effectively represent it in the computer tool. The aim is to keep the first experiment more focused and tractable. Currently because I have not included user profiles and skills piece of ACT, I am not verifying the benefits of combining PC-RE and ACT. To make the project tractable, I decided to focus on introducing the combination of PC-RE and ACT, representing the steps piece of the ACT in a computer tool, doing the experiment with the tool and see the effects of using the tool for defining the prompts compared to the typical paper and pencil method.

2.2. GeneratePrompt Tool

The ACT domain model is applied in the GeneratePrompt tool that I designed for defining the prompt set. The tool is organized along one dimension of the ACT model, which is the steps piece of ACT. A linear representation of ACT steps is embedded in the tool to clarify steps of travel. I believe this method can help clinicians consider all steps of travel, match person's need with these steps, and define a better set of prompts. A clinician will be able to define one or more prompts for each step. Defined prompts are transformed to standard XML format for prompting devices.

Figure 4 is a snapshot of the GeneratePrompt tool. Center area of the screen presents ACT steps in linear format on a travel map. Numbers 1 through 18 correspond to ACT steps. The user can navigate between steps either by clinking on each number, or by clicking the "Next Step" button at the bottom of the screen. The cell phone on the left pane is the area for defining and editing prompts. The user types text prompt on the cell

phone screen. Right pane shows title of the selected step along with a list of prompt(s) defined by the user for the step.

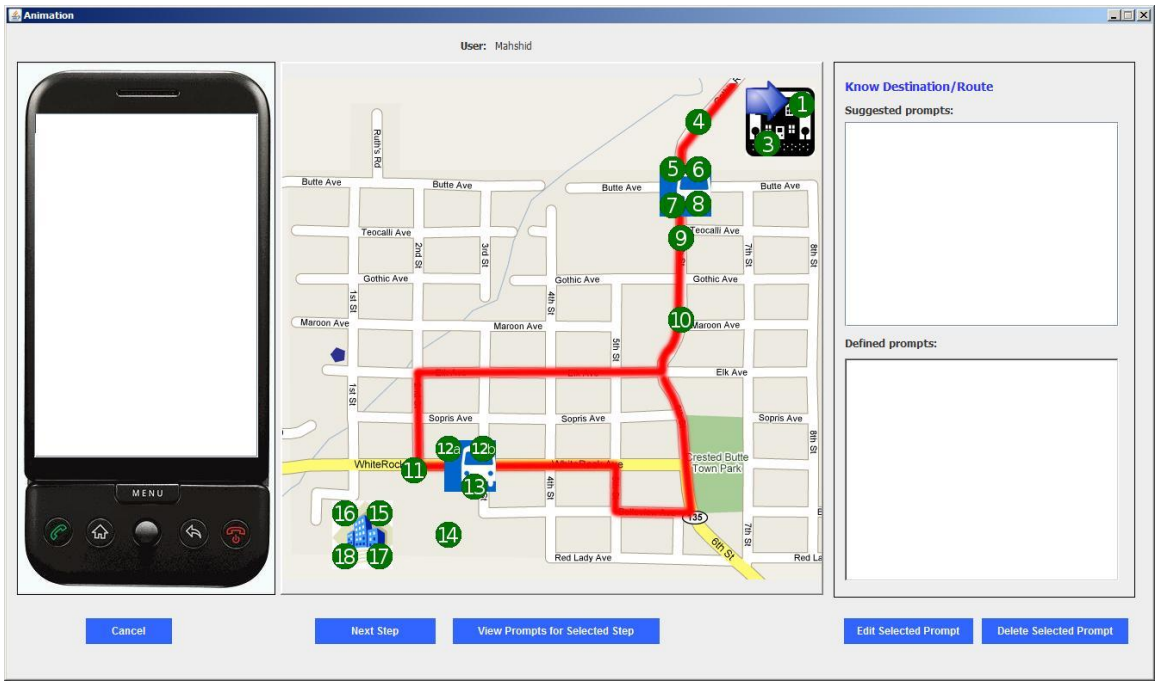


Figure 4. Snapshot of the GeneratePrompt tool.

CHAPTER III

RELATED WORK

Oliveira et al. [3] defined the concept of Domain-Oriented Software Development Environment (DOSDE). They used the domain knowledge, specified using an ontology, in software requirements analysis and design of the software system. They conducted a small study to verify their approach.

A domain model is mainly used as a key element in systematic software reuse, for example in [4,5,6]. To my knowledge, no other group has used a domain model in personal requirements elicitation.

Software personalization is also known as software customization or software variability in the literature. Most approaches in this area study software customization as a design problem. But the work by [7] casts customization as a requirements analysis problem. They propose a framework for requirements analysis based on user goals, skills, and preferences.

Work in [8] used pedestrian navigation system as a case study for “deep” personalization. By deep personalization they meant including knowledge of an individual's skills and limitations in requirement engineering process. They used the domain theory of navigation system to develop assessment techniques for individual's abilities. They then worked toward matching the individual with an assistive device.

Sohlberg et al. [9] worked on creating community navigation profiles for adults with chronic cognitive impairments. Such profile includes types of destinations, modes of transportation, frequency of travel, level/type of transportation support, and problems encountered by the travelers. In their research, they get advantage of a field study in a group of six individuals over a four month period, and a series of focus groups with relevant stakeholders.

Fickas et al. [10] also worked on community travel for people with cognitive impairments. They compared the effects of four different modes of prompting delivered via a PDA (personal digital assistant) on pedestrian route finding. They conducted a field study with 20 individuals with acquired brain injury.

Sullivan et al. [11] in Cognitive Levers Project introduced an architecture that links a mobile user with his/her support community. They developed a technical prototype as a proof-of-concept with two components: a 3D virtual real-time display for caregivers, and a simulated mobile prompting device. The virtual display allows the caregiver to view the location of buses and the virtual traveler. The simulated mobile provides personalized prompts to the traveler. Reminders can be delivered in various formats such as pictures, sound, movie, voice, and text. Other than the prototype, no real environment evaluation is reported to evaluate this architecture.

I looked at some available reminder systems that are not specifically designed for community travel. They are designed for creating reminders to remind people of their future activities, or to help elders or people with cognitive disabilities doing their activities of daily living. The main purpose for reviewing these systems was to find how

they evaluated their systems. The remaining paragraphs of this section introduce some of such reminder systems and explain their evaluation method.

Carmien et al. [12], as a part of Cognitive Lever project, developed Memory Aiding Prompting System (MAPS) as a meta-design or design for designers environment that empowers caregivers to act as designers. Using MAPS caregivers can create reminders to support people with cognitive disabilities in carrying out tasks that they would not be able to achieve by themselves. My work differs with this research in the sense that it is based on a domain model and I provide a real environment evaluation.

HYCARE [13] is part of the European project called “CogKnow”. The authors provide a simple software tool for caregivers to create reminding services for daily living activities. They classified reminding services into four kinds based on the observation of elder's daily activities: time fixed, time relevant, event urgent, and event relevant reminding systems. They have not tested their proposed prototype in the pilot sites.

The goal of authors in [14] is to study people who use location-aware reminders through their daily lives. For this purpose, they built a reminder application called Place-Its that runs on mobile phones. Using this application, each user can set notes to be triggered upon arrival or departure to some place they frequently visit. They performed a study with 10 participants over two weeks. They classified number and type (arrival/departure) of defined reminders and also categorized reminders into 6 categories. Users answered four questions after every reminder about whether the reminder was expected and whether it was delivered at the correct place, if the reminder was

remembered before the notification, and if the reminder changed what the participant was going to do.

In [15] a prototype context-aware tool called CyberMinder is introduced that helps users create and manage the reminders for some future activities. The authors specified desired features of a reminder system. They mainly focused on specifying rich context for reminders. The authors believed that CyberMinder provides some support for all features of an ideal reminder except one. Although promising initial responses are reported for CyberMinder, there is no objective evaluation of this system.

comMotion [16] is a location-aware reminder system. It learns the salient locations in its user's daily life by observing its user's travel over time. The user can define to-do lists for locations learned by the system. There are two parts that must be evaluated: the location learning feature, and the delivery of reminders. For evaluating and improving the location learning algorithm, GPS data was collected over a couple of months by the authors. The detail of this data is not reported. For testing the effectiveness of information delivery, the system was taught three virtual locations and feedback from four people was received. The authors admin that the results are non-conclusive and more extensive evaluation must be done.

CHAPTER IV

EVALUATION

Finding a theory for evaluating a reminder system is still an open research problem. One possible way is to set up real travels, send the prompts to the travelers and record their behavior. The usefulness or uselessness of the prompts and also missing prompts will be revealed after analyzing the traveler's behavior.

The goal of my research is not to actually evaluate the prompts. I was interested in getting ideas and doing experiments about incorporating the ACT model in the prompt definition task. I wanted to see how the ACT model can effectively be represented to the user.

As a preliminary step, I chose to work on a pilot study that would give me background in running experiments in the ACT domain. It does provide me with experience in applying the model in an experimental setting with stakeholders that I will eventually need to work with. Section 5.1 describes what I did in this study and discusses the results. Based on the results and lessons learned from this small study, I decided on the final evaluation methodology.

Typical practice is for care providers to free-think and write down prompts they think an individual will need in order to independently navigate. I will compare the free-think, paper and pencil condition (PAP) with the computer delivered ACT model.

4.1. Pilot Study

In the primary pilot study, I had two groups of graduate students, three people in each, who were not expert in rehabilitation area. One group took PAP approach and the other used the tool. The following hypothesis were tested:

H1: People using ACT-based tool define more prompts than people using paper and pencil.

Although some users in PAP group did not locate their prompts in appropriate places, no significant difference observed between paper and pencil and tool approaches. So the hypothesis was rejected.

However, I noticed some flaws in designing the experiment that affected the results. Part of the problem was that the participants were not experts in the field of cognitive rehabilitation. Few number of participants could be another reason that magnified the problem. Therefore, I decided to have more participants who are experts in rehabilitation field. Perhaps experts have better judgment on what prompts would be useful because they know the population.

In the primary study I asked participants to define prompts for a very forgetful person. In the final study I will ask participants to think of a specific client or individual they know well that has an impairment that affects the ability for that person to successfully leave their home, ride the bus to a destination, and return. This makes the experiment closer to real situation. In the final experiment, I will want participants to

think of the same person when taking the second approach, otherwise comparing the prompt sets for the two approaches does not make sense.

The primary pilot study showed that how precise the person was, had a considerable impact on number and accuracy of prompts. So, comparing two groups of people with different precisions cannot really reveal the difference between tool and PAP approaches. Having a user take both approaches will remedy this problem. Because I can compare the performance of one person in the two approaches.

In the version of the tool used in the primary study, all of the ACT steps were not explicitly shown; A grouping was applied to the ACT steps. Each group, specified by a star, contained more than one step. For the final study, I decided to have all steps of the ACT explicitly shown in the tool. Number of ACT steps will replace the stars.

I monitored users while working with the tool and found out some difficulties they had. Some users had problem with saving prompts. The tool was designed to save the prompt once the user clicks anywhere outside the phone area. The users looked for Save button. A Save button should be added to avoid this confusion. The cursor should be turned into hand on clickable areas such as steps. One person in PAP group defined some prompts for branching conditions, for example when the person gets lost. The tool did not allow defining such prompts.

4.2. Final Study

In the previous section, weaknesses of the pilot study were enumerated. To summarize, I concluded to have more participants who are experts in rehabilitation area.

All participants should take both PAP and Tool approaches. Participants should think of a specific person and the same person while taking the two approaches.

I am interested in whether a verified model of community transportation that lends itself to a graphical tool will facilitate the generation of prompts. There will be two different groups, each of them composed of about ten people who are expert in the rehabilitation field:

- Group 1: PAP-then-Tool. This first group will be provided paper and pencil to define prompts on a travel map, and then use the tool to define prompts.

- Group 2: Tool-then-PAP. The group will first use the tool and then paper and pencil to define prompts.

As mentioned before, I decided to have each participant take both PAP and Tool conditions. The question was which approach to take first and which one to take afterward. Because it is expected that the first condition, regardless of what it is, prompt ideas for the second condition, I decided to have two groups that take approaches in reverse order. One group starts with PAP and the other starts with Tool.

In the study, I am interested in comparing the performance of the participants in the PAP and the Tool approaches, and also testing the following hypotheses:

H1: Participants define prompts in a wider range of travel steps using ACT-based tool than using paper and pencil.

For comparing the range of defined prompts in PAP approach with Tool approach, I will need to manually assign each prompt defined with PAP to a step in ACT. Prompts defined by the tool are already organized in steps. Once the prompts organized in ACT steps, comparing range of them becomes possible.

H2: In their first tasks, participants who take ACT-based tool first, define more prompts than participants who take PAP first.

H3: ACT-based tool enables participants to define prompts more easily than using paper and pencil.

For conducting the experiment, in the PAP-then-Tool group I had eight graduate students from the department of Communication Disorders and Sciences at University of Oregon. In Tool-then-PAP group I had eight care providers from the Uhlhorn rehabilitation center.

In spite of limitations I had in finding participants for doing the experiment, I tried to select two comparable groups. Based on my experiment in the pilot study I needed participants that have background in rehabilitation area. I got a group of graduate students most of them had experience in working with people with disabilities. Uhlhorn group members had also clients with cognitive impairments.

In order to avoid the time and cost of providing computers for all participants at the two experiment environments, I used a three-page paper form in place of the tool. The first page of the form was the main screen of the GeneratePrompt tool with titles of ACT steps printed beside each number. The second and third pages contained a table, each row

provided title of one ACT step with a blank space for writing down prompts. Appendix C shows the paper form. I used a projector to show a demo of the tool to the participants and described how it relates to the paper form. For the PAP task, participant were given a blank sheet of paper with one sentence at the top indicating the task (appendix D).

The experiment was conducted over two days. At the first day, PAP-then-Tool group took both conditions respectively. In the second day, the Tool-then-PAP group took both approaches. The whole experiment time for each group was 30 minutes. At the beginning, participants read and signed the consent form (appendix A). Then they read the experiment description and listened to an oral description of the goal and first task of the study. Experiment descriptions for the two groups are slightly different. The only difference is in the order of tasks which is reverse for the groups. Appendix B is the description given to the PAP-then-Tool group. They asked their questions before getting started. After 15 minutes, forms for the first task were gathered and oral description of the second task was delivered. The second task took about 15 minutes. After gathering forms of the second task, participants filled out the post-experiment questionnaire (appendix E).

Chapter V reports results of the study and discusses them.

CHAPTER V

STUDY RESULTS

Table 2 shows the steps that each participant in the PAP-then-Tool group defined prompt for. In many steps, the participant defined the same prompts in the PAP and the Tool approaches. In some steps, the participants defined more than one prompt, so the number of prompts for each step is specified. Table 3 is similar to table 2, but for the Tool-then-PAP group.

As I mentioned before, I needed to manually assign each prompt defined in the PAP approach to its corresponding step in the ACT. Prompts defined by the tool are already organized in steps. There are two steps called "transfer" and "return" that are missing in the tool, but the participants in the PAP approach defined prompts for them. The transfer steps is when the traveler is riding the transfer bus. The return step includes every step after step 18 of the ACT model.

Table 2. Prompts defined for each ACT step by each participant in the PAP-then-Tool group.

Participant	Step / Cond.	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12a	S12b	S13	S14	S15	S16	S17	S18	transfer	return	Total
LZ	PAP	0	0	3	1	0	1	0	0	0	0	0	1	2	1	1	0	0	2	2	0	5	19
	Tool	0	0	2	1	0	1	0	0	0	0	0	1	1	1	1	0	0	1	2	0	0	11
DE	PAP	0	0	1	1	1	0	1	0	0	0	1	1	3	0	0	0	0	0	1	0	3	13
	Tool	1	0	0	1	1	0	1	0	0	0	1	1	1	0	1	1	0	0	0	0	0	9
CA	PAP	0	0	2	1	1	0	0	1	0	0	1	0	3	0	0	1	0	0	1	0	1	12
	Tool	1	1	2	1	0	1	1	1	0	0	1	0	1	0	1	0	0	1	1	0	0	13
AB	PAP	0	2	2	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2	9
	Tool	0	2	2	0	1	0	1	0	0	1	0	0	1	1	0	0	0	1	0	0	0	10
KS	PAP	1	0	1	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	5	11
	Tool	1	0	1	0	0	1	0	1	0	0	0	1	1	0	1	0	0	1	0	0	0	8
EO	PAP	0	1	1	1	0	0	1	0	0	0	0	1	2	0	0	0	0	0	0	0	5	12
	Tool	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	0	0	21
AR	PAP	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	4
	Tool	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4
SB	PAP	0	1	2	0	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	4	13
	Tool	0	1	2	0	3	0	0	1	0	0	0	4	0	0	0	0	0	0	3	0	0	14
Total	PAP	1	5	13	4	5	2	2	1	0	0	2	9	13	2	2	1	0	2	4	0	25	
	Tool	4	6	11	4	6	4	4	4	1	3	3	9	6	3	5	4	1	5	7	0	0	

Figure 5 represents the last column of table 2 as a chart and compares the performance of each participant in the two approaches. Figure 6 is similar to figure 5, but for the Tool-then-PAP group.

In figure 5, significant decreases from the PAP approach to the Tool approach can be observed for the participants LZ, DE, KS. The reason that the participants defined less prompts in the Tool approach is lack of return path steps in the Tool.

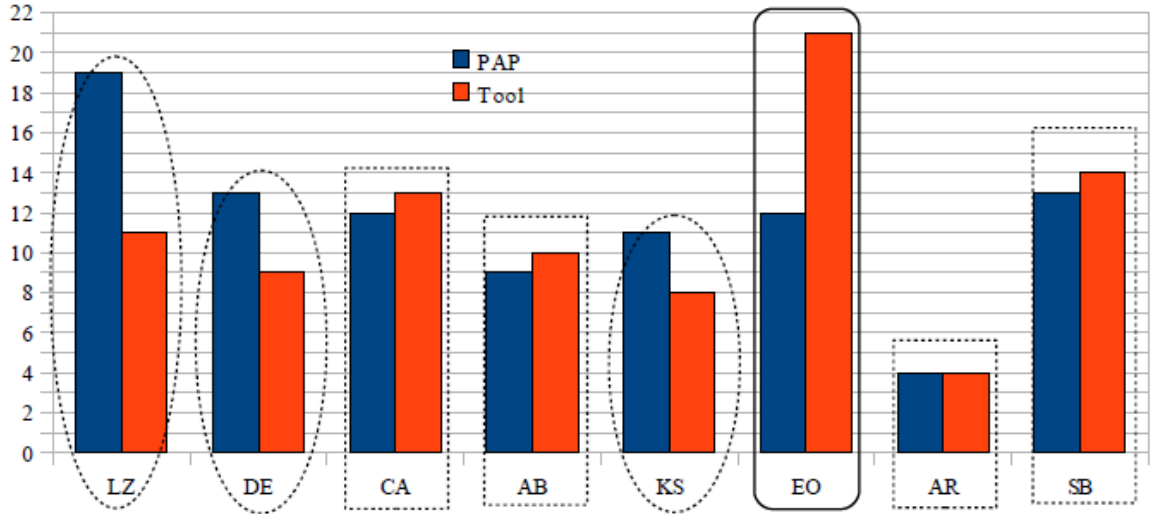


Figure 5. Prompts defined by each participant in the PAP-then-Tool group.

Decrease because of lack of return and transfer steps in the tool

The same prom pts in the two approaches

Not comparable results

The participants CA, AB, AR, and SB did almost the same in the two approaches.

There is a significant increase for EO, however the reliability of this participant's results is in doubt. Prompts defined by this user are general and they don't seem to be for a

specific person. The user's answer to the first post-questionnaire, that says “it is difficult to be as specific as possible” proves this thought. It can be implied from the defined prompts in the Tool approach, that the user had the mindset to define at least one prompt for each step and that is why the number of prompts increased significantly in the Tool approach.

Table 3. Prompts defined for each ACT step by each participant in the Tool-then-PAP group.

Participant	Step / Cond.	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12a	S12b	S13	S14	S15	S16	S17	S18	transfer	return	Total
NR	Tool	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0	15
	PAP	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	6
AA	Tool	1	1	1	1	1	1	1	1	2	1	0	2	0	0	2	2	1	0	0	0	0	18
	PAP	1	0	0	1	1	1	0	0	1	0	0	1	0	0	1	3	1	1	4	0	7	23
GB	Tool	2	2	1	1	1	1	1	1	2	2	1	1	2	1	1	1	1	1	1	0	0	24
	PAP	1	1	1	0	1	0	0	0	0	1	1	0	2	1	0	1	0	0	1	2	3	16
CC	Tool	2	1	2	3	1	1	2	2	2	1	1	1	1	2	1	1	1	1	3	0	0	29
	PAP	1	1	1	1	0	0	2	0	0	0	0	1	1	0	1	0	0	0	2	0	3	14
BB	Tool	1	1	2	2	1	1	2	0	2	1	2	1	2	0	1	1	0	1	0	0	0	21
	PAP	0	1	2	2	0	0	2	0	0	1	1	1	2	0	1	1	0	1	0	4	11	30
DW	Tool	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	2	0	0	21
	PAP	1	0	2	1	1	1	1	1	1	1	1	0	1	0	1	0	3	1	2	4	5	28
TM	Tool	1	1	1	1	1	0	2	0	0	0	1	0	1	1	0	0	0	1	1	0	0	12
	PAP	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
EM	Tool	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	11	0	0	32
	PAP	1	0	2	1	0	0	1	1	1	1	0	1	1	1	1	1	6	1	0	5	6	31
Total	Tool	11	9	13	10	8	7	11	7	10	8	8	8	9	7	8	7	6	7	18	0	0	
	PAP	8	5	13	6	4	2	6	2	3	5	3	4	7	2	5	7	10	4	9	15	35	

There are significant increases from the Tool approach to the PAP approach for the participants AA, BB, and DW. The reason for this increase is that these users added prompts for the return path and also prompts while riding the transfer bus in the PAP approach.

The user EM defined almost the same prompts in the two approaches.

Large decreases from the Tool approach to the PAP approach can be seen for the participants NR, GB, and CC. The user NR did not define a set of prompts in the PAP approach. She just wrote a description of the required prompts. Six sentences from this

description could be extracted as prompts. So, the two approaches for this user can not be compared based on number of prompts. The users GB and CC seem to have a wrong understanding of the Tool approach. This is the case also for some users in the PAP-then-Tool group.

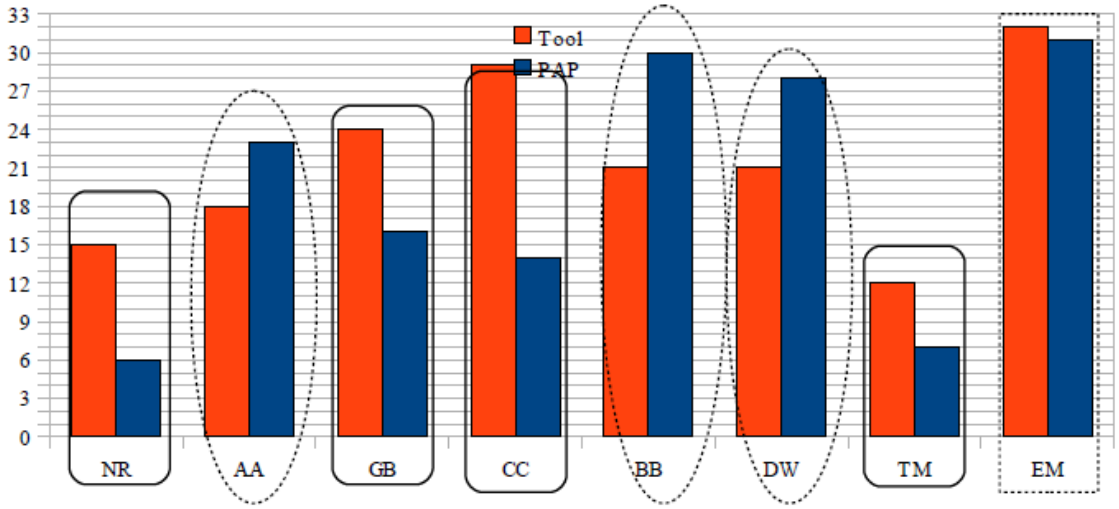


Figure 6. Prompts defined by each participant in the Tool-then-PAP group.

Decrease because of lack of return and transfer steps in the tool

The same prompts in the two approaches

Not comparable results

User TM was not able to complete the Tool condition because of her hand writing difficulty. So, her results in the two conditions cannot be compared.

5.1. H1

Hypothesis H1 is: "Participants define prompts in a wider range of travel steps using ACT-based tool than using paper and pencil." To verify this hypothesis, defined prompts are categorized according to ACT steps. Table 4 shows steps for which the

participant defined one or more prompts in one approach, but defined no prompts in the other approach. Notice that the results for the participant EO are not considered in this table.

Table 4. Range of prompts for the PAP-then-Tool group. Symbol √ in the ONLY-PAP row indicates steps for which the participant defined at least one prompt in the PAP approach, but no prompt in the Tool approach. Symbol √ in the ONLY-Tool row indicates steps for which the participant defined at least one prompt in the Tool approach, but no prompt in the PAP approach.

Participant	Step / Criteria	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12a	S12b	S13	S14	S15	S16	S17	S18	transfer	return
LZ	ONLY-PAP																					√
	ONLY-Tool																					
DE	ONLY-PAP			√																√		√
	ONLY-Tool	√														√	√					
CA	ONLY-PAP					√											√					√
	ONLY-Tool	√	√				√	√								√			√			
AB	ONLY-PAP																					√
	ONLY-Tool							√			√								√			
KS	ONLY-PAP																					√
	ONLY-Tool								√										√			
AR	ONLY-PAP													√								
	ONLY-Tool										√											
SB	ONLY-PAP																					√
	ONLY-Tool								√											√		

Table 5 is similar to table 4 but for the Tool-then-PAP group. Results for the participants NR, GB, CC, and TM are not considered in this table. According to table 4, 71.4% of participants, which is 5 out of 7, defined prompts for at least one step in the Tool approach, but not defined any prompts for that step(s) in the PAP approach. This percentage is 100% for the Tool-then-PAP group, which is 4 out of 4 participants. This evidence supports the idea that the ACT reminds some steps that are neglected while free-thinking.

The last two columns in tables 4 and 5 represent two steps that have no exact equivalent in the ACT model. Participants defined lots of prompts for these two steps using PAP, but no prompts using the tool, because there were no equivalent steps in ACT

for them. Transfer steps and return path are not completely supported by the ACT represented in the tool. Step 12b relates to transfer bus. It implicitly includes a cycle of steps 5 through 12a. However, this cycle is not explicitly shown in the model. This made some of the participants confused. They either wrote a portion of prompts for transfer in step 12b, or left writing prompts for transfer. After step 18 of ACT, which is "ID and Navigate to Transfer Stop", there should be a cycle from step 5 through 14 to cover the return path. In the ACT model, this cycle is indicated by an arrow connecting step 18 to step 5. In the linear version embedded in the tool this cycle is omitted.

Table 5. Range of prompts for the Tool-then-PAP group. Symbol √ in the ONLY-PAP row indicates steps for which the participant defined at least one prompt in the PAP approach, but no prompt in the Tool approach. Symbol √ in the ONLY-Tool row indicates steps for which the participant defined at least one prompt in the Tool approach, but no prompt in the PAP approach.

Participant	Step / Criteria	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12a	S12b	S13	S14	S15	S16	S17	S18	transfer	return
AA	ONLY-Tool		√	√				√	√		√											
	ONLY-PAP																		√	√		√
BB	ONLY-Tool	√				√	√			√												
	ONLY-PAP																				√	√
DW	ONLY-Tool		√										√		√							
	ONLY-PAP																				√	√
EM	ONLY-Tool		√			√	√					√								√		
	ONLY-PAP																				√	√

To sum up, hypothesis H1 is accepted, since ACT helped in knowing travel steps and defining prompts for them. However transfer steps need to be completed in the ACT model, and return steps should be represented in a way that reflects the return cycle.

5.2. H2

Hypothesis H2 states that: "In their first tasks, participants who take ACT-based tool first, define more prompts than participants who take PAP first." For testing this hypothesis, number of defined prompts at the first task for the two groups should be

compared. The first task for PAP-then-Tool group is PAP condition, and for Tool-then-PAP group is Tool condition. The following sets are number of prompts defined in the first task for the two groups. Notice that the results for the participant EO, NR, GB, CC, and TM are not considered in these sets because they are not reliable. The sets are sorted ascending:

First task of PAP-then-Tool: {4, 9, 11, 12, 13, 13, 19}

First task of Tool-then-PAP: {18, 21, 21, 32}

To test statistically if the two sets are significantly different, Mann-Whitney nonparametric test [17] is used. This non-parametric test makes no assumptions about the distribution of the data (e.g., normality). Mann-Whitney test shows that the difference between the two sets is highly significant, which approves hypothesis H2.

5.3. H3

After taking both conditions, participants filled out a post-experiment questionnaire, which contained five questions:

Q1. How easy or difficult was it to plan routes using the paper aids?

Q2. How easy or difficult was it to plan routes using the web site?

Q3. What, if anything, would have helped you do better planning with the paper aids?

Q4. What, if anything, would have helped you do better planning with the web site?

Q5. If given a choice, would you select the paper aids or the web site to do travel planning in the future?

I described to participants that by "paper aids" we mean the PAP condition and by "web site" we mean the Tool condition. These are terminologies I used in the forms that were approved by the Human Subject office.

Table 6 shows answers of each participant to the post-experiment questions. Columns in this table represent questions 1 through 5. The first eight rows, represent answers of eight participants in the PAP-then-Tool group, and the second eight rows show answers of the Tool-then-PAP group.

Participant AB in the PAP-then-Tool group did not answer the questions; This is the reason that the fourth row of the table is empty. Participant TM in the Tool-then-Tool group was not able to fill out the questionnaire completely because of hand writing impairment.

Answers to question five imply that among 13 valid answers, 9 people prefer ACT-based tool to free-think method for defining prompts. Answer of the first participant in the Tool-then-PAP to question five is "yes" which considered irrelevant.

4 out of 13 found the tool difficult and confusing. Two of them believed that there were too many steps and it was hard to follow some of them and to make them work for the specific client. In other words, they believed that free-think allows more tailoring to client needs. 9 out of 13 found the tool easier. Listing steps in order, or step-wise model are reasons explicitly mentioned by participants.

Table 6. Answers to five post-experiment questions per participant.

	Q1 (free-think)	Q2 (ACT-based tool)	Q3 (help with free-think)	Q4 (help with the tool)	Q5
PAP-then-Tool					
LZ	Moderately easy	Very easy	A map or bus schedule	Ideas for text prompt	Tool
DE	A little difficult and confusing	Not so difficult as previous	-	-	Tool
CA	Not too difficult	Much easier	Riding the bus myself	-	Tool
AB					
KS	Easy	Easier due to step-wise planning model	More structure... Where are you going? Can we have access to a bus schedule?	Step 7 is vague	Tool
EO	Difficult to remember to be specific. Easy to use simple language when writing prompts	Hard to follow some of the steps and to make them work for my client	A reminder to be as specific as possible	An explanations of the steps	Paper
AR	Confusing	Easier because of visuals and different colors	Having visuals	-	Tool
SB	Difficult to think of each step for which prompts would be needed	Much easier with steps listed in order	Some kind of visual aid	The steps of transfer are a bit confusing because the same steps are not repeated	Tool
Tool-then-PAP					
NR	Easy	Easy	-	-	Yes
AA	Harder to remember details in order/forget some	Easier except that there were some steps I didn't need	An outline	Pictures	Tool
GB	Easy enough; free form allows more tailoring to client needs	Felt a bit tedious; too many steps (but that really depends on client/route)	Nothing	-	Paper
CC	It was very difficult because of the many steps involved.	Easier than the paper aids but still difficult. The landmarks on the web site are helpful.	To have a notebook for a set of prompts for each trip (a template)	Bigger landmark picture	Tool
BB	Tedious but easy	Confusing	Ran out of room	The listed prompts were confusing	Paper
DW	Easy	More difficult	Actually going to the place while writing	Having the paper aid	Paper
TM	Difficult due to writing impairment				
EM	More difficult than tool	Easier than free-think	Nothing	Nothing	Tool

Regarding question three, which is about ways of making paper aids easier, participants mentioned the following ways: 1) Providing more information about the travel, for example where the destination is, 2) Giving participants the travel map or bus schedule, 3) Having a template of prompts, and 4) Providing some kind of visual help or letting participants actually take the travel, ride the bus and go to the destination.

Regarding question four about ways of making the tool better, following methods were suggested: 1) Providing an explanation of steps, 2) Step 7 and transfer steps are confusing, 3) Having landmark pictures, and 4) Giving some ideas or examples of text prompts.

Answers to questions one, two, and five approve hypothesis H3. Most of the participants believed that the tool made defining prompts easier.

5.4. Conclusion and General Considerations

I noticed some facts during conducting the experiment and while analyzing the results that are worth considering. Two participants provided a description about impairments and needs of their clients. It seems it will be useful to want all participants to do so, especially when the skills piece of ACT is included in the tool.

As mentioned before, participants had problem with transfer and return steps. In addition, the questions participants asked during the experiment, and the prompts they defined, reveal that they had not correct understanding of steps 2, 7, and 13, which are “Plan and Schedule Trip”, “Board Vehicle and Request Stop”, and “ID Return Stop”

respectively. Some of the participants requested an explanation of ACT steps. Some others seem to think of ACT step titles as example prompts which confused them.

Before the participants take the Tool approach, it should be clearly described to the them that they are not required to define a prompt for every step. They should just define prompts whenever they think necessary. This will avoid misunderstanding of the tool which I saw in my study for some of the participants.

The three hypotheses and the results of their verification is summarized below.

H1 (Defining prompts in a wider range of steps using the tool) —Step-based organization of prompts→ Accepted

H2 (Defining more prompts in the first task using the tool) —Mann-Whitney test→ Accepted

H3 (Defining prompts more easily using the tool) —Post-experiment questionnaire→ Accepted

It seems clear that there is place and desire for such an ACT-based tool for defining prompts. Using the tool, the participants defined more organized and concise prompts comparing to the PAP approach. However, the tool needs to be improved by disambiguating some vague steps and also adding explanation of each step. Adding landmark pictures to steps is another way of improvement. The linear representation of the ACT should be changed in order to effectively show the return steps.

CHAPTER VI

FUTURE WORK

Based on the results of the experiment, changing the representation of ACT model in the tool, so that it represents transfer steps and return path properly is the next step. Adding the skills piece of the ACT and verifying its effect is another future work.

This research aimed at verifying the ACT model, not the GeneratePrompt tool. Verifying the tool itself, that is figuring out how much the interactive computer tool is helpful in getting prompts comparing to the model on paper, might be the next step. Currently the tool is a linear representation of ACT steps on a fixed route. Different representations of the ACT model can be tested. For example, short video clips may be added at each step of the ACT. The user can pause the video at any time and define a prompt. Another possible change is instead of having a travel map with ACT steps specified on it, a video of travel can be made based on ACT steps. ACT titles and descriptions are shown as subtitles or in a side panel.

In the evaluation phase, one possible way for reducing the issue of groups comparability, is to have half of one group take PAP-then-Tool and the others take Tool-then-PAP. This would give the researchers more insight on the effect of ordering. This change should be considered in future researches.

Some of the care providers who took the experiment noted that taking an actual trip would be much helpful in defining prompts. A virtual travel according to ACT steps can be designed. In other words, ACT steps can be "instantiated" automatically or semi-automatically to make a model for a specific trip. ACT designates the concepts to be

instantiate from. For example, consider a person, John, wants to travel from UO campus to Gateway Mall. He wants to be at Gateway mall at 1:30pm. With the aid of Google Maps, the system knows that John has a 6-minute walking to Agate station, then he should take EmX bus to Eugene station. At the station he should take bus number 12 to Gateway Mall, and then there is a 1-minute walking to the destination. Exact times and expense of travel of reported in Google Maps. Street View service of Google can also be used to visualize the whole travel route from the John's point of view. Another services such as Weather forecasting can provide hints while travel planning.

6.1. Summary

I proposed a method for using a domain model in getting personal requirements. I focused on the problem of travel community for cognitively impaired people. The domain model I took advantage of was the ACT model. I discussed how this model can be used in integration with PC-RE framework to help in personal and contextual requirement analysis. A tool was built based on the ACT model to be used by clinicians to define required prompts for cognitively impaired people.

I conducted an experiment with two groups to compare the results of using the ACT-based tool and writing down prompts on a paper. All participants in the two groups took both tool and paper conditions, but in reverse order. The study showed that most participants preferred ACT-based tool to free-thinking and writing down prompts. They define more organized and concise prompts using the tool. The tool helped in considering some steps that were neglected during free-thinking. Some possible improvements to the model and the tool were discussed.

APPENDIX A

CONSENT FORM

Consent to Participate in the Travel Planning Project

You have been invited to participate in a research project conducted by Dr. Stephen Fickas from the University of Oregon. The goal of this project is to study how different types of travel-planning aids are used. If you decide to participate, you would be agreeing to the following:

____ I will be asked to take plan several trips in the Lane county area for hypothetical travelers.

____ The entire time needed for this experiment will take approximately 15 minutes.

____ I will be using paper documents and an experimental new travel-planning web site. A researcher will show me how to use the documents and web site before I start.

____ Before the experiment, the researcher will ask me some questions to collect information about my role as a travel planner. No personal information will be collected.

____ Immediately after the experiment, I will be asked to complete a brief questionnaire about my experience using the aids.

____ Data will be collected on my use of documents and the web site.

___ All the information collected about my participating is confidential. My name will not be stored with any of my information.

____ I may withdraw from this project at any time without any penalty or bad feelings being expressed toward me.

____ I may choose not to answer any question that I do not want to answer and still participate in the study.

____ Only researchers involved in this project will have access to my information. This information will be kept in a secure database within the computer science department at the University of Oregon. Only code numbers will be kept with this information.

____ If I have any questions about the project, I can call Dr. Stephen Fickas (541) 346-3964 from the University of Oregon.

____ If my questions are not answered to my satisfaction by project staff or if I have concerns about this project and my rights as a research participant, I can call the Office of Human Subjects Compliance at (541) 346-2510.

____ I was given a copy of this form. The researcher met with me and clearly described its consent.

Signature of Participant **Date**

APPENDIX B

DESCRIPTION OF THE EXPERIMENT FOR THE PAP-THEN-TOOL GROUP

Dear care provider:

We are building a reminder system for a person with memory impairments who becomes easily confused when traveling in the community. We are looking to see the typical prompts or cues that an individual will need in order to successfully travel from his/her home to a desired destination.

We will be asking you to think of a specific client or individual that you know well that has a memory impairment that affects the ability for that person to successfully leave their home, ride the bus to a destination, and return. You will go through **two different exercises** to think of cues that person needs to be successful.

Assume that the person you are writing cues for is carrying a cell phone that the prompts or cues that you will write down will be automatically shown at the appropriate time. The phone is a travel phone and will be programmed to display the prompts you write at the correct time.

First exercise:

For the first exercise, while you are thinking of your person, you will have 15 minutes to "free write" your prompts on plain paper sheet.

Second exercise:

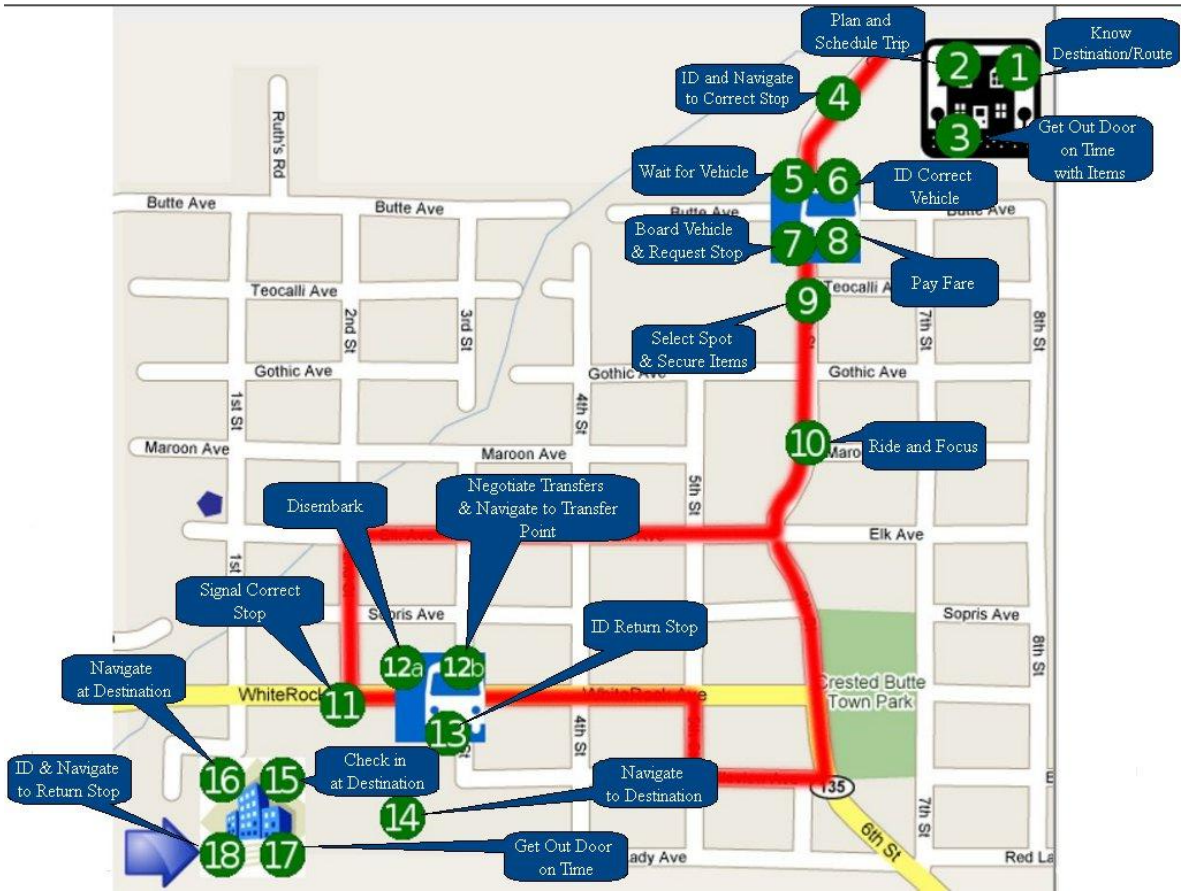
The second exercise will be similar. You will start all over writing the prompts for the SAME person, only this time, use the paper form given to you to write the prompts.

Thank you very much for giving us your valuable time.

Travel Planning Project Team

APPENDIX C

PAPER FORM FOR THE ACT-TOOL GROUP



ACT Step	Prompt(s)
1) Know Destination/Route	
2) Plan & Schedule Trip	
3) Get Out Door on Time with Items	
4) ID & Navigate to Correct Stop	
5) Wait for Vehicle	
6) ID Correct Vehicle	
7) Board Vehicle & Request Stop	
8) Pay Fare	
9) Select Spot & Secure Items	
10) Ride & Focus	
11) Signal Correct Stop	
12a) Disembark	
12b) Negotiate Transfers & Navigate to Transfer Point	
13) ID Return Stop	
14) Navigate to Destination	
15) Check-In at Destination	
16) Navigate at Destination	
17) Get Out Door on Time	
18) ID & Navigate to Return Stop	

APPENDIX D

SHEET FOR THE PAP TASK GIVEN TO THE PAP-THEN-TOOL GROUP

First exercise

write your prompts for the specific person you have in mind.

APPENDIX E

POST-EXPERIMENT QUESTIONNAIRE

Post-Experiment Questionnaire

- How easy or difficult was it to plan routes using the paper aids?

- How easy or difficult was it to plan routes using the web site?

- What, if anything, would have helped you do better planning with the paper aids?

- What, if anything, would have helped you do better planning with the web site?

- If given a choice, would you select the paper aids or the web site to do travel planning in the future?

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