

## **Assistive Tech in the Kitchen**

Culinary Gadget Gang:

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### **Techniques, Tasks and Users**

To evaluate the usability of our prototype smart stove, we designed scenarios for user testing to consider three tasks: using the memory assistance and kitchen organization tools, using the stove controlled by the phone app and finally the oven with physical assistance. Further, we made two equivalent variants of each scenario: one with assistance from our physical and digital prototype and the other serving as a control condition without assistance.

The memory assistance task had the users collecting ingredients from different parts of the kitchen. The group that received assistance from the prototype were shown where the ingredients would be in the app. For the stove task, the users had to prepare a cup of tea on the stovetop. The control group manually operated the stove through the buttons, while the assisted group manipulated the app's controls, with physical changes handled by the Wizard of Oz component of the study. Finally, the oven task had users making a pizza from the ingredients they had gathered. The control group manually operated the oven while the assisted group could use additional buttons on the physical prototype for Wizard of Oz physical assistance functionalities. These tasks are detailed further as a table within our "Task Performance" section.

In total, we gathered 4 participants for our different conditions. Users 1 and 2 completed the tasks in the control condition, without any assistance beyond conventional kitchen appliances. Meanwhile, users 3 and 4 completed the tasks with the smart stove and app. These 4 users were all students and had varying levels of cooking experience. They were selected based on convenience sampling as finding participants in our target demographic, the elderly was not feasible within the project's time, budget and research ethics constraints.

We used both qualitative and quantitative measures to consider the performance of the user, and the assistance provided by the smart stove. Qualitatively, the users were interviewed before and after the test. The interview prior to the scenario focused on evaluating the users' cooking backgrounds while the one after the scenario aimed to get their feedback on the design and the tasks. Additionally, a moderator during the scenario collected qualitative notes on user actions during the task, helping analyze how our design altered behavior.

Quantitatively, the users filled out a NASA-TLX questionnaire after they had completed the scenario. This questionnaire consisted of 6 20-point Likert scale questions that examine the usability and workload of the designed interface. The statistical significance of the NASA-TLX answers was then examined using one-way Analysis of Variance (ANOVA). Additionally, the performance of the users during the scenario was measured based on the duration it took for them to complete each task.

## Rationale

To evaluate the usability of our prototype smart stove, we used three specific tasks using the memory assistance and kitchen organization tools, using the stove controlled by the phone app and using the oven with physical assistance. These tasks were performed in two variations: using the physical (with advanced modifications according to our design) and digital prototype and without assistance (a generic stove). Incorporating three separate tasks in our study is useful for identifying specific strengths and weaknesses within our prototype. More specifically, the task of using the memory assistance and kitchen organization tools was useful for evaluating our digital prototype, using the stove controlled by the phone app was useful for evaluating the effectiveness of our choice of combining a digital and physical prototype in our design, and using the oven with physical assistance helped us to evaluate the physical prototype more in-depth. Overall, each task helped us to hone in on various components of our design, and in doing so, this method of evaluation helped us to evaluate how well we addressed our target issues: physical and mental strain, easy to use technology, and improved kitchen safety.

The use of a control condition by splitting our four participants into two conditions (with assistance/technological advancements of our design vs. no assistance/generic stove/oven) provided a standard to which comparisons could be made in order to accurately assess whether or not our design improved the cooking experience in comparison to the everyday stove. Control conditions help to clearly pinpoint explicit differences in the cooking experiences (when comparing our design to the generic stove) and confirm that these differences are directly motivated by our design. A control condition helped to determine the changes in behavior that our design motivates (e.g reduced bending, reduced time spent searching for kitchen ingredients, changed cooking time), which directly correlated to our target issues and in turn, taught us about the effectiveness of our design.

Conducting an interview prior to having the user engage in the task/scenarios helped to understand the users that we were presented with and what kind of perspectives were informing our study. We found this to be necessary since although we completed interview guides, the people that participated in usability testing are not the same people that we interviewed in our interview guides.

Additionally, having a moderator take live notes helped to ensure that the team actively recorded participants' comments and key data regarding the evaluation, without missing important details.

Furthermore, regarding the use of NASA-TLX to conduct a post-interview, NASA-TLX is the academic standard for evaluating the workload posed by different interface designs. Considering our physical and digital prototype, the NASA-TLX is a good fit and choosing it allows easy comparisons with other ubiquitous computing devices in the home and kitchen. Conducting a post-scenario interview using the NASA-TLX questionnaire allowed us to prompt more user feedback regarding our prototype/user scenario that they might not have commented on or

mentioned while performing the task. This questionnaire helps us to establish concise information/feedback regarding how much the users felt we addressed our target issues.

As for one-way ANOVA, it's currently considered the best statistical analysis method for comparing two scenarios with NASA-TLX. It makes good use of the scale-based format while rigorously determining the likelihood of a given result happening randomly. Quantifying the data using the one-way ANOVA helped to condense and summarize the written notes and data from the evaluation results into more readable and easily interpretable information that can be incorporated in further study regarding our focus, homecare technology.

## Study Results

Per the requirements that were outlined in Deliverable 3, we conducted user testing, NASA TLX surveying, and post-session interviews to evaluate our prototype, using the techniques that have been discussed in this class.

### User Testing

Our testing sessions were conducted throughout the day April 14th, 2022. The study consisted of a pre-test interview, 4 tasks that the participants were observed performing and encouraged to think aloud during, and post-test interview as well a NASA TLX survey. Each participant was interviewed individually by the moderator while notes were taken and Wizard of Oz was performed by two other group members. The total number of participants we interviewed was 4, 2 using our assistive technology prototype and the other 2 without for comparison.

### Pre-Test Interview Results

Participant Introduction:

- **User1:** 2nd Year CS, Intelligence/Info, Cooks about once a week, Has friends and family that also cooks regularly
- **User 2:** 3rd Year CS, People/Intelligence, Never cooks, but comes from family that values cooking
- **User 3:** SWE Graduate, Cooks every day except weekends (when they eat out)
- **User 4:** 3rd Year CS, Cooks every day

Cooking Experience:

- **User 1:** Lives in dorm with shared kitchen, Roommates often leave stove/oven running triggering several fire alarm incidents, Personally doesn't always monitor pan, Leaves to do other things and comes back to the kitchen to ensure that the food is not on fire
- **User 2:** Family is very food-oriented, They love cooking food from various cultures (Indian, Italian, American), When using a stove/oven they usually cook curries on top of

the stove and heat the stove up to medium/high, add ingredients and cook the meal as the stove heats up

- **User 3:** Enjoys cooking, Finds regular cooking improves quality of life, Heats up stove and waits for it to heat up, adds oil and start cooking
- **User 4:** Very enthusiastic about cooking, Regular meal: Chops and fries veggies on the stove using a pot

Smart Tech Experience:

- **User 1:** Great deal of experience with smart tech, Likes it when it performs well with minimal errors
- **User 2:** Family has minimal to no experience with smart tech, Family is a bit intimidated by smart tech, Has a Google mini that's connected to light bulbs in the house that participant uses to slowly introduce family to smart tech
- **User 3:** Only use timer when cooking, No other smart technologies, Finds that smart tech can be both helpful and annoying
- **User 4:** Minimal experience with smart tech, has a google home mini, but never uses the google home mini, "Smart Tech is convenient, but not necessary"

## Task Performance

Scenario and task details are outlined below:

### With Smart Stove

Index	Task	Actions	Script
1	Organize your kitchen	<ul style="list-style-type: none"><li>- Place each of the provided ingredients in different storage compartments in the kitchen</li><li>- Use the Smart Stove Kitchen App to help keep track of your placements:</li><li>- Click "Kitchen Organization"</li><li>- Click on corresponding numbered cabinet</li><li>- Click on "Edit" and begin adding to the</li></ul>	"In this task, we would like you to look over your provided ingredients and place them throughout the kitchen in the various numbered cabinets. For example, you could place some ingredients in cabinet 1 and some in cabinet 5. They can be in any arrangement you wish, but try to space locations out, not

		list	place all ingredients in just one or two cabinets. We would also encourage you to choose different locations from your last scenario. As you organize your ingredients, please use the Smart Stove Kitchen App to log and keep track of your ingredients.”
2	Make a cup of tea using the stovetop and the provided recipe instructions	<ul style="list-style-type: none"> <li>- Read recipe instructions:</li> <li>- “Boil” a cup of water (3 min)</li> <li>- Once boiling, add the 2 tsp of Thyme</li> <li>- Let sit for 3 min</li> <li>- Add 3 tsp of Cinnamon</li> <li>- Let simmer for 2 min</li> <li>- Remove from heat and serve</li> </ul>	“Now that you've organized your ingredients, please read the tea recipe and begin following its instructions in order to make a cup of tea.”
3	Distraction Task: Verbal questionnaire	<ul style="list-style-type: none"> <li>- Hear and verbally answer question provided in as much detail as possible</li> <li>- Keep track of kitchen activities simultaneously</li> </ul>	“We are now asking you to step away from the kitchen space and into the questionnaire space to answer a few questions. Feel free to pause the questionnaire session at any time to check on your cooking activities and utilize

			the Smart Stove Kitchen App to keep track of your burners and control them from a distance. Try to answer these questions in as much detail as possible. These questions are meant to be fun conversation starters.”
4	Make a pizza using the oven and the provided recipe instructions	<ul style="list-style-type: none"> <li>- Read recipe instructions:</li> <li>- Place dough on cast iron skillet</li> <li>- Spread 1 tbsp of sauce on dough</li> <li>- Sprinkle 1 tbsp of grated cheese over sauce</li> <li>- Place 3 pieces of pepperoni on the cheese</li> <li>- Place in oven and cook for 5 min</li> <li>- Remove from oven and let sit for 2 min</li> <li>- Serve</li> </ul>	“Please read the pizza recipe and begin following its instructions in order to make a small nacho platter. Please use the Smart Oven buttons to elevate the oven and automatically extract and insert trays into the oven.”

#### Without Smart Stove

Index	Task	Actions	Script
1	Organize your kitchen	<ul style="list-style-type: none"> <li>- Place each of the provided ingredients in different storage compartments in the kitchen</li> </ul>	“In this task, we would like you to look over your provided ingredients and place them

			<p>throughout the kitchen in the various numbered cabinets. For example, you could place some ingredients in cabinet 1 and some in cabinet 5. They can be in any arrangement you wish, but try to space locations out, not place all ingredients in just one or two cabinets.”</p>
2	<p>Make a cup of tea using the stovetop and the provided recipe instructions</p>	<ul style="list-style-type: none"> <li>- Read recipe instructions:</li> <li>- “Boil” a cup of water (5 min)</li> <li>- Once boiling, add the 3 tsp of Mint</li> <li>- Let sit for 3 min</li> <li>- Add 2 tsp of Rosemary</li> <li>- Let simmer for 3 min</li> <li>- Remove from heat and serve</li> </ul>	<p>“Now that you've organized your ingredients, please read the tea recipe and begin following its instructions in order to make a cup of tea. Use whatever methods or tools you would normally utilize in order to complete this task.”</p>
3	<p>Distraction Task: Verbal questionnaire</p>	<ul style="list-style-type: none"> <li>- Hear and verbally answer question provided in as much detail as possible</li> <li>- Keep track of kitchen activities simultaneously</li> </ul>	<p>“We are now asking you to step away from the kitchen space and into the questionnaire space to answer a few questions. Feel free to pause the questionnaire session at any time to check on your cooking</p>

			activities, but try to answer these questions in as much detail as possible. These questions are meant to be fun conversation starters.”
4	Make a pizza using the oven and the provided recipe instructions	<ul style="list-style-type: none"> <li>- Read recipe instructions:</li> <li>- Place dough on cast iron skillet</li> <li>- Spread 1 tbsp of sauce on dough</li> <li>- Sprinkle 1 tbsp of grated cheese over sauce</li> <li>- Place 3 pieces of pepperoni on the cheese</li> <li>- Place in oven and cook for 5 min</li> <li>- Remove from oven and let sit for 2 min</li> <li>- Serve</li> </ul>	“Please read the pizza recipe and begin following its instructions in order to make a small pizza. Use whatever methods or tools you would normally utilize in order to complete this task.”

The results of the task performance part of the user testing are outlined below. They are separated for each individual user and scenario, as well as the corresponding tasks, in order to allow for multiple notes on each user and simplify interpretation.

#### With Smart Stove

##### **Task 1: Organize your kitchen**

- User 1
  - Navigated task pretty easily and quickly
  - Placed parmesan on top shelf and sauce on middle shelf of cabinet 1 both physically and in app
  - Placed dough on bottom shelf and tea ingredients on middle shelf of cabinet 2 both physically and in app
- User 2



- Explored all app cabinets before proceeding with task
- Placed tea ingredients on the middle shelf of cabinet 2 both physically and in app
- Placed pizza sauce and parmesan on the bottom shelf of cabinet 1 both physically and in app
- Navigated back to cabinet 2 and placed pizza dough in cabinet 2 both physically and in app

### **Task 2: Make a cup of tea using the stovetop and the provided recipe instructions**

- User 1
  - Easily identified stove top and corresponding burner controls
  - Used the bottom right burner
  - Used Smart Stove's automatic up/down feature to adjust height of stove top
- User 2
  - Bent down to turn on stove top instead of using Smart Stove's automatic up/down feature to adjust height of stove top

### **Task 3: Distraction Task - Verbal questionnaire**

- User 1
  - Paused questionnaire distraction task to add tea ingredients to pot after 3 minute water boiling timer ended
  - Forgot placement of tea ingredients in kitchen and used the app to remember their location
  - Quickly finds tea ingredients, adds them to the pot, and resumes distraction task
- User 2
  - Received a notification from the Smart Stove that the top left burner had been active for 10 minutes, acknowledged notification, but chose to leave the left burner on and proceed with distraction task
  - Returns to kitchen to add more water to pot due to evaporation
  - Easily locates and adds tea ingredients to pot
  - Turns off burner by bending over instead of raising stove

### **Task 4: Make a pizza using the oven and the provided recipe instructions**

- User 1
  - Intuitively uses app to relocate pizza ingredients
  - Easily uses search feature of app at one point to find the dough ingredient specifically
  - Received a notification from the app that the burner had been on a for 10 minutes and turned off burner through app
  - Switches between app and recipes periodically

- Intuitively raises oven via the up button to be level with counter and presses the tray buttons to slide skillet onto tray and have it placed inside oven automatically
- Overall Time: 23:29.16
- User 2
  - Easily uses voice command search feature to relocate pizza dough ingredient
  - Bends down to cook for long duration
  - Eventually realizes the Smart Stove is height adjustable and uses buttons to raise stove and extract and retract trays to automatically slide skillet into oven
  - Overall Time: 18:24.20

### Without Smart Stove

#### **Task 1: Organize your kitchen**

- User 3
  - Places ingredients throughout kitchen
- User 4
  - Places ingredients throughout kitchen

#### **Task 2: Make a cup of tea using the stovetop and the provided recipe instructions**

- User 3
  - Quickly begins boiling water
  - Looks through cabinets to relocate tea ingredients
- User 4
  - Takes longer to relocate ingredients
  - Struggles to locate appliances such as pots and pans
  - Quickly begins boiling water

#### **Task 3: Distraction Task - Verbal questionnaire**

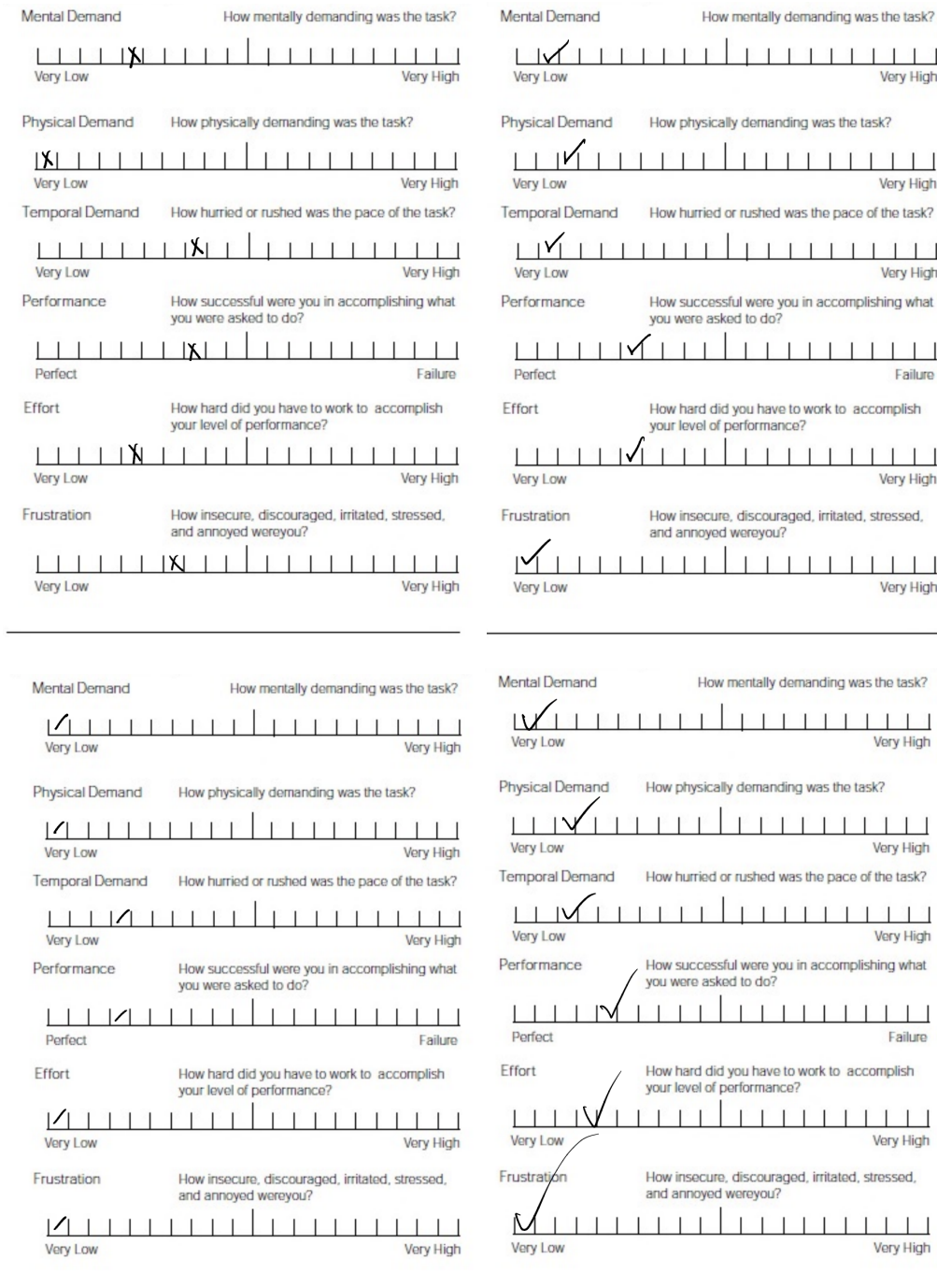
- User 3
  - Experienced no difficulties participating in distraction task as well as monitoring kitchen activities
- User 4
  - During the distraction task, participant forgot that their tea was boiling

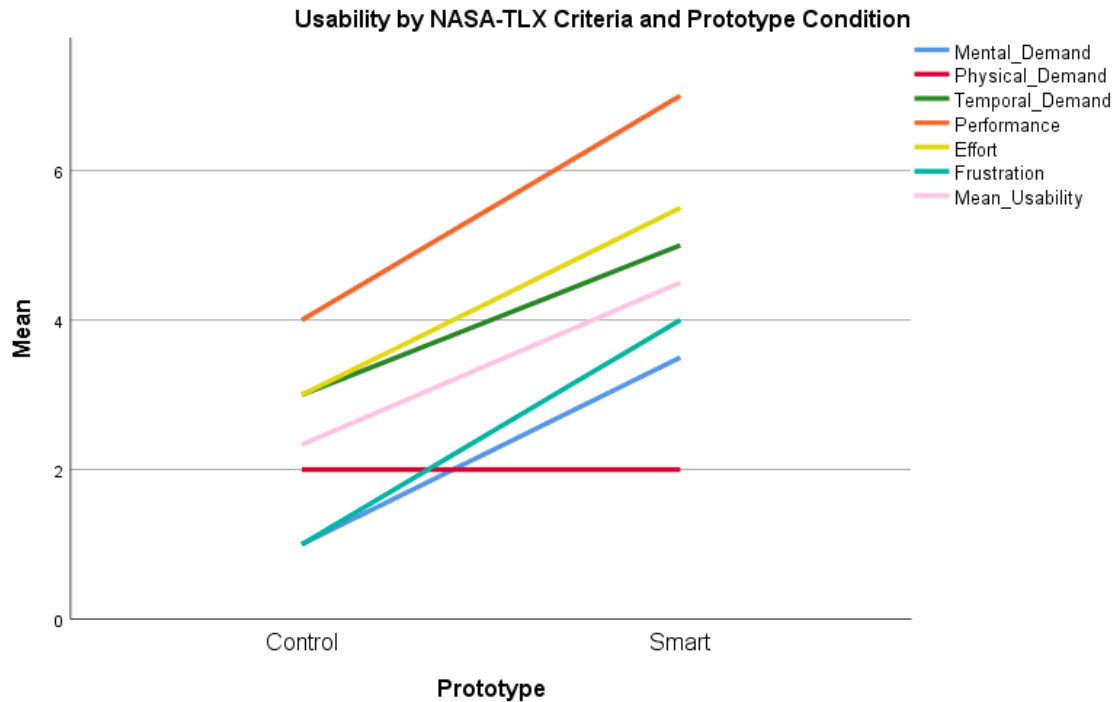
#### **Task 4: Make a pizza using the oven and the provided recipe instructions**

- User 3
  - Took 5 minutes to relocate pizza ingredients
  - Bent down to place pizza in oven and take it out after cooking
  - Overall Time: 24:33.00
- User 4

- Bent down to place pizza in oven and take it out after cooking (more inconvenient because participant was tall)
- While preparing the pizza participant still didn't remember to turn off tea pot burner
- Overall Time: 21:29.23

## NASA TLX Results





This graph shows a comparison of averages in the usability criteria for the different conditions in our Control group and the group using the smart stove. Note that the NASA-TLX is designed such that lower numbers imply greater usability, and all answers were within the lower half of the 20-point Likert scale for the NASA-TLX questionnaire.

### Post-Test Interview Results

Ratings of Ease of Tasks (1 being very easy, 5 being very difficult):

- **User 1:** 1
- **User 2:** 2
- **User 3:** 1
- **User 4:** 2

Was there anything about the scenario particularly difficult?

- **User 1:** Found cabinet numbering confusing, but that was our goal: To increase kitchen layout confusion to see if app helped manage it
- **User 2:** Not really
- **User 3:** Found it pretty straightforward, but disliked bending down so frequently
- **User 4:** Found recipe instructions somewhat vague. Revealed minor back pain from bending a squatting around regular stove

What would you have done differently? (There were 2 interpretations of this question that we did not anticipate, but the responses were insightful regardless so we kept them).

- **User 1:** Place burner controls further away from the burners to further increase safety.
- **User 2:** “I shouldn't have left my water on the stove too long or added boiling water even after I left the pot on the stove that long”
- **User 3:** Place burner controls further away from the burners to further increase safety
- **User 4:** “What I would've done differently is turning off the stove (for tea) before making the pizza”

#### Additional Comments/Feedback:

- **User 1:** Have the elevation control panel not attached to Smart Stove so that users can easily access it regardless of current height.
- **User 2:** “Space efficient since you can raise/lower the stove. You can use the stove to save space. You may be able to hook this up to a Google home mini and connect the stove to other smart devices.”
- **User 3:** After explaining Smart Stove differences from Regular Stove: “Would def buy this. I hate bending down to get stuff.” Thinks the design is useful especially if you live with people of various heights.
- **User 4:** “I am very dissatisfied with the current system of the stove and as a college student you tend to forget important stuff while cooking because you are doing other things. You tend to forget to turn off the stove or turn off the oven. I wish there was a mechanism to cater to these types of issues as well.”

## Discussion and Analysis

Based on observational data taken during the testing sessions, there seems to be positive reception of the Smart Stove prototype. However, the heuristic evaluation including the NASA TLX results seems to tell a different story. We will outline the observations we made and other data collected as well as predictions for why the results of the heuristic evaluation are as they are below.

The testing session consisted of a pre-test interview with questions about the participants' background with cooking and smart technology, four tasks for actual testing including organization, cooking, and distraction tasks, as well as a post-test interview including questions about difficulty of tasks and a NASA TLX survey which each participant filled out.

In the pre-test interviews, we observed that our participant base has a computer science background with a mixture of cooking experience from never cooks to cooks daily. In terms of smart technology, either they or their family members have some experience with smart technology, like Google Home Minis for example, but use of the smart technology with kitchen tasks was not mentioned by them. We recognize that our participant base is different from our

intended user base, the elderly, and we tried to simulate memory lapses through the distraction tasks and observation of physical movements while testing.

We will now discuss the individual tasks and the participants' performance on each. Users 1 and 2 were the participants using the smart stove technology while Users 3 and 4 were the control group using the stove without the smart technology. For the first task of organizing the kitchen, Users 1 and 2 used the Smart Stove app to place their ingredients in cabinets around the kitchen. User 1 jumped right into placing the ingredients based on each cabinet and learned as they went while User 2 looked through each cabinet before deciding where to place each ingredient. They both easily were able to type in their ingredients to each cabinet, but there was slight confusion with the numbering of the cabinets. This helped them in later tasks when looking for ingredients in the case where they forgot where they placed them. Users 3 and 4 did not use the app and placed their ingredients in cabinets wherever they pleased. For the second task, users were given a recipe for making tea. User 1 quickly identified the burner controls and decided to use the adjustable height feature to better suit their height preference. User 2 also found the burner controls but did not adjust the height and it was observed that they bent slightly to put the pot of water onto the stove. Both Users 3 and 4 quickly began "boiling" their water on the stove. They were also observed to bend down to place their pot as they didn't have the adjustable height at their disposal. During the third task, the users were in the midst of making their tea when we pulled them away to ask them various distraction questions. User 1 set a timer for their boiling water and left the distraction tasks to add their ingredients to the water. User 1 forgot where they placed their ingredients, so they went back into the app and were able to quickly identify where they placed the tea bags. User 2 did not remember that they had water on the stove and received a notification from the app that their burner had been on for ten minutes. User 2 acknowledged the notification and went back to the stove to add more water to account for evaporation, and they easily gathered the tea ingredients and placed them into the water, again bending down as they did not adjust the height of the stove. User 3 kept up with their boiling water during the distraction task, frequently leaving the distraction space to go check on their water and adding ingredients. User 4, however, forgot their water was boiling and had to be reminded after ten minutes that they should still be keeping up with the tea task. Task 4 was making the pizza, and User 1 used the app and smart functionalities frequently. To find their pizza ingredients, they used the search feature of the app to locate which cabinet they placed it in. They frequently went back and forth between looking at the provided recipe and the app to locate needed ingredients. In the midst of making their pizza, they received a notification that their burner had been on for ten minutes as they did not turn off the stove for their tea yet, so they used the app to turn off the burner. User 1 intuitively raised the stove using the buttons on the side to make the side compartment level with the counter. They ejected the tray with the "out" button, placed the skillet with pizza onto the tray, and pressed the "in" button to make the skillet go into the oven to cook. Once cooking was done, they ejected the tray using the "out" button again. User 2 while making the pizza also used the app to find ingredients by using the voice search option. User 2 originally put the pizza into the oven by bending down and using the front downward door, but

eventually remembered that it was height adjustable and was able to make the side compartment level with the counter and used the “out” button to eject the tray when done cooking. Both Users 3 and 4 took more time to locate ingredients for their pizza, and each bent down when using the front downward door to input their pizzas and also take out after cooking. There was a significant amount of bending for User 4 as they were taller than other participants.

In the post-test interviews, Users 1 and 3 rated the tasks as a 1 on difficulty level, while Users 2 and 4 rated the tasks as a 2 on difficulty level based on a five-point scale. This indicates that our tasks were fairly easy to execute and the participants did not have much difficulty with them. When asked if there was anything particularly difficult with the tasks, User 1 indicated that the cabinet numbering was confusing, which we wanted to simulate a somewhat confusing structure for testing purposes but there definitely can be improvement with the naming of cabinets within the app. Users 2 and 3 said the tasks were straightforward, but User 3 found bending down to be annoying. User 4 indicated that the recipe instructions were vague and also had problems with bending down to use the oven. The next question asked was what each participant would do differently and we did not anticipate the two interpretations of the question but appreciated the answers nonetheless. Users 1 and 3 both mentioned improvements to our prototype, and that the burners should be moved to a different location to avoid having to reach over the potentially hot stove. This is a great improvement idea to our prototype and we definitely take it into consideration when outlining improvements in a section below. Both Users 2 and 4 mentioned what within their execution of the task they would have done differently, and they were the two that forgot to turn off the stove without a reminder so they both indicated they would have remembered to turn off the stove during the testing period. We also asked a general ending question about additional feedback they wanted to give us. User 1 gave another suggestion for improvement which is to move the elevation control panel off of the stove, another good suggestion which we took into consideration in the improvements section of this deliverable. User 2 generally liked the premise of the Smart Stove and said it was space efficient. They also would like to see it connected to another smart device like a Google Home Mini which would integrate better into their current smart ecosystem. Users 3 and 4 were given a breakdown of the Smart Stove as they didn't use it during testing, and User 3 said they would definitely buy this stove as they hate bending down to take things out of the oven, and it would also be useful if people of various heights were all using the same appliance. User 4 also seemed to be interested in the idea of the reminders associated with the app portion of our prototype design. As a college student, they tend to forget certain things when they're busy so they would like a mechanism that would help increase safety while cooking.

Based on our observations, we can see that through the intended uses of the Smart Stove, there was less frequent bending to input and retrieve items from the oven, as well as on the stovetop. This is very positive data as it shows that our intended results were achieved; we want users to not have to bend down as often to use the appliance as to not irritate their potential back pain but still get full use of a stovetop or oven. We could see that the kitchen organization portion of the

app also had mostly positive results; users were able to more quickly find their ingredients when using the app as opposed to not having it, but the cabinet numbering can definitely be improved so as to not confuse the user. Finally, in terms of cognitive help, two of our users did forget to turn off the stove and had to be reminded to turn it off. The notification from the app prompted User 2 to turn off the stove, and User 4 would also have received a notification if they had been using the app, and we can assume this would have also prompted them to turn off the stove as our verbal reminder to them did.

One-Way ANOVA for NASA-TLX						
		Sum of Squares	df	Mean Square	F	Sig.
Mental_Demand	Between Groups	6.250	1	6.250	2.778	.238
	Within Groups	4.500	2	2.250		
	Total	10.750	3			
Physical_Demand	Between Groups	.000	1	.000	.000	1.000
	Within Groups	4.000	2	2.000		
	Total	4.000	3			
Temporal_Demand	Between Groups	4.000	1	4.000	.444	.574
	Within Groups	18.000	2	9.000		
	Total	22.000	3			
Performance	Between Groups	9.000	1	9.000	4.500	.168
	Within Groups	4.000	2	2.000		
	Total	13.000	3			
Effort	Between Groups	12.250	1	12.250	3.769	.192
	Within Groups	6.500	2	3.250		
	Total	18.750	3			
Frustration	Between Groups	9.000	1	9.000	1.000	.423
	Within Groups	18.000	2	9.000		
	Total	27.000	3			
Mean_Usability	Between Groups	4.694	1	4.694	2.600	.248
	Within Groups	3.611	2	1.806		
	Total	8.306	3			

We analyzed the statistical significance of the NASA TLX results using one-way Analysis of Variance (ANOVA), shown above. Since we had a small sample size due to the number of users we could find, we considered the criteria for significance as  $p < 0.2$ . The only 2 NASA-TLX metrics that met this condition were performance and effort with a p-value of 0.168 and 0.192 respectively. However, contrary to our expectations these were both worse in the smart stove assisted group.

While none of their differences were statistically significant, the most relevant metrics for our study were mental demand, physical demand and mean usability. Notably, there was no difference in physical demand across the different tasks. The mean mental demand and usability were both worse for the smart stove condition, which we discuss further in evaluating the limitations and problems with our NASA-TLX data.



Based on our observations, we were surprised to see that the NASA TLX indicated that the mental demand and usability were worse for the Smart Stove condition. Upon further analysis of the collected data, we predict that the users in Smart Stove condition evaluated the experience with the appliance itself in their NASA TLX responses, while the control condition evaluated the tasks themselves. In the control condition, the participants were using a “normal” stove and oven without any added features, mundane tasks which they perform regularly, so it is expected that they would not think these tasks would cause much mental demand. In the Smart Stove condition however, the participants are learning a new application which they have never used and are also using a stove with added features they must remember. While they did indicate the tasks were still simple, for the first time using an appliance, it would be expected that users would have to take some time to learn the different mechanisms. So while the NASA TLX may seem to indicate our Smart Stove was more difficult to use, our observational data, outlined above, shows that it did help with the actions of bending and it was good for reminders if users were to forget their stove or oven was on and we would ultimately say that our prototype shows good potential.

## **Design Implications**

During the brainstorming and ideation stages of our project (Deliverables 1 & 2), we outlined a list of usability goals and design criteria to assess our prototype designs in the later stages. Our designs focused on simplicity (making sure our design is simple and intuitive to use), clarity (making sure every item is clearly labeled and has a corresponding icon), ease of use (making sure that all the interfaces we’ve designed are easy to navigate through without any confusion), safety (making sure that the interfaces do not pose any danger to the user but instead reduce hazards in the kitchen), and adaptability (making sure the organization component of the app design is customizable and modifiable to serve the user’s needs). Throughout the prototype design process, we made sure that we followed our design guidelines and met all the usability goals and design requirements. Our digital prototype design is very straightforward and easy to navigate through, so that it is easy for anyone, especially the elderly, to use. All buttons are clearly labeled, each element has a corresponding icon that shows it visually, features implemented in the app assist users with cooking and reduce hazards in the kitchen, and the organization component of the app is customizable, where a user can set up their kitchen however they want and name each cabinet whatever they want. Additionally, important functionalities of the design, such as turning off a burner or calling a primary contact, only take a minimal number of steps to complete (more specifically turning the burner off takes two steps to complete, and calling a primary contact only takes one step to complete). Our physical prototype design also follows the same design guidelines. Buttons, burner knobs, and any interactive element on the physical stove are labeled accordingly and easy to use. Based on the results of our users’ feedback and evaluations, we can conclude that our prototype design is pretty effective and meets our design criteria. Almost all of the design choices we’ve made during the design

process met our usability goals and design requirements. During our testing sessions, we detected a few problems with our current design, such as placing the burner control knobs in a potentially dangerous position and having an unorganized way of mapping cabinets in the app to cabinets in the kitchen, that could be fixed to improve the useability of our prototypes and increase the safety of our users. These changes and improvements are outlined in the next section.

## UI Changes and Improvements

After conducting the testing sessions and getting feedback from our users and the TA from Deliverable 3, we have identified and listed several UI changes and improvements that can be made to both of our digital and physical prototypes, if we were to continue working on this project.

### **Digital Prototype:**

Add a 3D view of the user's kitchen layout in the kitchen organization component of the app

- Priority: High
- Source: users' feedback
- Rationale: during the testing sessions, users had trouble mapping the cabinets on the app to the corresponding cabinets in the kitchen
- Solution: include a feature in the kitchen organization component of the app that lets the user scan their kitchen during kitchen layout setup; the app will be able to identify each cabinet and provide a direct mapping of the cabinets, in the case when a user tries to find a specific ingredient, the cabinet that contains the ingredient will be highlighted in the 3D view.

Add the ability for the user to adjust a burner's temperature and oven settings

- Priority: Medium
- Source: TA's feedback
- Rationale: With our current app design, users could only turn kitchen appliances on and off, but won't be able to adjust a burner's temperature (low, medium, or high) or the oven settings (setting the temperature when turning the oven on in the app)
- Solution: add "low," "medium," and "high" buttons under each burner that is currently on, so that the user can change the temperature of the active burner (if the user doesn't want to turn it off); also add a popup screen of a keypad to set the oven temperature when the user turns on the oven in the app.

Add the ability for the user to adjust the stove's height in the app

- Priority: Low

- Source: users' feedback
- Rationale: during the testing sessions, users had trouble pressing the height adjustment buttons when the stove was in its normal position (stovetop aligned with the countertop)
- Solution: add the stove height adjustment buttons (up and down) in the kitchen appliance control component of the app for an easier control.

### **Physical Prototype:**

Change the placement of the burner control knobs

- Priority: High
- Source: users' and TA feedback
- Rationale: during the post-test interviews, multiple users mentioned that the placement of the burner control knobs was a safety concern; TA also pointed this out in deliverable #3
- Solution: move the burner control knobs to the front (or the bottom looking down from the top view)

Change the placement of the stove's height adjustment buttons

- Priority: High
- Source: users' feedback
- Rationale: during the testing sessions, users had trouble pressing the height adjustment buttons when the stove was in its normal position (stovetop aligned with the countertop) since it is located on the side of the stovetop
- Solution: placed the control buttons on the wall near the stove, so that it is in one fixed spot and easy for the user to access

## **Critique**

One major takeaway from overall project experience regarding UI design is that technology is not effective if it is not easy to use. Many of the components/concepts that were taught in this course and that our group got a chance to put to practice vouched for this idea, such as the six fundamental design principles. Ease of use directly correlates with how well a technology promotes good user-technology interaction. Good design is produced when the user is prioritized first and kept at the forefront of a designer's mind.

Regarding project teamwork, we learned about the importance of having multiple perspectives inform a project/design. Many of our group members had varying strengths/skills. Collaboration helped us to learn about the importance of leveraging the strengths within a group in order to develop or accomplish a goal or task. We also learned that working with multiple people is useful for gaining multiple perspectives about a topic, which was crucial concerning this project as we sought to develop a design that needed to reach a wide audience. More specifically, each of us

had different cooking backgrounds and knew different people, including the youth, older individuals, healthy people, those who struggled with physical pain, those with plenty of cooking experience, and those with little cooking experience, who have had varying experiences in the kitchen that informed our design.

If we were to start over, one thing we would do differently is alter our interviews when completing our interview guides to incorporate a formal survey regarding what types of technologies/devices users are most interested in, prefer working with the most, are most comfortable with, and find most interesting and easiest to use (e.g. mobile apps, robots, smart kitchen devices). This could have better informed our design choices and perhaps reduced tradeoffs involved in implementing our design.

Regarding our evaluation plan, some strengths of our evaluation plan include having the participants perform multiple tasks, which helped address various components of our design, the use of the NASA-TLX questionnaire because it incorporates a Likert scale, which can be useful for giving the participants options to provide concise answers to our questions rather than leaving the questions completely open ended, which can lead to vague responses that are not as informative, and the use of control conditions. One thing that we would change that could have helped our evaluation plan was recording a video or an audio while we conducted the user-testing. This could have been useful for ensuring that we collected accurate data about the user experience outside of the written notes. These could have been a good reference point to ensure that no important details were accidentally left out of the notes. Another thing that we could have included or changed regards the tasks that we had the users perform. More specifically, we could have had the user cook a different food item, such as pasta, that requires a more complex cooking process. A more complex cooking process might have introduced more obstacles to assess the effectiveness of our design and its ability to help a user overcome these obstacles. Introducing more obstacles could have highlighted more weaknesses in our design to address and improve. Lastly, to improve upon our evaluation plan, we could have also included a timed task that required the user to cook a food item within a set/amount of time to assess what kind of hazards the user might experience in a scenario where the user is rushing to cook a meal. Through this scenario, we could assess how well our design addresses/mitigates safety hazards that a user might be more prone to experiencing while rushing and address our target goal of improving kitchen safety.

What we would have done differently knowing what we know now includes implementing some of the above suggestions/mentions regarding our evaluation plan and its weaknesses. Incorporating some of these suggestions could have been useful for discovering more about the effectiveness of our design and what can be changed or improved upon. We would probably also address the pain points that some of the users pointed out about our design listed above: placement of the burner knobs on the physical prototype, placement of the stove's height buttons, lack of a feature to adjust height from the app, lack of a feature to adjust burner temperature from the app, and lack of a 3D view of the user's kitchen layout.