

# Comparison of interaction styles on large and small touch sensitive interfaces

Jesper J. Bisgaard  
Department of Computer Science  
Aalborg University  
Frederik Bajersvej 7E  
DK9220 Aalborg East, Denmark  
[ondeged@cs.aau.dk](mailto:ondeged@cs.aau.dk)

Morten Heise  
Department of Computer Science  
Aalborg University  
Frederik Bajersvej 7E  
DK9220 Aalborg East, Denmark  
[mheise@cs.aau.dk](mailto:mheise@cs.aau.dk)

Carsten Steffensen  
Department of Computer Science  
Aalborg University  
Frederik Bajersvej 7E  
DK9220 Aalborg East, Denmark  
[cs@cs.aau.dk](mailto:cs@cs.aau.dk)

## ABSTRACT

In this paper, we compare four distinct interface configurations which are tested in a controlled environment setting to assess the time of task completion and the subjective level of user satisfaction. Two different styles of interaction; direct manipulation represented by a WIMP design and menu interaction represented by a Wizard design, combined with one of two input devices; large touch screen or PDA touch screen, constitute a configuration. Eight persons from a homogenous group were selected as test subjects and each performed the same three tasks on each of the four interface configurations. We conclude that large screen as input device for both interaction styles provided generally quicker completion times than both configurations with PDA as input device, though this is nuanced when looking at specific types of tasks. Through the testing and the following discussion, we find that user satisfaction and completion time is not necessarily convergent on one form of interaction

## 1. INTRODUCTION

Interaction styles are a key topic in HCI and different kinds are well documented in the literature [1]. Since first recommended by Norman [7] in 1986, the particular style of direct manipulation has received a great deal of attention and is widely applied. Several comparative experiments have proved direct manipulation preferable among alternate interaction styles [2]. That in regard to both speed, low error rate and user satisfaction.

Touch screens are literally speaking the ultimate input device for direct manipulation, and has undergone research arguing its pros and cons [9]. An experiment comparing mouse, touch screen, number keys, and arrow keys for selection words from an encyclopedia [10], found the touch screen quickest for the task.

A smaller variant of touch screens are the ones used for PDA's. Only few comparative experiments among interaction styles for PDA's have been performed. Kjeldskov et al. examines how input devices; function keys, cursor movement keys and direct pointers respectively fit with different interaction styles when using a PDA [5] Among their conclusions are that direct pointers had the best overall performance as input device and the direct manipulation style performed equally well regardless of input device.

We have noticed a lack of experiments comparing large touch screen interfaces with smaller ones as those of a PDA, as only a single one has come to our attention. That is an experiment were

four alternate means of input; smart board, "semantic snarfing"<sup>1</sup>, mouse and laser pointer were compared to see which one performed best in selection tasks on a large display [6]. The results of the experiment from best to worst performance are identical to the order in which the means of input are mentioned above.

As clarified through this section previous comparative experiments show an advantage of direct manipulation as choice of interaction style. Furthermore touch sensitive interfaces, either big or small, is emphasized as a well performing choice of input device. Only a single experiment has included a comparison of large versus small touch sensitive interfaces only including one kind of interaction style. To argue further about the differences in performance between the large and small touch sensitive interface additional experiments are required, which this article serves to do.

The article is structured by an introductory presentation of an experimental design setup followed by a report of actual test execution and concludes with an analysis of the test results.

## 2. EXPERIMENTAL DESIGN

We have developed an experimental design to compare four different interface configurations to decide which one provide the quickest completion rates for three different tasks, and to argue the level of user satisfaction associated with each.

Interaction style	Input device	Interface configuration
Direct manipulation	+	Large screen WIMP
Menu interaction	+	Large screen Wizard
Direct manipulation	+	PDA WIMP
Menu interaction	+	PDA Wizard

Figure 1 the four distinct interface configurations

<sup>1</sup> A PDA interface mirroring the large screen intended for remote control through direct mapping.

As shown in Figure 1 an interface configuration is composed of an interaction style and an input device.

To facilitate the experiment we have developed a system to support students in a group formation process. It is essentially a database of students containing their pertinent data as well as their topic of interest.

Four distinct prototype systems were implemented. Two systems running on a simulated large touch screen and two systems running on a PDA, these systems employ a WIMP based style of interaction and a wizard based style of interaction, one on each display type.

The systems contains all the features required to complete the tasks we asked the test subjects to complete, but are otherwise “pure” prototypes in the respect that they are not intended for further use or sustained development.

## 2.1 Large Screen WIMP

This system employs a WIMP based style of interaction and runs on a simulated large touch screen device. The system allows a user to relocate the windows representing a student in an arbitrary fashion. The system displays pertinent data on the student such as phone number, current semester and their primary topic of interest.

## 2.2 PDA WIMP

This system is designed to be an equivalent system to the Large Screen WIMP type of interaction. As screen real estate is very limited on a PDA type device it is only possible to move boxes up or down as desired, otherwise the two interfaces are equivalent in both form and function.

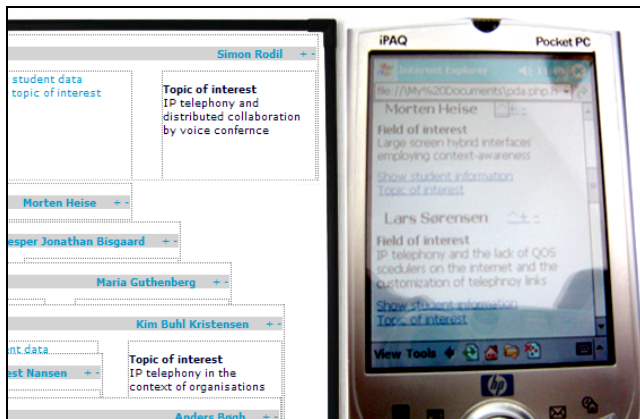


Figure 1 The two WIMP interfaces

## 2.3 Large Screen Wizard

This system employs a Wizard based style of interaction and runs on a simulated large touch screen device. The system allows the users to navigate a hierarchical 3 level structure to obtain data and information on a student. This is done through a wizard like interface.

## 2.4 PDA Wizard

This is a mirror image of the Large Screen Wizard interface scaled down to run on a PDA instead, the interaction style and

dialog structure is exactly the same, only the size of the screen is changed.

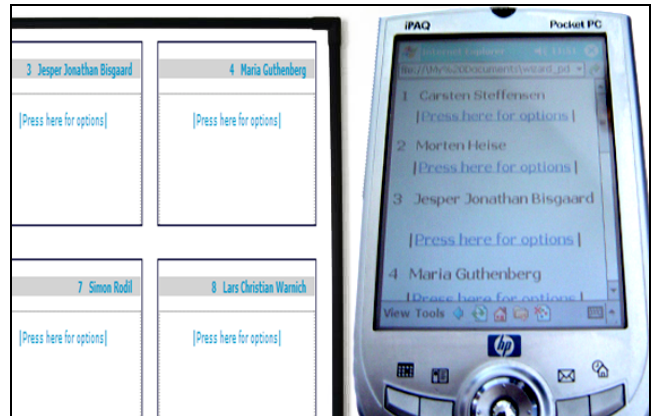


Figure 2 The two Wizard interfaces

## 2.5 Test subjects

All test subjects were recruited at Aalborg University at the 8<sup>th</sup> and 10<sup>th</sup> semesters of the informatics line at the Department of Computer Science. The subjects were slightly unevenly distributed with regard to gender as only one female participated in the tests. The subjects have a great deal of experience with normal desktop systems, although all participants expressed a limited experience with large touch screens and PDA's.

## 2.6 Test method

The method adopted for this test is based on a stringent comparative focus. The test was performed in a single marathon setting at the usability lab at Aalborg University. The usability lab is comprised of three rooms, where one room serves as control station for all recording devices. This room has a see through glass wall so it is possible to observe the interaction taking place in the large “test” room.

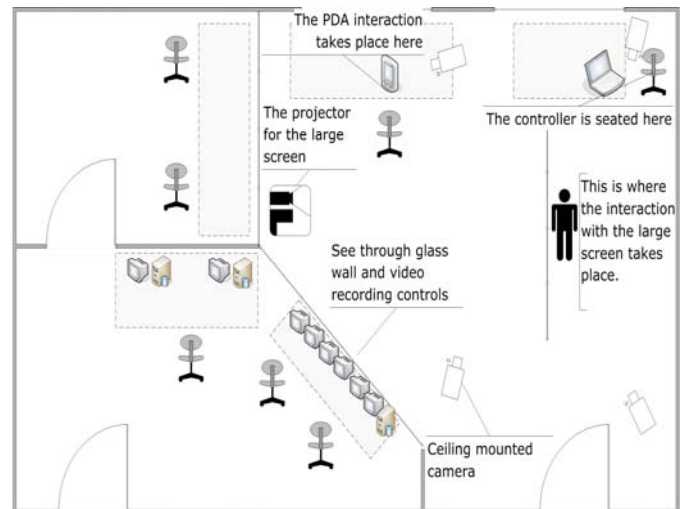


Figure 5: Configuration of test room

For the test room we adopted the configuration displayed in Figure 5. A projector with a VGA input was placed on a height/tilt adjustable stand firing onto a see through screen

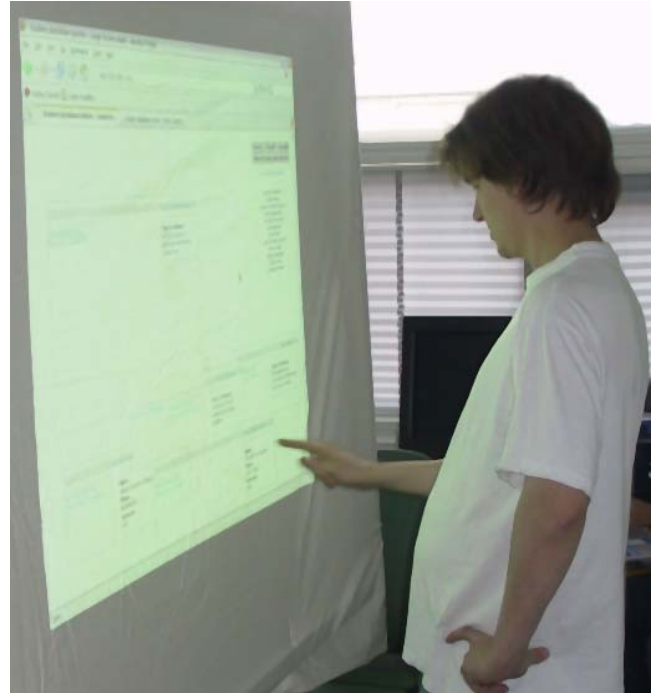
mounted in a head height configuration as can be seen in Figure 6. That way we simulated a large touch screen interface. The screens ability to catch input and react accordingly was handled by a “Wizard of Oz” setup. A controller is placed so he has a clear view of the gestures of the test subject as well as the screen. He then controls the actual interaction in accordance with the gestures and taps of the test subjects. The PDA based interaction is placed at a adjacent table where the test subjects use a Ipaq 3600 with a WiFi card to interact with the systems as seen in Figure 7, The table where the Ipaq is located is covered by a ceiling mounted camera as shown in Figure 5. The large screen is covered by two ceiling mounted cameras as shown in Figure 5. All interaction and spoken comments were recorded by mixing the signals of the cameras into a picture in picture configuration for the large screen interaction, and a single picture configuration for the PDA. The tests were performed in an 8 test subjects by 4 device configuration. This was performed in mixed configuration pattern per subject as seen below in Table 1.

	Test 1	Test 2	Test 3	Test 4
Subject 1	Large Screen Wimp	PDA WIMP	Large Screen Wizard	PDA Wizard
Subject 2	Large Screen Wizard	PDA Wizard	Large Screen Wimp	PDA WIMP
Subject 3	PDA WIMP	Large Screen Wimp	PDA Wizard	Large Screen Wizard
Subject 4	PDA Wizard	Large Screen Wimp	Large Screen Wizard	PDA WIMP
Subject 5	Large Screen Wimp	Large Screen Wizard	PDA WIMP	PDA Wizard
Subject 6	Large Screen Wizard	Large Screen Wimp	PDA Wizard	PDA WIMP
Subject 7	PDA WIMP	Large Screen Wimp	Large Screen Wizard	PDA Wizard
Subject 8	PDA Wizard	PDA WIMP	Large Screen Wimp	Large Screen Wizard

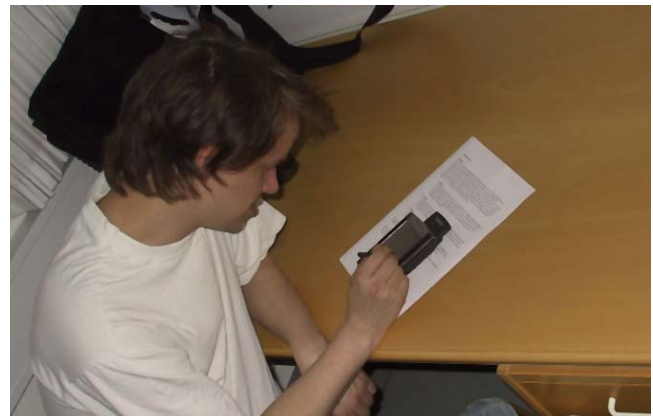
**Table 1: Schedule for test**

## 2.7 Actual Tests

The tasks which we asked the subjects to perform were based on the common tasks associated with the formation of project groups in the start of a typical semester at Aalborg University. This normally takes the form of a session in plenum where lecturers explain the suggestions they have for projects, and students can suggest projects as they see fit.



**Figure 6: Pilot testing the large screen WIMP**



**Figure 7: Pilot testing the PDA WIMP**

The common tasks associated with this are the following;

1. Find someone who has the same interests.
2. Find someone you already know from previous work.
3. Find someone from your semester.

The tasks we asked our test subjects to complete are roughly comparable to this. The task descriptions were as follows;

### Task 1

Last semester you were in a group with “Name of student 1” and “Name of student 2”. Find these two fellow students and compare their topic of interest for this semester.

### Task 2

Find two fellow students interested in writing about “IP Telephony” and check their phone numbers so you can call them with regard to forming a group this semester

### Task 3

Find two fellow students from your current semester, for the purpose of this test assume that you are currently at the 8<sup>th</sup> semester of the Informatics line. Find the topic of interest for the two students you just found.

These tasks cover a common set of tasks associated with the group formation process, and also demand a level of comparative interaction for the test subjects. The test subjects were asked to complete these tests, while using a “Think Aloud” protocol. This was done to capture any qualitative data that might be available through this experiment.

## 2.8 Data collection

The experiments were video-taped and recorded onto DV tape, where after a collected version was collated by using all the available tapes onto a master DVD disc containing the full set of recorded video.

## 2.9 Data analysis

First step of the data analysis was timing the completion rate of individual tasks by reviewing the recordings and using a stop clock. We considered a task begun by initiating interaction with the system. More precisely that very moment finger or pen respectively made first contact with the screen. Hereby we eliminated the variation in time spent interpreting the task. Completion of task was determined by the test managers verbal declaration hereof.

The completion rates were timed by two researchers individually to secure correct timing. A deviation of five seconds or more between parallel measures required an additional timing to decide which previous timing to disregard.

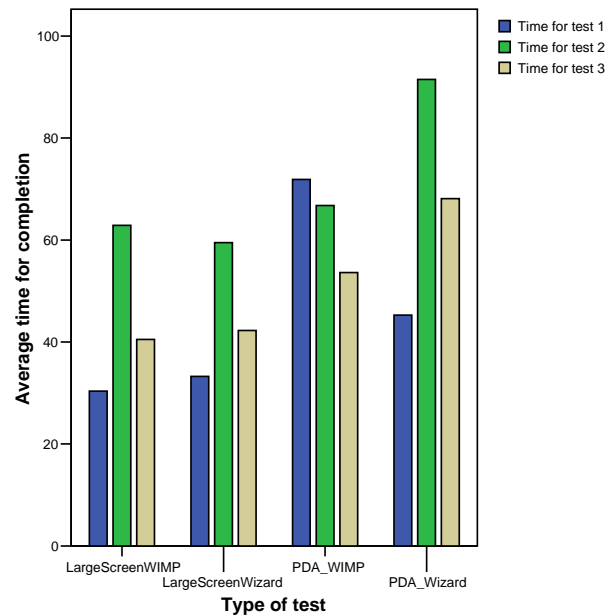
After this, the data were collated into a single table of time by using an average of the individual times recorded. Then the data were processed in a spreadsheet calculating means, performing two-way ANOVA to argue significant differences and creating graphs for presentation of the results.

## 3. RESULTS

Our results begin with a comparison of the overall completion times for all tasks between the four interface configurations to determine which configuration provided quickest task completion. Next we compare the completion times of the three individual tasks to see how type of task influence on the results.

### 3.1 Average time of completion

The graph in Figure 8 details the average time used for each task. As the graph shows the Large Screen WIMP interface allows the highest average speed of interaction in both Task 1 and Task 3. The Large Screen Wizard allows the highest speed of interaction in Task 2. On average the large screen interfaces commanded a distinct advantage over the PDA based WIMP style of interaction in test 1. There was a 1/3 faster rate of completion from the large screen interfaces to the PDA based Wizard interface in test 1. Test 2 commands no obvious advantage to any one interface, but the PDA based Wizard interface has a slightly higher average time of completion. Task 3 shows an advantage for the large screen interfaces.



**Figure 8: Average time of completion for each task**

An ANOVA test decided the advantage of large screen interaction to be significant as  $p = 0.006$ . A post-hoc test was performed to decide between which data groups, in our case the four interaction styles, the significant difference exist.

Comparison	Significant? ( $p < 0.05$ )	t
LWimp & LWiz	No	0.043
LWimp & PWimp	No	2.483
LWimp & PWiz	Yes	3.039
LWiz & PWimp	No	2.440
LWiz & PWiz	Yes	2.996
PWimp & PWiz	No	0.556

**Table 2: Post-hoc test results for overall completion rate**

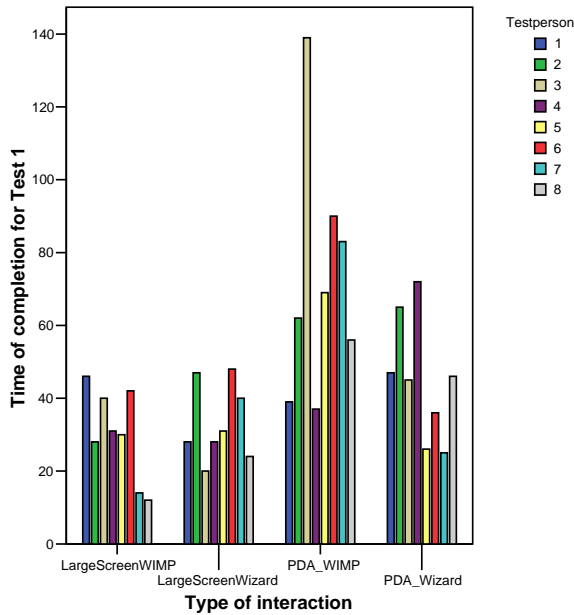
As shown in Table 3, two comparisons proved a significant difference between interaction styles. Both large screen WIMP and Wizard provided significantly faster overall task completion than PDA Wizard.

### 3.2 Time of completion for individual tasks

In this part we analyze the time of completion for each individual task and compare the four interaction styles to see if there are significant differences.

#### 3.2.1 Task 1

As Figure 6 details the two large screen styles of interaction has a distinct advantage in comparison to those of the PDA. This tendency was also seen when looking at the average time of completion for this particular task, see figure 9, so the “Search and compare” type of task appears to be at an advantage when employing large screen interfaces. There seem to be no remarkable difference between the two large screen styles of interaction.



**Figure 9: Completion rates for task 1 for each subject**

An ANOVA indicate that there are significant differences in the measured data as  $p = 0.001$

The following post-hoc test reveals between which interaction styles the significantly difference lie.

Comparison	Significant? ( $p < 0.05$ )	t
LWimp & LWiz	No	0.277
LWimp & PWimp	Yes	4.105
LWimp & PWiz	No	1.464
LWiz & PWimp	Yes	3.828
LWiz & PWiz	No	1.187
PWimp & PWiz	No	2.641

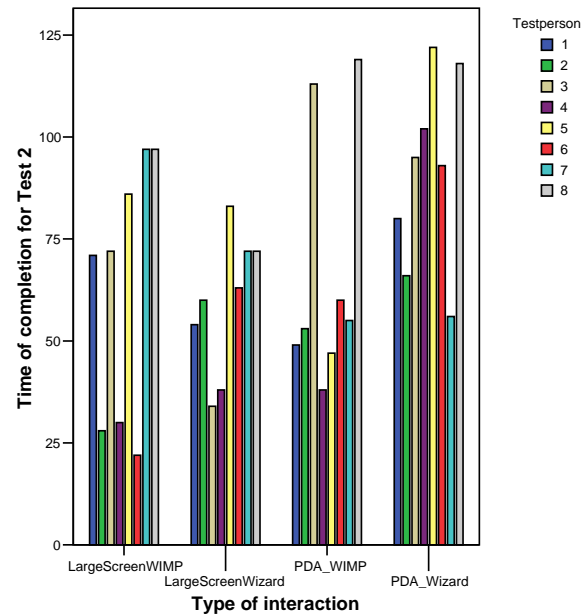
**Table 3: Post-hoc test results for task 1**

As shown in Table 5 the PDA Wimp interface provided significantly slower completion rates than both large screen interfaces for this particular task.

### 3.2.2 Task 2

The details of Figure 10 show a much dispersed level of completion time, this is consistent with the large difference between minimum and maximum time of completion which is presented in Figure 9. As the average time of completion also indicated, the “Search and Find” nature of task 2 has no distinct advantage, neither between large screen interaction or PDA based interaction, nor in the WIMP or Wizard styles of interaction. ANOVA substantiate this by concluding  $p = 0.087$

The average time of completion is higher, and the minimum time spent on a task are at their highest when using a Wizard based PDA style of interaction.



**Figure 10: Completion rates for task 2 for each subject**

### 3.2.3 Task 3

Completion rates for task 3 as illustrated in Figure 11 shows no immediate advantage to any one type of interaction, but indicate a slightly lower time of completion for the large screen based interfaces. No significant differences exists as ANOVA results in  $p = 0.112$ .



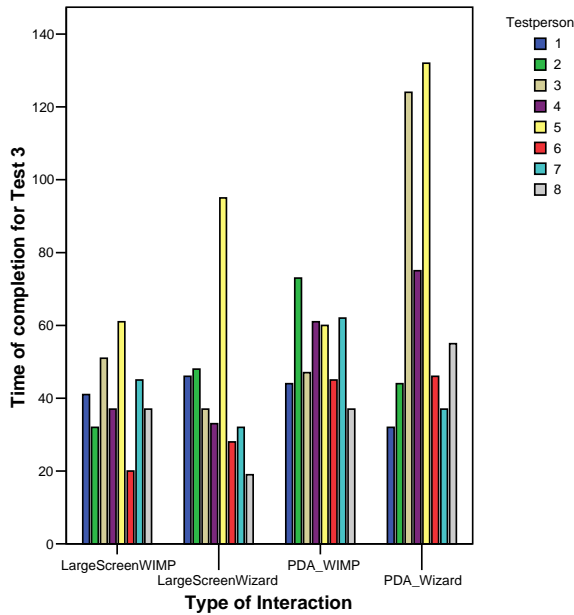


Figure 11: Completion rates for task 3 for each subject

### 3.3 Min/Max time for completion

The difference between minimum and maximum time of completion are summarized in Figure 12, 13 and 14. If one looks at Figure 12 it becomes apparent that Task 1 has a distinct advantage when performed on a large screen. The common strategy for a “search and compare” tasks such as this was to find the students concerned and either remember their topic of interest, or when using the WIMP style of interaction, to place the two students next to each other and compare their interests side by side.

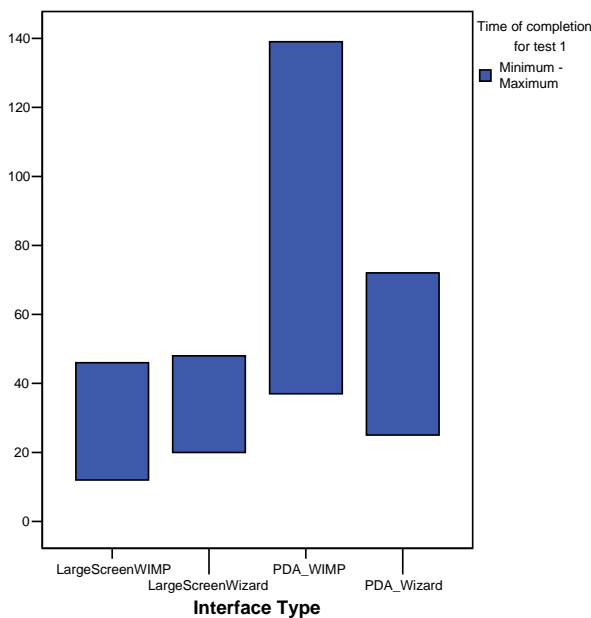


Figure 12: Min/Max time for completing task 1

Task 2 is based on a pure “search and find” tasks, and as such the differences observed in the comparative Task 1 becomes less apparent. As Figure 13 shows the Large Screen Wizard actually has an advantage in difference between minimum and maximum time of completion as the gap is quite a bit smaller here. This is consistent with the average time of completion for Task 2, see figure 8, which is the lowest when performing the task in the Large Screen Wizard style of interaction.

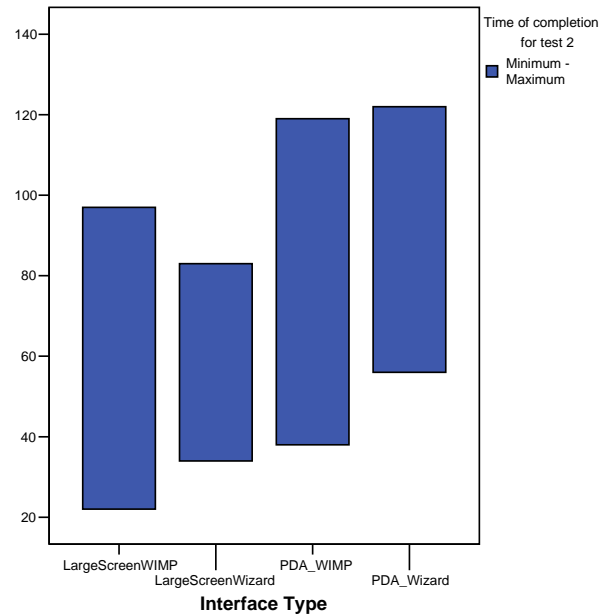
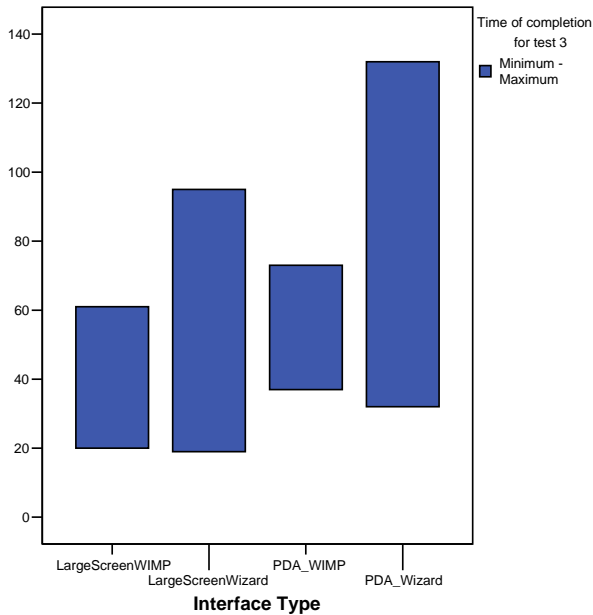


Figure 13: Min/Max time for completing task 2

Using a PDA there is simply insufficient screen space to perform a comparison side by side, so the test subjects were forced to remember the topics of interest which we conclude as reason for the rather large difference in minimum and maximum time of completion. When looking at Task 3 it can be seen in Figure 14 that the two WIMP styles of interaction have an advantage here. Task 3 is based on a “Search by comparison and compare” strategy, and as such the mode of search becomes a bottleneck for the test subjects. As the information detailing the students current semester is not available in an overview form when using the Wizard style of interaction it requires at least two taps and two levels of hierarchal search to allow a comparison by semester. So it can be claimed that the WIMP style of interaction has a distinct advantage when the search strategy requires a comparison to determine if a given entry is a hit or a miss.



**Figure 14: Min/Max time for completing task 3**

### 3.4 Results summary

We could prove significant difference between both large screen configurations compared to the WIMP style of interaction on the PDA interface for a “Search and compare” type of task, like Task 1.

For a “search and find” type of task, like Task 2, no significant differences in time completion rates were proved, but large screen wizard interaction had both the lowest average completion rate as well as the least span between min and max completion rate.

In the “Search by comparison and compare” kind of task exemplified in Task 3 no significant differences among interfaces or interaction styles were identified. Nevertheless we see indications that a WIMP style of interaction regardless of interface, according to average and min/max completion rates, seems preferable for this kind of task.

### 3.5 User satisfaction

All test participants expressed a preference for employing the WIMP based style of interaction for the large screen. Two of the participants also expressed a preference for the PDA based WIMP style of interaction. This is not singularly convergent with the time of completion. It would appear that subjective user satisfaction is not necessarily a function of task completion time. All participants also expressed a distinct annoyance at the hierarchy of information imposed by the Wizard based style of interaction in either PDA or large screen based interaction. This annoyance is not reflected in the test results, and as such indicates that time of completion is not a singular deciding factor in user acceptance or preference with regard to the employed interface for this particular type of application.

## 4. CONCLUSION

We have performed a comparative experiment to decide which among four configurations of an interface provides the quickest completion time for three distinct types of tasks. We conclude that

large screen interfaces applying either of the two interaction styles, WIMP or Wizard, are quicker in overall performance than both PDA based configurations. Regarding specific types of tasks a large screen interface regardless of interaction style performed best for a “Search and compare” type of task. A “search and find” type of task, though with slim justification, was best performed on a large screen wizard configuration. Finally a “Search by comparison and compare” type of task indicated a WIMP style of interaction, whichever interface is chosen, to provide quickest completion time. Finally we found that user preference for a given interface configuration is not necessarily equal with the one providing the quickest completion time.

Some limitations exist in the experiment that we have made. We have used a homogeneous group of experienced users in regard to interaction with a computer. All of them had tried both using PDA’s and touch screens before, albeit this was expressed as limited. This is a limitation of our results as we can only say something in regard to how they performed and nothing about e.g. novice users.

Our sample size of eight test subjects is rather small and even though we have proven some significance in our results, expanding the sample size could impact on this. The same is true with the results which proved no significant difference. In order to investigate the indications which we found further it is necessary to perform additional experiments with an expanded sample size.

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