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Short Paper

User Interface Design for Public Kiosks: An Evaluation of the Taiwan High Speed Rail Ticket Vending Machine

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Low hardware costs and high staffing costs have resulted in an increase in public information and transaction kiosks. Ticket vending machines are one important subset of such kiosks. These machines must offer efficient service with zero tolerance for human error, require no user training and be accessible to a wide range of users. This study evaluates the user experience of the Taiwan high speed rail ticket vending machine in light of recent research results in human computer interaction. Several design problems are identified and improvements are suggested. A set of user interface design heuristics are suggested that can help kiosk designers avoid the most common design mistakes.

Keywords: public kiosk, ticket vending machine, touch sensitive display, user interface, human computer interaction

1. INTRODUCTION

Unmanned electronic kiosks have been around for decades, but their deployment has grown sharply during the recent decade, due to low-cost hardware and high cost of human staff [35]. For instance, train stations often have advanced ticket vending machines. A well-designed kiosk can help increase the profits of an organization and contribute to customer satisfaction.

Information kiosks are used in many applications including interactive city guides [18], self-service banking [24], assimilation of votes [7], low-cost public Internet access [13], photo manipulation and printing [25], user testing of online books [30], interactive technical manuals [10], collecting responses to questionnaires [3], education and promotion of child safety [9] and raising the education level of underprivileged children [32].

The design of user interfaces for public kiosks is challenging. A kiosk user interface

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must be self explanatory and accessible without prior training. Furthermore, few assumptions can be made about the skill level and knowledge of the users. Users may suffer from cognitive interference due to stress and the user interface must support the user task and minimize the probability of error. Next, user may have physical and cognitive constraints such as limited vision, difficulties with physical movement and lack the ability to read. Senior users make up the largest user group often suffering from physical constraints. Age and hearing diminishes with age and most elderly users have corrected vision. As many elderly users suffer from diseases such as Parkinson's disease that greatly affect their motor skills. In contrast, young children may not be able to read and their movements are often large and uncontrolled. Interfaces for children are therefore often equipped with easy to hit targets such as large buttons.

This study focuses on a common kiosk type, namely ticket vending machines for travel applications. Typically such machines are equipped with a touch sensitive color display [1, 34] which is used for most of the interactions. The touch sensitive display has emerged as a practical input technology compared to physical keyboards, speech recognition [12, 20], interaction through personal mobile devices [15] or interaction through kiosk sensors such as cameras [5]. Touch sensitive display kiosks are easily programmed using conventional development tools [11], can be used to build tangible user interfaces [19] and are robust to vandalism. Future commercial displays may also provide tactile feedback [4].

Two methods of assessing user interfaces are common, namely expert evaluation, such as heuristic evaluation [22], and user centered evaluation which can be done by observing users as they work or through post analysis [2]. This study presents an expert evaluation of the Taiwan high speed rail ticket vending machine based on a set of design heuristic for public kiosks.

2. DESIGN HEURISTICS FOR PUBLIC KIOSKS

Maguire [21] summarized a set of solid guidelines for the design of kiosks in public spaces which included the physical characteristics of the kiosk such as dimensions, viewing angle and location, how to engage use, privacy, the use of colors, icons and graphics and how to structure menus. However, these do not fully address issues faced in current kiosk interfaces [31]. The following heuristics are proposed based on our experience and recommendations from the research literature.

- **Heuristic H1:** *Avoid unnecessary visual elements.* Users in public spaces are usually in a hurry. Any view should be limited to a minimum of information. Any excess information adds unnecessary noise that may divert the user from the task at hand [6].
- **Heuristic H2:** *Make text and elements visible with sufficient contrast* [21]. Norman's action cycle describes that adequate visibility of interface controls and system feedback is crucial for the user to identify valid actions and to evaluate the state of the system [23]. Moreover, visibility is dependent on sufficient contrast. High contrast is especially important for users with reduced vision. For instance, sensitivity to light decreases with age. Moreover, sufficient contrast in brightness ensures that users with various forms of color blindness will be able to perceive the visual elements in an interface.

- **Heuristic H3:** *Avoid language selections – make pages multilingual.* The literature that focuses on i18n (internationalization) stress the importance of translated content [36]. Desktop applications can often be configured to support the language of the user, and web-sites often switch to the language of the user automatically according to the browser locale. However, a public kiosk is not personal. A kiosk has to serve different users with different cultural and language backgrounds. Unless some advanced identification mechanism is employed, such as inserting a credit card with the user's locale embedded, there is no way for the kiosk to know the origin of the user. Moreover, language selections incur extra steps that slow down the users. This heuristic is inspired by physical signposting in public spaces where several languages are used simultaneously.
- **Heuristic H4:** *Communicate on multiple channels – minimize the need for reading.* The kiosk designer is not limited to text. In addition, the user interface may employ graphical representations, sound, color and spatial position all at once [33]. A combined message is believed to be more robust to misinterpretation than single channel communication. Moreover, a user unable to read the text may understand the intended meaning from a graphical non-textual representation, and a visually impaired user may benefit from audio feedback.
- **Heuristic H5:** *Show instructional videos on the start page.* We cannot assume anything about the experience and skill-level of the users. The start page can thus be observed by bystanders who are skeptical or afraid to use of the kiosk. As the video is played automatically, no action is required from the user.
- **Heuristic H6**: *Provide clear affordances – make actions visible.* Visibility is essential for the user to see what can be done. Moreover, what the user sees need to afford some action, *i.e.*, the visual presentation informs the user how something is used [23].
- **Heuristic H7:** *Avoid unnecessary steps.* This heuristic extends H1 from the spatial dimension to the temporal dimension. *I.e.*, only the necessary steps should be included, as any excess steps slow down users and increase the probability of problems occurring.
- **Heuristic H8:** *Prefer direct selection over selection by cycling through items.* Cyclic based interaction is common in consumer electronics where one cycles through options in order to reach the desired state, such as setting digital alarm clock [26]. Such interaction styles are used when there is a lack of real estate or cost prevents more elaborate and usable solutions. Time is traded for function. However, touch screens do not have these limitation and such solutions are therefore unnecessarily slowing down users. More direct solutions exploiting the available real-estate are more appropriate.
- **Heuristic H9:** *Solicit the advice of experts on language and culture.* This heuristic is based on our observations that developers, managers and engineers often are not sufficiently trained to provide translations of sufficient quality [17]. Moreover, their understanding of a foreign culture, which provides the context for communication, is incomplete. Since members of a design team usually have the same background, they may all be insensitive to the problems that occur with a low-cost DIY solution.
- **Heuristic H10:** *Use geographic layout for geographic data.* This heuristic is proposed based on our observations that users tend to respond better to spatial layouts with geographical mappings of geographical data than lists where the same data are ordered alphabetically, thematically or chronologically.

- **Heuristic H11:** *Rely on recall not memory* [28, 29]. This well-known heuristics is the basis for current-day windowing systems versus command line user interfaces. With a graphical user interface, users recognize what they can do from what they see through elements such as icons [16]. With command line interfaces the users need to remember the commands. It much easier for humans to recognize something rather than to recall it.
- **Heuristic H12:** *Use confirm and next buttons sparingly – provide back buttons* (*undo*). Most textbooks on HCI, including Norman [23], states that actions should be reversible, via undo functions. In a kiosk paradigm this means that is should be possible to go back to a previous view. Consequently, confirm and next buttons are unnecessary, unless the dialogue requires multiple steps.
- **Heuristic H13:** *Avoid unnecessary accuracy and detail*. This heuristic is based on our observations that kiosk designers often transfer web or desktop paradigms uncritically to the kiosk paradigm. On the desktop user are not usually under the same time pressure, stress and other environmental constraints as they are in public. For instance, the specification of time does not need minute accuracy when a transaction is dependent on the user selecting from a few discrete times only, *i.e.*, to select a given train from a schedule with a handful options, to select a movie showing available a given evening.
- **Heuristic H14:** *Do not allow illegal choices*. This well-known design guideline stems from Norman's recommendations for avoiding errors by restricting illegal choices.
- **Heuristic H15:** *Request information sequentially, not simultaneously*. This heuristic is a consequence of the wizard interaction style, which is recommended in situations where a system is only used once and the user is a novice. This allows the purpose of each view to be clear and prevent essential items from being overlooked or forgotten.
- **Heuristic H16:** *Reveal all the needed steps from the start.* A well-known principle in user interface design is to provide navigational aids [14]. The navigational aids should inform the user about where the user is, how the user got there, what the user can do and why the user should want to do a particular action. When in a stressful situation such as operating in an unfamiliar and foreign virtual environment it is important that the user's confidence in the system and motivation for using the system is established.

Heuristics H3, H7, H8, H9, H10 and H13 are novel to this study. Heuristics H1, H2, H4, H6, H11 and H14 are based on general advice commonly cited in the literature on human computer interaction, while heuristics H3, H5, H12, H15 and H16 are derived from the literature specific to public kiosks. Combined the collection of heuristics outlined herein comprises the framework for which touch-screen-based public kiosks, such as the THSR ticked vending machine, can be evaluated.

3. THE THSR TICKET VENDING MACHINE

This evaluation is based on the ticket vending machine in deployment December 2, 2007 at Taoyuan High Speed Rail Station. The authors have no involvement in the planning, design, implementation and deployment of the system described herein.

3.1 The Start Page

Fig. 1 shows the start page of the Taiwan High Speed Rail (THSR) ticket vending machine. The bilingual page provides text in both traditional Chinese characters and English. The large text occupying the main view of the page wishes the customer welcome and a video showing an advertisement for THSR is provided in the centre of the page. The text in a slightly smaller font at the bottom of the page tells the user to touch the screen. This text is the most important element on the page.

Fig. 1. The start page.

Fig. 2. An improved start page.

Beneficial characteristics of the start page are that it is simple and not cluttered (H1), provides strong contrast between the black text and the white background (H2) and is bilingual and understandable by customer groups that can read English or Chinese (H3).

However, the start page is also problematic. First, the user needs the ability to read either traditional Chinese characters or English as the page is dependent on textual communication. One obvious improvement is to communicate the action on an additional channel using an illustration or clear icon (H4). An illustration could communicate that this machine is for purchasing high-speed rail ticket in the exchange for money.

Second, the video used on the middle of the page is an advertisement for THSR. However, someone physically standing in front of the machine has most likely made the decision to use THSR and this person does not need to be persuaded to purchase a ticket.

Alternatively an instructional video about how to use the machine could be shown (H5). An instruction video would further help users unable to read or not familiar with the two target languages to understand the process before starting the transaction (see Fig. 2).

Third, the start page does not visually signal what to do (lack of affordance). The text simply says “touch the screen” and not “touch the screen to start”. The user should be provided with clear visual affordance, such as a button with the text “start” or “buy ticket” in both languages and pictorially (see Fig. 2). A button would signal that it needs to be pushed and the text “buy ticket” would provide the remaining information (H6).

Four, the welcome message on the start page is an unnecessary element of noise that could be omitted. Users standing in front of the vending machine are most likely in a hurry, want to purchase a ticket quickly and do not care about pleasantries.

3.2 Language Selection

Fig. 3 shows the main menu page that immediately follows the start page which is presented in Chinese. Most users will be Chinese language fluent. However, foreign

Fig. 3. Main menu (Chinese).

Fig. 4. Main menu (English).

visitors will have to choose English by pressing the yellow "English" button at the bottom of the page which will take them to the English language main menu as shown in Fig. 4. On the English language page there is a similar option to go back to the Chinese language version by clicking on the yellow button in the bottom left corner.

The designers of the machine are using a textual description of the language which is in accordance with the recommendations of Maguire [21] and others. Unfortunately, many kiosks use flags to indicate language. This is problematic as there is not a one-to-one mapping between the flag of a country and a language. For instance, should a PRC, a ROC or some other flag be used to signal Chinese? Chinese is spoken in many countries, and many languages are spoken in Taiwan, including Mandarin, Hakka, Hokkien and a number of Austronesian languages. English is also spoken in many countries including Scotland, Ireland, Canada, South Africa, Australia, Malta to mention a few.

One may argue that the explicit language selection and the two separate language versions are unnecessary when providing bi-language support for two visually dissimilar languages such as English or Chinese. An alternative is to make use of just one set of bilingual pages such as the start page, where all the buttons are labeled in both Chinese, English and pictorially using some icon language as an additional channel of communication (H3). An analogy can be drawn to the real world – when entering the physical train station all the signposting and labels are provided in both English and Chinese. It is not feasible to have a separate English language and Chinese language station.

It is also unlikely that a bilingual interface will cause any interference. The Chinese text will be completely incomprehensible noise to the English language visitor, and the Chinese visitor will automatically be drawn to the Chinese text that they are most familiar with – even if they know English.

Eliminating the language selection facility will reduce the number of steps for the English language users and the number of visual elements for all users and consequently reduce the stress and perceived complexity of purchasing tickets (H7). The language selection option incurs a mode in the interface. The complexity of the user interface is reduced by eliminating the language mode of operation (H8) [37].

The yellow language toggle button is clearly visible as its yellow color strongly contrasts the gray background (H2). Furthermore, the orange color of the three topmost menu items is also visible as it is in strong contrast to the gray background. The gray button at the bottom gives the impression of being inactive in comparison to the orange buttons. What is the purpose of putting this button on the main menu if it cannot be used?

3.3 Language Issues and Textual Communication

The labeling of the menu buttons in Fig. 4 is not optimal and probably not proofread by a language expert (H9). The option “non reserved seat” means to purchase a seat without reservation at reduced cost. “Tickets without seat reservation” would be a better description.

The menu option “reserved ticket” implies that the user has already reserved tickets that are ready to be purchased, but the next option “pick up ticket” gives the same impression. What are the differences between the two? The former means “ticket with seat reservation” and the latter means that the user can pick up an existing ticket if he/she has booked the ticket by phone or through the Internet. It is unclear what “platform ticket” entails. This option will issue a ticket not valid for travel allowing its holder access through the ticket gates so that the holder can see a guest on/off the platform and help with luggage. The concept of such a visitors access pass is unusual. Perhaps the text “Platform access pass for non-travelers” would invoke the right associations? An additional channel of communication with icons could help reduce the ambiguity (H4).

3.4 Signaling Meaning with Graphical Symbols

Fig. 5 shows the menu where the user determines whether to purchase a one-way or round trip ticket. This is relatively unproblematic although these are US-centric terms. In England it is more common to use the terms single and return tickets. A visual representation would alleviate this altogether as shown in Fig. 6 which illustrates how this is done by the Swiss Rail Corporation. One arrow is used to signal a one way ticket and two arrows pointing in opposite directions are used to signal a return ticket. Note that the direction of the arrow is consistent with the Western reading direction, *i.e.*, from left to right. A user study would need to be conducted in order to determine which direction the arrow should point in Taiwan as most travelers will be used to both reading directions.

3.5 Specifying Geographical Locations

Fig. 7 shows how to select destination and Fig. 8 shows how the choice is confirmed. This is an illustrative example of how geographical locations or destinations are effectively visualized and how input is efficiently solicited (H10). The THSR ticket vending machine employs a geographical representation of the options which clearly matches the mental model of the travelers. Users unable to read can either count stations or recognize the location visually on the map (H11). The destinations are indicated on a map and a line to regularly aligned buttons with station names are presented. It can be difficult for some users to press the small targets on the map, while the large buttons are easier to hit without error. The mapping of button to actual location is communicated by their relative position and the connecting line between the button and the location on the map.

Colors are effectively used to signal where the user is departing from (gray), and where the user can travel (bright orange), and once the choice is made, red is used to signal the choice. One may argue whether this extra step is necessary as the user could be taken directly to the next page (H7). If the user has made a mistake he/she can always return and select a different destination (H12). Some users explore how various choices

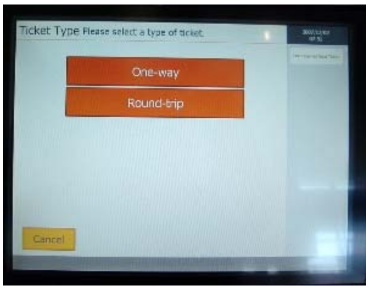

Fig. 5. One way or a round ticket.

Fig. 6. Pictorial one way and return ticket (Swiss Rail Corporation).

Fig. 7. Selecting destination.

Fig. 8. Confirmation of selection.

affect the price through trial and error when they are unaware of the ticket pricing policy [8]. A yellow less noticeable box on the left can be used to alter the departure station. This is probably a less frequently used operation and is therefore less visible due to its color.

Icons can also be used as an additional effective channel to communicate destination. At each station a simplified illustration of some landmark or object frequently associated with that station that travelers are familiar with could be used. For example, a drawing of the famous Chiang Kai Shek Memorial Hall or the Taipei 101 skyscraper could represent Taipei, the drawing of an airplane could represent Taoyuen (close to the international airport), a drawing of a computer chip could represent Hsinchu, *etc*. However, the effectiveness of each symbol should first be assessed using a panel of test subjects.

THSR only has eight stations. It is therefore easy for users unfamiliar with the geography of Taiwan to scan the list for the desired station. Furthermore, all the station names can be displayed simultaneously with a relatively large and legible font. However, most train networks are more complex and it may not be enough real-estate on the screen to display all the stations simultaneously, and Maguire recommends that no page has more than 12 options [21]. Therefore, a different station-selection strategy is necessary.

One common, but problematic, strategy for specifying destinations on ticket vending machines is through text input (H11). The machine may provide an on-screen virtual keyboard where the users input the station name. Often users only need to input a few characters in order to retrieve a short list of viable alternatives. Text input of station names is challenging for several reasons: First, the users need to remember the name of the station (H11). Second, the users must know the spelling of the place name. In some countries this may be difficult if the characters are different from the English alphabet.

Fig. 9. Destination input with onscreen virtual QWERTY keyboard (from the Swiss Rail Corporation).

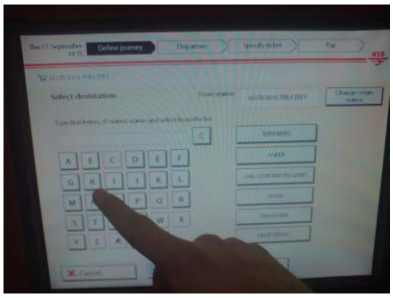

Fig. 10. Destination input with onscreen virtual alphabetical keyboard (from the Norwegian Rail Corporation NSB).

Fig. 11. Specifying ticket quantity on the THSR ticket vending machine.

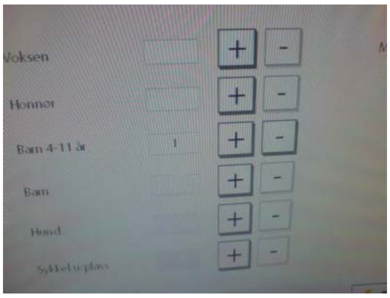

Fig. 12. Specifying quantity on NSB ticket vending machine.

Furthermore, the user needs to be able to use a keyboard. One option is to provide a virtual QWERTY keyboard as shown in Fig. 9. This strategy works well for users who are experienced in using computers with QWERTY keyboards [27], which include most users nowadays. However, several grave examples existing where vending machines are provided with non-standard keyboard such as the one in Fig. 10 which is a grid of letters in alphabetical order. This strategy is mostly suitable for users who are completely unfamiliar with computers. Alphabetically ordered keyboards are difficult and slow to use for customers already familiar with the QWERTY layout.

3.5 Specifying Quantities

Fig. 11 shows how to select the number of people traveling. Users are presented with two lines of numbered buttons. The top line is used for specifying the number of adult travelers and the bottom line the number of children. Direct quantity input is intuitive and efficient. Other vending machines such as the one shown in Fig. 12 take quantities far too literary where they have to input the specific number by cycling through the digits with the plus and minus buttons (H8). The approach taken in the THSR is also practical as it is unlikely that more than five people will be traveling together and rarely more than 3 children (H13). The default values are one adult and no children and the regular user can therefore proceed to the next step. When used correctly, no user will need to touch the screen more than three times during this step (H7).

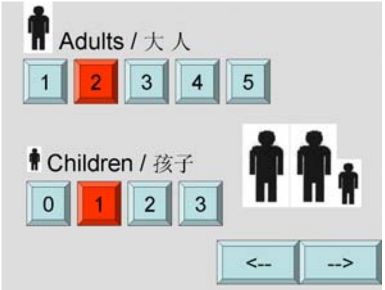

Fig. 13. Alternative feedback on quantify.

Fig. 14. Specifying date of departure.

The system state could be better communicated by providing feedback on an additional channel by presenting a visual presentation of the number of people selected, *i.e.*, if there were two adults and one child selected the dialogue would display the family pictorially (H4). This concept is illustrated in Fig. 13.

The confirm button is needed on this page as the user may wish to specify two different, but related quantities, *i.e.*, both the number of adults and children. This dialogue could be expanded to include dogs, bicycles, push-trolleys and senior citizens.

3.6 Date and Time

Fig. 14 shows how the user specifies the departure date. The designers have chosen a calendar-metaphor which is a sensible choice. The calendar metaphor involves arranging the dates in a two-dimensional grid were each column represents the weekdays and each row the weeks of the month. However, the implementation of the calendar metaphor is problematic. First, it does not look like a calendar. A physical calendar shows the entire month, *i.e.*, also dates that are passed. This is often illustrated by deactivated buttons that cannot be selected. However, such past dates help signal the overall impression of the calendar.

Second, the numbers are ambiguous. The user must guess that the first number is the month (12 for December) and the second the day of the month. This is a US-centric number ordering. In other parts of the world these numbers are arranged in reverse order. Furthermore, the repetition of the 12-number representing December on each button is superfluous as it adds clutter and noise (H13). An economic alternative is to display the text “December” at the top of the calendar and just include the day of the month on each button. Third, it is not clear how to purchase tickets beyond one month. Four, the confirm button is redundant (H13). As soon as the user has selected a date he/she should be taken to the next part of the dialogue. Five, the interface allows the user to select invalid dates (see Fig. 15). Dates with no seats should be deactivated (H14).

Finally, the day of the week boxes have the same visual style as each of the calendar entries. They therefore invoke the false affordance of pushing. The interface complexity would be reduced by eliminating this false affordance through a different visual style.

Fig. 16 illustrates how the users indicate when they wish to travel. The benefits of the adopted solution is that most users will recognize the alarm clock metaphor and know how to specify the desired time by using the up or down arrow buttons. However, the buttons may have to be pressed many times (scroll through the digits) before the desired

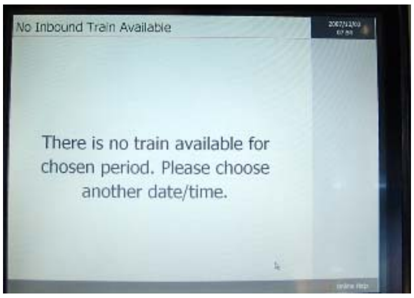

Fig. 15. Invalid choices are possible.

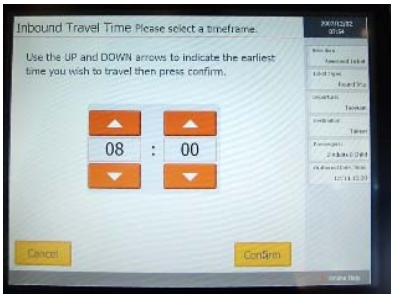

Fig. 16. Specifying time.

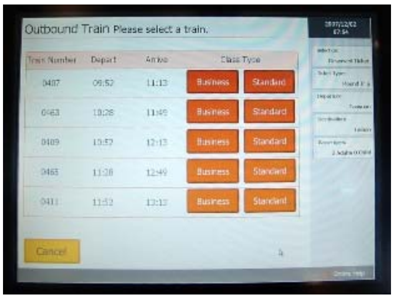

Fig. 17. Selecting the desired service.

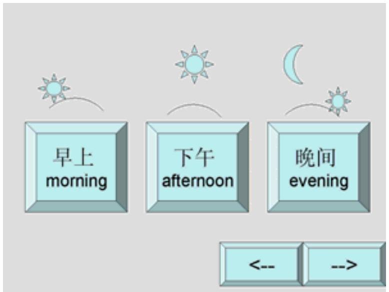

Fig. 18. The approximate time of the day.

time is displayed. A stateless strategy where the user selects the desired time with one push directly would be more efficient (H8) and could be equally understandable.

The specification of time is approximate and the system subsequently lists the closest alternatives on the next page (see Fig. 17). Here, the user selects the desired service. The dialogue could be made stateless by asking users for the nearest hour, where all way menu with icons allowing users to select morning, afternoon or evening (see Fig. 18).

One problem with the selection list in Fig. 17 is that it has redundant buttons, *i.e.*, two columns of buttons, where one column represents business and the other standard. The mental load and the potential for error is reduced if the user just has to focus on selecting the desired service and let the user choose between a business or economy ticket in a separate dialogue. However, this will introduce an additional step and an additional touch of the screen (H15).

3.7 Orientation and Navigation

The THSR ticket vending machine provides an orientation bar at the right side (see Fig. 17). However, many users are likely to miss the orientation bar due to its lack of visibility. First, it is displayed in a weaker gray tone that blends into the background. Colors with a stronger contrast should be used (H2). Second, it is positioned on the right side where users are less likely to look. Western users typically scan pages from left to right [26], and the same phenomenon is likely to be true in modern day Taiwan. Many vending machines therefore place the orientation and navigation bars at the top or at the bottom from left to right. Third, the orientation bar appears gradually as the steps are filled in as future steps are not indicated. During the first step (see Fig. 3) the orientation bar at the right hand side is empty and the user will not recognize it as such. The user has no reason to expect to find anything useful in that part of the interface at later stages of the transaction. A better strategy is to show the entire set of steps from the onset and use colors to code which steps have been finished, the current step and future steps (H16).

3.8 Acceptance for User-Centric Evaluations

The problems identified herein can be attributed to a lack of user involvement during the development phase – a phenomenon which is not uncommon in Taiwan, especially in the consumer electronics market. With user-centric development, users are brought in throughout the design process to test various aspects of the user interface through low-fidelity prototypes, before the actual system is built. Such testing on representative users will help greatly eradicate usability problems. The shortcomings in the design process of the THSR kiosk may be rooted in the computer science education in Taiwan. There are currently only a handful of universities that includes HCI-subjects in their curriculum, and Taiwanese researchers are under-represented in prestigious international research journals and conferences within HCI. It is therefore hoped that the examples provided herein will help illustrate the problems and the need for better design through appropriate design processes with appropriate focus. There is often no single correct solution, but rather a myriad of possibilities with various consequences. The purpose is to make design decisions that benefit a majority of the users.

4. CONCLUSIONS

A set of user interface design heuristics for public kiosks were presented and discussed in terms of the THSR ticket vending machine. The analysis revealed several weaknesses in the existing user interface and a number of improvements based on the proposed design heuristics were suggested. The improvements of highest priority include reducing the two language versions to one bilingual language version, pictorial representations should be included as an additional channel of communication, future steps should be visible on the orientation bar and its visibility increased by using colors and horizontal positioning, confirm buttons should be removed on the destination pages and the date and time pages, scrolling should be replaced by direct selection on the time selection page and the service selection page should be separated into two independent dialogues. The resulting user interface would be more robust, more tolerant to user mistakes, more intuitive and efficient to use. However, the main focus of this paper is the usability problems that arise with public self-service systems. The solutions sketched throughout this paper are therefore merely meant as suggestions to highlight that other, perhaps better, solutions exist. When designing such systems it is important to apply design processes where the possible design space is adequately explored by the design team such that one can maximize the accessibility of the product accompanied by user-centric evaluations.

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