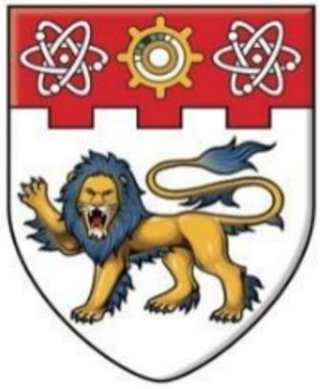

NANYANG TECHNOLOGICAL UNIVERSITY

Usability Evaluation of Electrolux EMT25507 Microwave

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Introduction

The microwave is an electric oven that heats and cooks food by exposing it to electromagnetic radiations. Since its invention and mass market production, the microwave has become an essential kitchen appliance in every house. Due to its limited application (i.e. heating up food), the marketing of microwaves has been increasingly relying on the design and the accessibility/usability of microwave functions, rather than the technology itself. Electrolux the second largest multinational kitchen appliances manufacturer in the world. In the following paper we will evaluate the usability of the Electrolux EMT25507 Microwave.

The Electrolux EMT25507 Microwave is installed within the walls of the desired room. It is characterised by a fairly simple and minimalistic design: no physical buttons, a small LED screen, a pushable panel blended within the contours of the microwave. The smooth surface and the monochrome colours, allow the microwave to "disappear" within the wall.

The aesthetics of the microwave as well as the explanation of the various functions of the microwave can be found in Appendix A. Figure 1 is how the Electrolux EMT25507 Microwave looks like. Figure 2 explains the various functions of icons on the left side of the microwave.

Materials and Methodology

The experiment consists in evaluating the accessibility of four tasks on the Electrolux model EMT25507 Microwave. The experiment took place in the kitchen where the microwave is located. A total of four subjects, two male and two female, undertook the experiment, each one attempting all four tasks. Subject One is a male aged 28, an Architect by profession. Subject Two is a female aged 25, an Occupational Therapist. Subject Three is a male aged 25, an Electrical Engineering student at Nanyang Technological University. Subject Four is a female aged 25, a Business Development executive. All the subjects had no prior experience using the microwave

and were not allowed to try using the microwave before the experiment. Participating in the experiment would be the first time the subjects interact with the microwave.

The experiment had three parts to it, a briefing, tasks execution, and a feedback session. The whole of the task execution and the feedback session was filmed with a camera; each action taken by the subject during the execution of the task was recorded and logged as a sequence of steps to be analysed. The recording of the process was only carried out after the subject gave consent during the briefing.

Part One, Briefing

Subjects were informed that the purpose of the experiment was conducted for an academic module offered in Nanyang Technological University, HP3003, Engineering Psychology. It was communicated that at any point in time during the experiment, should the subject find the task insurmountable, the subject could give up. No help would be rendered by the experimenter, except to inform the subject if the task is completed or not. Subjects were also told to use the talk-aloud protocol to verbalise their thoughts as they carried out the tasks. To aid them with our expectation, we showed the subjects an example of the talk-aloud protocol which we want them to mimic using a video (J VV, 2013). The talk-aloud protocol was included to make sure that we understood their thought process and for us to record and analyze the information. The verbalized thought process would help give insight into how the subject interacted with the microwave, and identify common problems as well as come up with suggestions on how to better design the microwave. We ended the briefing by seeking the subjects' consent to film the process for recording, documenting and presenting purposes.

Part Two, Task Execution

Four tasks were given to the subjects to accomplish, the tasks are:

1) Grill a piece of food for 5 minutes.
2) Change the power of the oven to 500 Watts.
3) Use the preset functions to heat up 350g of vegetables.
4) Set time in microwave to 3:30pm.

For the instructions given to the subjects for each task, please refer to Appendix B.

Part Three, Feedback Session

Two to three questions were posed to subjects to allow them to share their experience interacting with the microwave as well as collect suggestions on how the microwave could be improved. The list of questions can be found in Appendix C. The suggestions were recorded and consolidated.

Usability Testing and Data

Below outlined the correct steps needed to complete each task as well as an overview of common problems users faced while performing each. Suggestions for fixing these issues are discussed in the following section. For the raw data collected from the subjects, please refer to Appendix D.

Task 1, Grill a Piece of Food for 5 Minutes

This task in an ideal scenario would take 12 button presses to perform. The exact steps are shown below.

1) Press the  button once.
2) Press the '-' button 10 times.
3) Press the  button once to start the grilling.

The first task is unique in that this was the subjects' first interaction with the system as a whole. This came with its own set of effect as users grew accustomed to the microwave. All subjects failed to properly complete the task on their first attempt, each not realizing that they had not switched the microwave to the grill function. Secondly, subjects generally struggled with setting the time to 5 minutes. The default grilling time is 10 minutes, but the subjects did not follow the ideal steps to set the time; rather, they often reset and added up, subtracted slowly, or some combination of the two.

In addition to struggles with finding the grill function and setting the time, most subjects struggled with general navigation of the system interface. This was made most apparent in the failure of 3 out of 4 users to correctly start the microwave. Subjects did not identify  as the start button. While this is the most shocking and clearest example of users not understanding the iconographic language employed by Electrolux, we observed similar problems as subjects tried out buttons attempting to decipher what effect they had.

There are many concepts from the fields of engineering psychology, design, and human-computer interaction that apply to this product.

Subjects showed the extent of both the gulf of evaluation and the gulf of execution. In terms of (attempted) task completion users did not appear to have a clear plan for fulfilling the requirements of the task. They were unsure both of what actions were available to them as well as what most of the explicit buttons would do. After performing some action, subjects were often visibly confused at what had occurred, taking a moment to reevaluate the current system status. It was not always clear to them if correct forward progress was being made.

It was obvious to see that there was a great disconnect between the varying conceptual models at play. Neither the evaluators nor the subjects are privy to the design model, but there was

clearly a disassociation between the design model, the user's conceptual model, and the system image. The system image is built from the design and engineering teams at electrolux and the perceptions of the end user. The minimalist design and uninformative buttons served to fracture the user's model from that of the designer. While most users would eventually come to better understand the system, it took far longer than it should have.

One of the biggest problems this microwave has is its language. The entire system is predicated on hard to decipher pictograms. These images do not even always conform to industry standards (as with the On/Off buttons) or even convey much meaning on their own (such as the blank square). The designers are asking the users to understand and learn an entirely new metaphorical language with their icons instead of relying on constructs such as standards or words.

With the new language comes the problem of a user's memory. It is well documented that in terms of effort expended and attention needed, recognition vastly outpaces recall (Budiu, 2014). For most any operation the user has to memorize a complex series of inputs as well as memorize which of a dozen buttons is the correct one. Those buttons of course being unlabeled and requiring memorization themselves. Instead of relying on the fact that people cannot help but read words when presented to them (Augustinova & Ferrand, 2014) or rely on years of inbuilt experience with standard icons, the designers created their own system, harming the user's impression and ease of use.

The communication between the system and the user leaves a lot to be desired as we have already discussed, and this can continue to be seen in the microwaves use (or lack thereof) of feedback. Button presses that do cause action have a sound cue accompanying them, but the evaluators noticed that users would repeatedly tap on a button that did not appear to do anything. There was no feedback visual or auditory for presses that would cause no action. Related to this,

the use of capacitive buttons removes the possibility for haptic feedback such as what you may get with a dome-capped button.

Task 2, Change the Power of the Oven to 500 Watts

This task in an ideal scenario would take 3 button presses to perform. The exact steps are shown below.

1) Press the  button 3 times.

Subjects fared better on this task compared to the first one. Part of this could be contributed to carryover effects and gained knowledge from the first trial. Everyone completed the task in a single trial. Similar to the first trial, subjects struggled to find which button, or set of buttons would change the power level. Many of our subjects saw the power ratings on the preset functions and believed they were making correct forward progress, not realizing that the correct solution was not related to the submenu they were in.

The feedback given by the microwave was not clear in this scenario. Most subjects at some point entered the preset function selection menu and saw those wattage displays. They incorrectly assumed that they were on the right track, despite not actually having any effect on the real power level of the microwave.

Interestingly, the disconnect between system image, the user's mental model, and the design model continued and expanded during this task. One user developed her mental model by pressing on two buttons at the same time. However, the pressing on two buttons is not an intended interaction method and only one of the button presses is likely to be registered. Consequently, the participant mistakenly registered her new mental model as functional, affecting her following task.

Subjects were also observed to have interacted with the display screen directly by pressing on the screen. This could be due to the familiarity of touch screen devices in their everyday life. Increasingly, more technological products incorporate an LCD touch screen to facilitate the human-computer interaction ("Case history: Touching the future", 2008). The design of the microwave made it more ambiguous for the subjects because the interface mimicked how touchscreen would look like. Seamless, without boundaries, no button edges, the whole right panel of the microwave is fixed with a continuous piece of glass. This "deception" of the microwave being a touchscreen device along with the increasing amount of touchscreen devices, it is no wonder subjects tried interacting directly with the display screen, but to no avail.

Task 3, Use the Preset Functions to Heat 350g of Vegetables

This task in an ideal scenario would take 12 button presses to perform. The exact steps are shown in the table below.

1) Press the  repeatedly for 8 times until  is seen on the display.
2) Press the  button to start the heating.

Task 3 proved the most difficult in general across subjects. One participant failed to complete the task, giving up after three trials and over 150 button presses. The struggles can most generally be laid at the feet of poor communication between the user and the system. This button  was not clear as the presets function and this icon  was not clear as the vegetables. Subject 4 even thought that the icon for vegetables looked like a turtle. Every single participant cycled through the list of presets more than once searching for the correct option. Even though the task was made less complex than it could have been, by keeping the default weight of 350g, subjects still struggled to complete the task.

As with Task 2, we saw another interesting interaction method indicative of touch devices. One participant attempted to swipe across the buttons to change the current displayed values. Further analysis of these ideas will be discussed in the improvements section, but for now it was clear that even three tasks into the experiment, users still did not have a complete or accurate model for how the system worked.

Task 4, Set Time in Microwave to 3:30pm

This task in an ideal scenario would take 42 button presses to perform. The exact steps are shown in below.

1) Press the  twice
2) To set the amount of hours press the Setting pads (+/-).
3) Press the  to confirm
4) To set the amount of hours press the Setting pads (+/-).
5) Press the  to confirm.
6) To change display in standby mode, press + or - and set **OFF.**
7) Press the  to confirm.

Despite this task having the highest average number of button presses to complete (85.5 or 55.5 if subject 4's DNF is removed), task 4 proved easier than task 3. Users generally identified this button  to be related to time, and all eventually used the button. From there it seemed largely like luck for some of the subjects to get to the clock function. A single press will enter the timer function, while double tapping the button enters the clock setting function. Whether intended or not, 3 out of the 4 managed to progress as far as setting the time. Universally, however, subjects voiced their dislike for how time was set. Pressing the + button thirty times in a row to reach 3:30

proved tedious for our users. All subjects attempted to use the 10sec or 5min buttons to speed up their progress, but to no avail. Generally speaking repetition of any action is undesirable, but forcing the users to press the same button thirty times in a row takes things to a whole new level. The 5 and 10 buttons which normally affect time did not do so in this case. The inconsistency of what these buttons did contributed to poor user impression of the device. Consistency across modalities is a key usability heuristic and one that we will discuss later. Repetitive motion, besides being annoying and bad for people with RSI issues is also discouraged as boredom, complacency, and frustration lead to errors (Norman, 2013).

General Remarks from User Testing

From this experiment, it was found that the average number of steps the subjects took to complete each task was significantly more than the ideal. This is portrayed in the Table 1 below.

Task	Ideal Number of Steps	Average Number of Steps Taken by Subjects
Grill a piece of food for 5 minutes	6	35.5
Change the power of the oven to 500 Watt	3	27
Use the preset functions to heat up 350g vegetables	12	38
Set time in microwave to 3:30pm	42	85.5

Table 1. Comparison between ideal steps and average steps taken by subjects.

These large differences in steps proves a point that the current design of the microwave is not as intuitive as it can or should be. If the microwave was better designed and if experiments like this was conducted prior to the market launch of the microwave, it would prove to be very much useful. From the experiment we see that the design and human-computer interaction of the Electrolux microwave commit various mistakes that was discussed in the previous section. The gulf of execution, gulf of evaluation, bad systems image and the lack of user feedback confused the subjects. Only 4 tasks were used for this experiment and already the subjects were unable execute the functions. We can only imagine and predict how much mores steps subjects would take for more complex tasks.

Subject Suggestions from Product Testing

A multitude of struggles surfaced as the subjects tried to execute the various tasks assigned to them. On top of the observations we made, we also gathered feedback from the subjects and asked for their opinions on the microwave and how they thought the microwave design could improve. We reviewed and consolidated their thoughts and got the following suggestions.

A common frustration the subjects encountered was the inefficient addition and subtraction of time to the microwave. This frustration was expressed during task 4 when subjects had to press the  button 30 times for one of the steps just to fulfill the task. It was suggested that the microwave could include a “press and hold” function to be more efficient. Others suggested to use a scroller or a dial that allows for quicker adjustments.

All the subjects also mentioned that the icons used were not intuitive and difficult to decipher. It was unanimous that the subjects preferred if there were words used instead of the ambiguous icons. Also, one subject mentioned that though the microwave had many functions, it

made the microwave very complicated and suggested removing some of the functions that were redundant.

Overall, though the subjects found the microwave aesthetically pleasing, they all had trouble figuring how to use the microwave. All the suggestions made were to reduce the gulf of execution and gulf of evaluation. They would rather sacrifice the aesthetics of the microwave, in order to achieve a more user-friendly microwave.

Usability Expert Analysis

Heuristic Evaluation

The authors undertook a heuristic evaluation of the Electrolux EMT25507 following the 10 heuristic system set out by the Nielsen Norman group (Nielsen, 1994). Below are our observations and findings from the usability expert's heuristic evaluations. Severity rankings are based on a standard system of 1-5, 5 being the most severe, 1 being the least.

The first heuristic is "visibility of system status." Throughout our testing we noticed consistent problems in this domain. First and foremost, when testing the evaluators would often press buttons with no apparent results. There would be no visual or auditory cues to indicate that an input had been received (either positive or negative). These buttons, despite being readily available, and possibly used just moments before were now met with no feedback whatsoever. In a related note, besides general navigation issues and lack of clarity of button interaction (discussed earlier in Usability Testing Data), it was difficult to create an accurate or usable mental model of the underlying system. For example, after selecting the defrost setting options were limited to moving up or down the weight of the product, with no use of the favourite button, and needing to use the back/home button twice in order to return to a neutral screen. Conversely, while in the presets section, the favourites button was actionable and only one use of

the home button was needed. The system is not devoid of feedback and information, buttons do beep (when correctly pressed), the LCD display will show some information, a chime alerts users that the cooking has finished (after watching the clock countdown). Generally, we score the severity of the lack of visual or auditory input for invalid button inputs to rank as a 4. The problems surrounding visibility of 'menu navigation' also rank as a 4.

The second key heuristics is on "match between system and the real world." The microwave oven has several key areas where there is a distinct lack of useful, familiar language—a key component of the second heuristic. While the microwave has a very sleek design, with a nice LCD display system, it fails to take full advantage of that feature. The design language employed by the manufacturers largely fails to match a typical user's knowledge. Iconographic displays and languages can transcend language barriers, but all too often we found ourselves unsure of what a given button would do (special acknowledgement goes to the completely empty square indicating function change), or what an icon on the screen meant such as the preset icons for pasta, auto, or vegetables. The system-oriented, unfamiliar terms and general lack of fully cohesive language demonstrates a mismatch between system and real world. The electrolux receives the highest severity rating of 5 for this heuristic.

"User control and Freedom" is the third heuristic focusing on the ability to exit from a mistake, undo or redo an action. Once again, unfortunately the microwave does not support much of these features. On one hand, it is with relative ease that a press (or multiple presses) of the Stop/Clear button will erase allow for a complete exit from what the user was doing. However, all progress will have been lost. This is a bit of a nuclear approach. Many actions taken do have an easy recovery, if not explicit undo/redo (the NN heuristics have somewhat of a focus on HCI). Adding or subtracting time/weight often occurs in a looping fashion and via the +/-

buttons. This does make it easy to make relatively quick and easy changes. Overall a severity score of 2.

Heuristic four relates to “Consistency and Standards”. Once again, the EMT25507 receives mixed reviews from evaluation. Electrolux did not go completely off-piste with their icons and methodology for interaction and use. For example, their use of a snowflake in part of the defrosting icon, having a row of triangles atop the containing box for the grill, a fan for convection cooking. All of these are relatively standardized through the cooking industry (the actual readability of such icons are left for further debate in future research). That being the case, icons such as the infamous blank box, the unusual stop/clear button, the lack of a clear start button all prove that Electrolux failed to take into consideration the extent to which its iconographic design choices would affect users, both first-time and expert. Severity rating: 3.

“Error Prevention” marks the fifth heuristic. As best we could tell, there are not explicit methods by which the microwave oven systems acts to prevent error. An argument could be made for presets being in place to avoid the possibilities of overcooking, but that seems a stretch of logic. With that said, the evaluators feel that it would likely not be appropriate for the microwave to disallow functionality. As discussed in heuristic 3, the user is free to move between modes, clear all progress, or enter a setting unintentionally. A balance must be struck between aggravating the user with some form of confirmation and the lost time. The suggestions section enumerates ideas that could aid in error prevention such as blanking out buttons that would cause an abrupt exit from the current selection. The question of ease of recovery is not included in the scope of heuristic 5, but we will still score the system at a 2.

Heuristic six, “Recognition rather than recall”: This could be considered on of the microwave’s key failures. Almost all advanced interactions are entirely predicated on

memorizing a complex series of button presses. Those buttons are not labeled, nor do they all conform to standard logographic design. Consistently the evaluators where left guessing what to do, or remembering back from previous experiences what a button did. This receives our highest severity rating of 5.

Heuristic seven, “Flexibility and Efficiency of Use”, refers to features that allow the more experienced user to navigate the system more easily and quickly. There are some options for quicker, or at least different, options for heating food. The favourites menu and presets offer different options from completely manual settings. That being the case, there are no advanced, high speed ways to access or launch these functions. The user does have to option to self program their own favorite setting to which we applaud the manufactures. However, this option is restricted so that only one self-made preset can be made. A mixed bag overall, resulting in a score of 3.

Heuristic eight is where the EMT25507 truly shines—aesthetic and minimalist design. Without a doubt the design is paired down and minimalist. It is beautiful to look at, sleek with unobtrusive icons, a pleasing brushed stainless steel construction. Despite what the expert evaluators have said to the contrary, the microwave does a fair job balancing frequent features, and those less common. The most relevant options are readily accessible. Severity 1.

From the very good, we now arrive at the very bad. Heuristic nine sees us at “Help users recognize, diagnose, and recover from errors”. The system does a miserable job communicating if the user is attempting to perform an invalid option. There is no sound cue, visual cue, nor dialog (via the LCD display) to communicate with the user what they are doing is a problem. More often than not, errors result in either a complete loss of progress through a task or the

accidental activation of the microwave with settings they did not want. We rank the severity at a 4.

The tenth and final heuristic relates to “Help and Documentation”. The professionalism of a large company manufacturing consumer goods does the microwave good here. The help documentation is easily accessible either through the packet with the original box or found online. The manual we had includes four different languages: Dutch, English, French, and German. Notable for its absence is Swedish, the native language of the parent company. Furthermore, given the product is being sold in Singapore it would not go amiss to have some of the other four national languages such as Malay or Chinese. Concerning the content of the help documentation, it is very thorough and offers clear and concise instructions for operating the microwave. Photos are included as well as pictograms of each icon. These are made use of during the instruction. We are pleased overall. Severity: 1

Fitts Law Analysis

A formal analysis in the sense of generating ID values was not undertaken. The authors, however, would briefly like to discuss a few notes relating to this form of examination. A discussion was briefly had and will be further expanded upon in later sections about the implementation of the capacitive buttons from the perspective of feedback and general engineering. Each of the buttons is the same size and shape. This immediately comes into conflict with some of the ideas of Fitts Law. Because each button is the same size, as the user drifts to buttons that are further away, the other button’s Index of Difficulty grows. Along this line, the most used buttons (Start and Stop) are not centrally located relative to the other buttons. This means that the average distance traveled to reach them will be high. Combined with their small size and possible capacitive problems, and the ID quickly increases.

While the the evaluation team can acknowledge the stop button being close to the open button, opening the microwave will stop any cooking immediately making that proximity relatively useless. As the stop is also the clear function it would serve its function better in a higher, more centrally located area, closer to the other buttons. Increasing the size of both the start and stop buttons would also alleviate some of the problems.

Suggestions for Future Development and Product Improvement

From this experiment, it was made clear that there were many problems associated with the usability of the microwave from Electrolux. The evaluation team has therefore worked on a suite of suggested improvements to the system.

Overhaul and Redesign Iconography/Language

Without a doubt, the single biggest problem faced by the users when interacting with the microwave oven were the gulfs of execution and evaluation. More explicitly, users could neither formulate a plan of action nor could they determine of a given step in that plan had the desired effect. This is largely due to the poor communication systems the microwave has. The icons are clearly not as informative or intuitive as the designers would have hoped for.

We suggest a complete graphic overhaul of the icons on the buttons and the LCD screen. Working with the graphics team and conforming to international standards of non-verbal communication could help user interaction. For example, the power button  only bears a passing resemblance to the IEC standard  . The much-maligned blank square  has no real relation to its function of changing the mode of the microwave to grill, convection, combi, etc. A change to a picture of a grill, of actual *micro*waves, a combination of the two or something else would be more informationally dense.

The above solutions work, but we feel Electrolux can go further. Icons still need to be interpreted. Words, on the other hand, do not. It would not take much effort to add labels to each of the buttons and to display the appropriate information via text on the LCD display. Having the word “Function” followed by “Grill”, “Convect”, etc. after pressing a labeled button would do a lot of good to decrease the number of incorrect button presses. Explicit labels like “Power”, “Presets”, “Vegetables”, “Popcorn”, “2x for Clock”, would immensely help users comprehension of the system status.

Add Audio/Visual Feedback

In keeping with the above suggestions and troubles users had with determining what was and was not a valid input option, we suggest adding explicit feedback for incorrect options or otherwise indicating that an action cannot/should not be taken. There are two options we suggest that are not mutually exclusive. First, an error or incorrect sound could be given when a user presses a button that does not or will not do anything. This would indicate to the user that an input was received, but it was not a valid one and no system update would occur. Adding this sound would reduce repeated, frustrated button presses where the user seemed unclear as to whether the system received their input, and if that input was correct. Furthermore, this system already has standing within the microwave at present. A beeping noise is present for every valid press made, it therefore it not too much to ask for an invalid sound to likewise be added. The evaluators are quick to stress that these sounds (both correct and incorrect) should be toggleable through some sort of setting, but having the initial option would speed learning, and prevent frustration.

A second option would be to make use of lighting to show users which buttons should or should not be pressed at a given time. If each of the buttons were to be backlit, the illumination or

lack of illumination could be used as a method of demonstrating which buttons presented valid options for progressing a sequence, given the past inputs.

Re-evaluate the Buttons

We have already discussed in brief the use of capacitive buttons as the input method, both in the Fitts Law analysis and the user testing section. The capacitive buttons did not always accept input that was otherwise thought to be valid. Increasing the size of these buttons would aid in overall user experience, as they would have to be less precise when inputting actions. However, capacitive buttons may not be the best for a kitchen appliance. They are known to not work as well when the users has wet or otherwise dirty fingers, something that is likely to happen in a kitchen environment.

An alternative, therefore, would be to move forward with a dome-capped button, or otherwise fundamentally physical system of input. These buttons are much more robust to state of the finger. Additionally, pressing down the button gives a nice sense of feedback to the user. They *know* that a signal was sent to the system.

Complete Overhaul of the UI to a Touchscreen Device

During user testing and subsequent analysis, the evaluators noticed an interesting pattern of interaction emerge from some of the users. Users attempted to touch the LCD screen or swipe at the buttons to change the current selection. We believe this to be born out of a familiarity with touch devices in the modern world. Phones, computers, point-of-service machines, and more all use touch-based interfaces. Samsung has even created fridges with enormous touch screens on them, proving that, at least in theory, adding a touch-based interaction system could work in reality (Samsung, 2018).

Making the entire interface a touchscreen provides several interesting advantages. First of all, a touch screen has a much higher density of pixels to work with and can therefore show more information in a more dynamic way than their staid counterparts of a fixed LCD display. Hierarchical menus could be made explicit, labels could be dynamically displayed. Reliance on pictograms would be removed as any number of languages in collaboration with icons/photos could be used. Only the information that needed to be displayed would be displayed, the rest could be hidden, meaning that users would no longer press a button and lose their progress on a task.

Limitations

The authors stand by the conclusions drawn from the evaluation of the microwave oven. However, we would likewise like to take this opportunity to discuss a few of the limitations of the study. Firstly, the sample size of subjects tested was small (n = 4). On one hand, for most usability testing a number in this range is sufficient, the users were taken from a convenience sample. Each was a university student aged Singaporean. As Electrolux is an international brand, it may have been advantageous to seek a more diverse set of subjects because not all users could be considered to be young, well-educated, and English speaking.

Additionally, the tasks and testing structure could have been better controlled and designed. Only four tasks were given to each participant. While the authors are confident that these tasks are representative of a wide range of use cases (common, everyday tasks, rare tasks, advanced-use tasks, etc.), more data about user interaction could have come from a larger number of tasks. The authors did undertake a heuristic evaluation to more fully understand all parts of the system to bolster our understanding of the system. Similarly, all the tasks the subjects were asked to perform were done in the same set order. This of course can lead to carryover effects from one trial to

another, making the data less reliable overall. Future studies would do well to introduce better counterbalancing by randomizing the order in which tasks are given.

Conclusion

In conclusion, we discovered that the Electrolux EMT25570 microwave had many problems pertaining to its usability. After testing four users across a range of tasks problems with the gulf of execution, gulf of evaluation, language, feedback or the lack of it, and the disassociation between the design model, the user's conceptual model, and the system image were made apparent. Addressing such issues, we proposed several suggestions for future developments to improve the usability for the microwave. Firstly, and most importantly, communication between the users and the system needs major improvements. The design language employed by Electrolux left users and evaluators feeling confusing and made them feel as though they lacked control over the system. Moving away from minimalist icons and adding in text labels (in conjunction with the pictograms) both on the buttons and on the LCD display would be a massive quality of life improvement. Keeping in line with communication between the user and the microwave, we also suggest adding in audio or visual indicators of valid/invalid options. Not only would these decrease the likelihood of repeated, frustrated tapping of buttons, but they also aid in making the microwave more accessible to users with disabilities as multimodal options tend towards inclusivity. The final idea in this line of improvements is a possible switch to dome-cap (or other physical) style buttons. These have inbuilt feedback and are less likely to suffer from problems presented by fingers that were handling food.

Finally, Electrolux could take a decisive step away from the industry and move forward with a touchscreen based system. Precedence has been set by other manufactures, and there are

unique benefits to doing so. Allowing for better communication, more control, and closing the gap between execution and evaluation, the touchscreen input offers a bold choice.

Electrolux's design and engineering team did not set out to create as flawed a product as they did. But our evaluations of the EMT25507 serve to show that either through negligence, lack of foresight, or inadequate real-world testing serious usability problems can crop up in a product, hurting the users experience and hurting the company's image. Taking the advice set forth by the evaluators in this report, we feel that Electrolux's next generation of products can truly shine.

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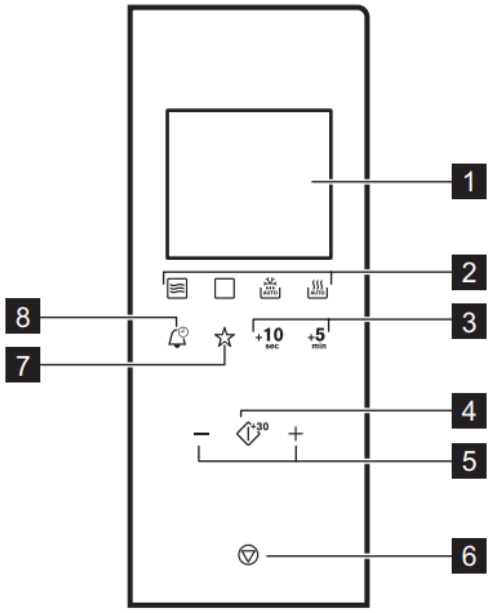
Appendix A

Electrolux EMT25507 Microwave

Figure 1. Electrolux EMT25507 Microwave. Retrieved from https://www.darty.com/nav/achat/encastrable/micro-ondes_expresso_encastrable/micro_ondes_gril_encastrable/electrolux_emt_252070x.html



	Symbol	Function	Description
1	—	Display	Shows the settings and current time.
2	AUTO AUTO	Function pads	To set the microwave / grill / convection / combi / auto defrost and auto cooking function.
3	+10 sec , +5 min	Time Set pads	To set the desired time.
4	+30	Start / +30 sec	To start the appliance or increase the cooking time for 30 seconds at full power.
5	— , +	Setting pads	To set the time, weight or temperature.
6		Stop / Clear	To deactivate the appliance or delete the cooking settings.
7		Favorite	To save one favorite combination of cooking parameters.
8		Clock	To set the clock / reminder.

Figure 2. Button Functions. Retrieved from https://www.manualslib.com/products/Electrolux-Emt25507-4357305.html

Appendix B

Instructions to Subjects

Instructions given to the subjects for each of the tasks:

1) You have a piece of meat that you would like to grill. Set the oven to grill for 5 minutes.
2) You would like to lower the power of the oven. Set the oven to 500 Watt.
3) You have a bowl of vegetables you would like to reheat. Using the preset functions, warm up the 350g of vegetables.
4) The clock on the microwave is currently incorrect. Please set the time to 3:30pm.

Appendix C

Feedback Questions

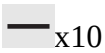
Two to three of the questions listed below are asked to each subject at the end of the experiment:

1) What difficulties did you face during the experiment?
2) How do you think this microwave could be improved?
3) How do you think the design of the microwave could be improved?
4) Did anything stand out to you while completing the tasks?
5) How did you find the microwave aesthetically?

Appendix D

Subject's raw steps

Subject One:

Task	Steps											
1	Attempt 1:											
	1		2		3		4		5		6	
	7		8		9		10					
	Attempt 2:											
	1		2	 x10	3							
2	Attempt 1:											
	1		2		3		4		5		6	
	7		8	 x2	9	 x3						
3	Attempt 1:											
	1	 x28	2									
4	Attempt 1:											
	1	 x2	2	 x3	3		4		5		6	
	7		8	 x30	9		10					

Subject Two:

Task	Steps

1	Attempt 1:											
	1	+5 min	2	— x10								
	Attempt 2:											
	1	AUTO x25	2	☐	3	—	4	🔔	5	☐ x8	6	≋ x6
	7	AUTO	8	AUTO	9	☐	10	≋	11	☐	12	— x11
	13	+	14	▽	15	— x10	16	☐ x7	17	— x10	18	▽
	19	☐	20	— x10	21	▽	22	☐	23	— x10	24	☐
	25	— x10	26	+30								
2	Attempt 1:											
	1	AUTO x18	2	☆	3	AUTO x5	4	≋	5	☆ x4	6	▽
	7	≋ x3										
3	Attempt 1:											
	1	AUTO x18	2	+30								
4	Attempt 1:											
	1	🔔 x2	2	— x9	3	🔔	4	+ x19	5	+10 sec	6	+ x11
	7	🔔										

Subject Three:

Task	Steps											
1	Attempt 1:											
	1	+5 min										
	Attempt 2:											
	1		2	+x2	3	+30	4		5	+x32	6	
	7	+x30	8	+30								
	Attempt 3:											
	1		2	−x10	3	+30						
2	Attempt 1:											
	1	+	2	☆	3	x3	4		5		6	
	7	AUTO	8		9	−x2	10	x2				
3	Attempt 1:											
	1	AUTO	2	+x3	3	−	4	AUTO x3	5	+30	6	
	7	AUTO	8	+x2	9		10	☆ x2	11	AUTO x6	12	AUTO
	13	AUTO	14	−	15	+10 sec	16	AUTO x3	17	+30	18	
	19		20	AUTO	21	+x2	22	+5 min	23	+10 sec	24	
	25	AUTO x4	26	AUTO x2	27		28	AUTO x3	29	AUTO x2	30	+10 sec

	31	+5 min	32	— x2	33	▽						
	Attempt 2:											
	1	AUTO x4	2	AUTO x2	3	+	4	AUTO x3	5	AUTO x2	6	□
	7	AUTO x5	8	AUTO x2	9	+ x2	10	≋ x2	11	AUTO x5	12	AUTO x3
	13	≋ x2	14	AUTO	15	— x3	16	▽ x2	17	AUTO	18	□
	19	AUTO	20	+ x2	21	AUTO x2	22	▽ x2	23	AUTO	24	+30
	Attempt 3:											
	1	AUTO	2	+ x2	3	+5 min	4	+10 sec	5	□	6	▽
	7	+ x2	8	🔔	9	▽	10	+30	11	▽	12	AUTO
	13	+ x11	14	— x9	15	☆ x4	16	▽	17	☆ x6	18	AUTO
	19	🔔	20	+	21	▽	22	AUTO	23	+ x2		
4	Attempt 1:											
	1	+	2	▽	3	🔔	4	+ x2	5	+5 min x3	6	▽
	7	🔔	8	+5 min x3	9	▽	10	🔔	11	+5 min x3	12	+10 sec
	13	▽	14	🔔 x2	15	+ x3	16	🔔	17	+ x30	18	🔔

Subject Four:

Task	Steps											
1	Attempt 1:											
	1		2		3	 x21	4	 x2	5		6	 x2
	7		8	 x6	9		10	 x8	11		12	 x10
	13											
2	Attempt 1:											
	1	 x2	2		3		4		5	 x4	6	
	7	 x2	8	 x2	9	 x2	10		11		12	
	13		14	 x2	15		16		17	 x2	18	
	19		20		21	 x2						
3	Attempt 1:											
	1		2		3		4		5		6	
	7											
	Attempt 2:											
	1		2		3		4	x23	5	x3	6	x8
	7											
4	Attempt 1:											
	1	x2	2		3		4		5		6	x17

	7		8		9		10		11		12	
	13		14		15		16		17		18	
	19		20		21		22		23		24	
	25		26		27		28		29		30	
	31		32		33		34		35		36	
	37		38		39		40		41		42	
	43		44		45		46		47		48	
	49		50		51							

From this point, subject 4 started to tap on multiple icons at the same time making measurement difficult. The subject spent the subsequent 4 minutes using a multi-touch approach and finally giving up on the task.