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Text Input on Mobile Devices from Cultural and Educational Aspects

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Abstract. Tablet computers and other mobile devices are widely used in education and other life activities. However, touch screen keyboards are not adapted to languages using alphabets with more letters than the English alphabet has. In this paper, we analyze the existing keyboards on such devices for various languages, influence of keyboard usability on the number of typing errors, and propose keyboard design guidelines for non-English languages. As an example, the layout for the Lithuanian language keyboard (32 native letters and 3 foreign letters) has been presented here. The described solution is not strictly related to the peculiarities of the Lithuanian language alphabet (apart from the number of letters), therefore it is suitable for other languages using a similar number of letters.

Key words: mobile device; tablet computer, text input, touch screen, screen keyboard, national keyboard, multilingual keyboard, keyboard usability, keyboard design, keyboard layout.

1. Introduction

In quite a short period of time mobile devices, especially tablet computers (tablets), have become an important tool for many people in their life activities. They are used to access information and knowledge, to communicate and collaborate with others (e.g. Lou *et al*., 2013); become more and more popular tools for different forms of learning. Mobile technologies provide learners with the opportunity to reach instructional material at any time and in any place. A learner becomes a creator of one's learning process and its active participant. The quality of such learning depends not only on the quality of learning materials and methods, teacher competencies to use technology but also on tools and communication used (Vilkonis *et al*., 2013).

The text is entered into tablet devices by means of a touchscreen keyboard, handwriting on the screen, or voice input. Whereas the latter two methods lack efficiency in many languages, the screen keyboard is still the main text input tool. So it is very important to ensure that the keyboard, as one of the main parts of human–computer interface, were easy to use, natural and friendly.

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We have discussed the problems of easy typing with mobile phone hardware keyboards and presented their solution in our previous paper (Dagiene *et al.*, 2011). Here we concentrate on a solution of typing problems with touch screen tablet keyboards. The same solution is valid for other mobile devices with touch screens.

The tablet computer keyboard can be national (letters of one language are available for input) or multilingual (letters of more than one language are available).

Images of keys for screen keyboards are programmable; therefore it is much easier to modify the layout, in comparison to physical keyboards. The only thing that restricts the arrangement of such a keyboard is the tablet screen size. The screen area must be shared between the keyboard picture and area for typed text (there should be enough space for the keyboard itself and the main content view where the text input occurs). Designers of the optimal keyboard for the English keyboard claimed that no more than a half of a device screen (Knox, 2012) should be used for keyboard the picture.

On the one hand, the flexibility of tablet's screen keyboard can be used to adapt it to the needs of a particular language so that it fulfills the requirement of localization: "the localized software should look and feel as if it has been developed in the target culture". On the other hand, this flexibility may cause a baseless variety of tablet keyboards for the same language environment. Therefore, we should find an optimal decision.

However, at present, tablets are distributed with keyboards that do not meet the previously mentioned requirement to many languages (de Judicibus, 2012), e.g. normal alphabet letters are put on the second panel. Even the English keyboard for tablets is treated not as comfortable and optimal as the one for personal computers (Go and Endo, 2008). It has also been noticed that normal users of a QWERTY keyboard on a touchscreen device are limited to typing at a rate of about 20 words per minute, which is slower as compared to the rates achieved on physical keyboards.[1]

The observations in the field of education show that students tend to write less using the touch keyboard than they would with an external keyboard (Strain-Seymour *et al.*, 2012; Davis *et al.*, 2013).

This paper aims to analyze the existing tablet keyboards for various languages and offers keyboard design guidelines for Lithuanian and other non-English languages. For this reason, in Section 2, we discuss the concept of a multilingual (physical/screen) keyboard and note that many national touch screen keyboards are provided as multilingual, based on English. In Section 3, the results of a poll and analysis of the influence of the keyboard quality on misspelling in users' texts are presented in short. Section 4 deals with a design of a national touch screen keyboard, using Lithuanian as an example. And finally, the recommendations and conclusions on non-English touch screen keyboard design are provided.

[1] Faster Typing on Touchscreen Tablets with New Keyboard Layout. Cellular News, 17th Apr 2013. Available: http://www.cellular-news.com/story/59570.php.

2. Multilingual vs. Non-English National Keyboards

A multilingual, or international, keyboard that would be suitable for all languages does not exist due to a limited number of keys. However, it is possible to expand a set of characters, adding the third and fourth level to the keyboard, or using some keys as combining keys (also known as "dead keys"). In this way, the set of typing characters may be increased up to 2 or 3 times. So, multilingualism may be achieved only for a limited number of languages.

In reality, a multilingual keyboard is a national keyboard, augmented with the letters and some symbols of other languages mostly needed for users, speaking the main language of that keyboard. Characters of the main (national) language are normally typed, whereas the characters of other languages may be typed with the same keyboard, but usually in a less efficient way (e.g. pressing more than one key to type a character).

According to the convenience or inconvenience of character typing, the characters fall into 4 categories:

1. Native language characters on a national (not multilingual) keyboard.
2. Native language characters on a multilingual keyboard.
3. Foreign language characters, typed using the third or fourth keyboard level, but displayed as labels on the appropriate keys.
4. Foreign language characters, typed in a combining way (using a combining character) and having no labels on the appropriate keys.

Sometimes, a combined way of typing is used to type not frequently used native language characters. The speed of typing characters with diacritics in French, Spanish, and German languages has been compared by experiments (Bi *et al.*, 2012) using method where such characters were on the first level and typed directly or were obtained using combining method. It was concluded that slowing down the typing speed because of the combining method is acceptable if the frequency of letters with diacritics is less than 4%. According to the Frequency Dictionary of Lithuanian Language the frequency of letters with diacritics in Lithuanian written texts is about 6.3%.

MacKenzie and Tanaka-Ishii (2007) described the number of keys for text entry from the concept of a key-ambiguity continuum. In their concept, if each symbol is assigned to a dedicated key, it has no ambiguity. If several symbols are assigned to a key, such as a key with upper and lower case letters, it creates ambiguity. The ambiguity increases if we assign more symbols to the key.

Notionally, each language may have a multilingual keyboard, based on that language. In practice, multilingual keyboards are not widely used even on personal computers due to an increased ambiguity.

Let's investigate an example in "press-and-hold" behavior on tablet keyboards. On a physical keyboard, when we press and hold a key, usually the symbol is repeated. On touch keyboard when a key is pressed and hold, alternate characters are shown in an appearing bar next to the key. This advantage can be effectively used to create multilingual keyboards. For example, to access letters ã, å, à, á, â, ä, æ when the letter "a" key is pressed and hold.

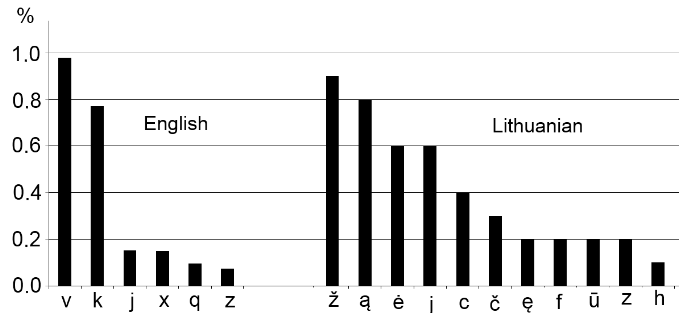

Fig. 1. A distribution of less frequently used letters of English and Lithuanian languages.

However, today's tablet computers are distributed with many non-English language keyboards that remind a multilingual keyboard, based on English (e.g., Lithuanian keyboard on Android 4.0.3 devices used this "press-and-hold" feature to type normal letters of the Lithuanian alphabet with diacritics).

After a two year experience with iOS tablet computer an IBM consultant wrote: "… developers at Apple have taken to the virtual keyboards a simplified approach compared to the typical configuration of a physical keyboard <…> This approach can be a serious problem in some languages like Italian, for example, which makes a frequent use of accented characters. <…> For now, writing in Italian on an iPad is definitely not comfortable at all" (Knox, 2012). These findings fit for the Lithuanian language even more, because the frequency of the Lithuanian accented letters is 6.3% comparing to Italian 1.1%. The frequency of 6.3% may seem not significant; however, the comparison of English and Lithuanian letters with a similar frequency of use gives the results, visually presented in Fig. 1.

To select a character from the "press-and-hold" menu the user should wait for about 250–500 ms (Davis *et al.*, 2013). This includes one additional step, comparing to the 4th category of characters on multilingual physical keyboards discussed at the beginning of this section.

As we can see in Fig. 1, English alphabet letters J, X, Q, Z are less frequent than that most infrequent accented letters in Lithuanian. However, it is even not even intended to put these letters (J, X, Q, and Z) on a "press-and-hold" menu or other panel of the English tablet keyboard. Obviously, other languages should also put all their alphabet letters on the default panel of the national keyboard. Efficiency may not be the only factor to be considered in the design. Product designers should also consider how native speakers conceptualize diacritic characters (Bi *et al.*, 2012).

3. Keyboard Influence on the Writing Accuracy

The user opinion poll, conducted in Lithuania, revealed a dependency between the keyboard used and mistakes made in a written electronic text (particularly, not using Lithuanian accented letters). 165 active computer users participated in the poll. 58.1% confirmed

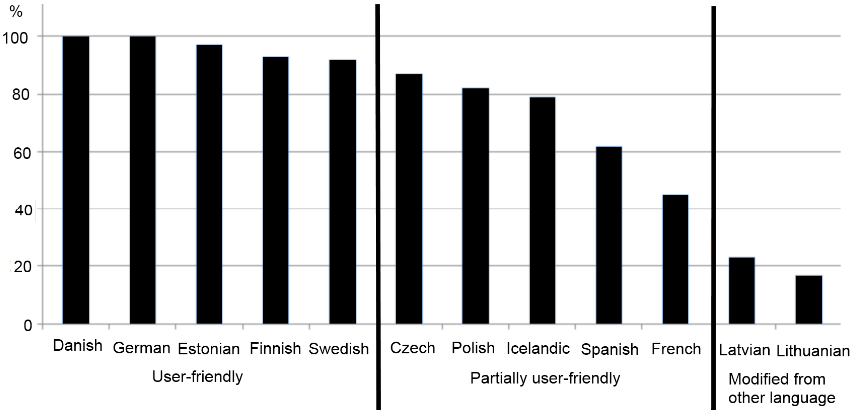

Fig. 2. Dependency of the writing accuracy on the keyboard category.

that they omit letters with diacritics in electronic text writings. 85% of them mentioned " Letters with diacritics are more difficult to type" as a reason for misspelling the text Grigas and Pedzevičienė (2009).

Later on, the analysis of keyboards of 12 non-English speaking countries has been made to see if there is a relation between the keyboard quality and writing accuracy of users. The keyboards were grouped into 3 categories:

1. *User-friendly keyboard* which lets typing specific letters (e.g. letters with diacritics) in the same way as other letters. This category includes Danish, Estonian, Finnish, Swedish, German keyboards.

2. *Partially user-friendly keyboard* where some special letters are more difficult to type (additional key press is needed, no letter label on the key, etc.). Such keyboards are usually used for languages with a large alphabet (e.g. Czech alphabet has 42 letters). This category includes Czech, Icelandic, Spanish, Polish, and French keyboards.

3. *Modified keyboard on the basis of other language*. This type of keyboard is partially user-friendly, where all specific letters are more difficult to type, and using a physical keyboard designed for the other language. Lithuanian and Latvian keyboards fall into this category. Both use a physical keyboard designed for US. Lithuania also has a keyboard defined by the national standard that can be treated as full user-friendly, but it is used by about 1% of computer users. So, it has no significant influence on the results.

Figure 2 shows the percentage of correctly written registration data (user's name, city name, etc.) in a wide used Skype application.

The results clearly show the dependency between the keyboard category and misspelling in the user profile data.

Studies, conducted to compare on-screen multi-touch keyboard and physical keyboard usage efficiency and typing accuracy for English keyboard, conclude that users do not perform as well in terms of text entry efficiency and speed using a multi-touch interface as with a traditional keyboard (e.g. Varcholik *et al.*, 2012). The case of non-English languages is much more problematic.

Computer devices with keyboard input are widely used in education, so it is crucial to enhance the keyboard design.

Fig. 3. Alphabetic panel for the English keyboard on Windows 8 (Knox, 2012).

4. Keyboard Space Optimization for Non-English Languages

In this section, we discuss the possibilities of adding non-English letters in an effective way of Latin-based languages to the touch keyboard.

Microsoft Corporation has carried out experiments and space allocation research for screen keyboards (Knox, 2012). It is considered that the keyboard should not take more than a half of a device screen. However, it was concluded that obscuring about half the display works fine because text enter is most often a modal activity, where the user's focus is on typing and not on the periphery. For this reason the numeric row, Tab and Caps Lock key have not been included into the alphabetic panel of the Windows 8 screen keyboard. These keys and some special character keys have been moved to a separate panel. The more keys are included, the more mistakes are likely to be made. This is partly because more keys mean that the keys need to be smaller and there is a greater likelihood of hitting a key that a user did not intend (Dagiene *et al.*, 2011). As a result, an optimized keyboard pictured in Fig. 3 has been designed. Note that the removal of some less frequently used letters of the English alphabet (see Section 2) from the default alphabetic panel has not been considered.

Similar optimized keyboards are used in iOS and in some devices running the Android operating system (tablets, mobile phones, etc.), GPS devices.

When the touch keyboard for a non-English language is considered, we usually deal with extra keys for some specific letters of that language.

The easiest solution is to add one additional row of keys (e.g., instead of the numeric row). This solution is included in some devices. The keyboard would have five rows instead of four. The height of the keyboard would increase by 20%, reducing the space for the main content on a screen. This would be a step back, having in mind the results of experiments and research described in Knox (2012). Decreasing the space for text input is especially sensitive in the case of using tablets in schools. For example, the Lithuanian keyboard (as compared to English) needs a space for 9 additional letters on the alphabetic panel. Tablet computers are widely used in education, starting from the primary school, so every country should consider the hygienic norms for text labels on the keys. In Lithuania, the default font size, recommended for textbooks and other methodological materials for grades 3–4 (primary school) is 14 pt, for grades 5–6 (lower basic school) is 12 pt, for grades 7–10

Fig. 4. Alphabetic panel for the English keyboard on Android 4.

Fig. 5. Lithuanian keyboard (Variant 1).

(upper basic school) is 11 pt, and for grades 11–12 (secondary school) is 10 pt.[2] Therefore, we should look for better solutions.

The second solution is to prolong each row by 3 keys. That would cause the following changes in space. Let us take a keyboard, optimized according to the research results described in Knox (2012) and having no numeric row, Tab and Caps Lock keys. For the experiment we use the Android keyboard on Samsung Galaxy Tab 2 with 10.1 inch screen device. In this case, the row consists of 10 letters or necessary punctuation mark keys and one 1.2 times wider backspace key (Fig. 4). It makes up 11.2 conventional letter keys. We will treat them as a keyboard width measurement unit. The key row, prolonged by 3 additional letter keys, would be 14.2 units wide, i.e., 28.6% longer. To fit it into the screen, the key width must be reduced by the same ratio, i.e. 28.6%.

This variant has a reserved place in the bottom row where the space bar is located. If the key width of three top rows is reduced, the bottom row key width would be naturally reduced by the same ratio. Then, there is a space for new keys, e.g. allocated for frequent punctuation marks that are in letter rows on the English keyboard.

Nine keys should be distributed in 4 rows. One row gets 2.25 additional keys in average. To get the whole number of keys, we can change the width of control keys, indents, space between the keys. Increasing the keyboard's width up to $11.2 + 2.25 = 13.45$ units (20%), we get a keyboard with the same optimal quality as its prototype discussed before (Fig. 5).

The letter layout displayed in Fig. 5 corresponds to the Lithuanian keyboard layout used for physical keyboards, defined by the standard LST 1582:2012 (2012). Other layouts are also possible, e.g., QWERTY. Then English letters would be in the same place as in the English keyboard, and Lithuanian letters with diacritics on one side of the keyboard, e.g., on the right.

[2]Ministry of Health of the Republic of Lithuania. Order on approval of hygienic norm HN: 22:2003 *School textbooks* (in Lithuanian).

Fig. 6. Lithuanian keyboard (Variant 2).

We will call keyboard Variant 1, displayed in Fig. 4, a prototype of the next optimized Variant, discussed below. Letters Q, W, and X (that are not in the national alphabet) are the rightmost keys of rows 1–3 (Fig. 5). The property of a multilingual touch keyboard when the user presses and holds the key to select more characters may be used to reduce the width of the rows. Letters Q, W and X can be attached to any letter of the national alphabet, e.g., to letter V that reminds W or letter Ė that is the rightmost key of the middle row.

In Variant 1 the space bar has been reduced. The user experience research results state that the space key should be centered and wide; 80% strikes of the space bar occur on the right side (de Judicibus, 2012). Inclusion of 4 necessary punctuation marks (two keys in the bottom row) reduced the width of the space bar. It can be partially restored if some other keys were removed, e.g. the language switch key or the last typed symbol key. The language switch key is not included even in physical keyboards, it is not usually needed to change the language of typing text (the property of a multilingual keyboard may be used), so it can be moved to the second keyboard panel for symbols or keyboard properties. Variant 2 of the Lithuanian touch keyboard with described modifications is shown in Fig. 6.

Variant 2 (Fig. 6), compared to Variant 1 (Fig. 5), has reduced the width by 1 key (from 13.55 to 12.55 units), i.e., 7.4%. Compared to the English keyboard (Fig. 4), Variant 2 increased the width by 11.8% (i.e., from 11.3 to 12.55 units). Two variants of keyboard layouts for Lithuanian language have been discussed above. However, they may be used as well for other languages using Latin alphabet located in three rows. Variant 1 may be directly applied for languages using alphabet containing 32–35 letters, including foreign letters present in ASCII, such as Q, W, and X in Lithuanian case. Besides Lithuanian, this set of languages includes such languages as Spanish, Italian, Polish, Turkish, Hungarian, and even more such languages exist outside Europe. Languages using 28–31 letters (e.g. Albanian, Danish, Estonian, Finnish, German, Norwegian, Romanian, Slovenian, and Swedish) require modified Variant 1 with only one extra key in a space row. Languages using 36–39 (e.g. Icelandic, Latvian, and Portuguese) letters require modified Variant 1 with extra key on every row.

Variant 2 is Lithuanian-specific, as it uses standardized Lithuanian ĄŽERTY keyboard layout where rarely used foreign letters Q, W, and X are located at the right ends of the rows. In QWERTY keyboards, language-specific letters are located there. Thus, Variant 2 or its modifications may be used with care considering the frequency of language-specific letters to be typed by the "press and hold" method.

5. Conclusions

1. The need to take additional actions while typing some letters of the alphabet (e.g., press two keyboard keys instead of one) is a source of typing errors. The number of mistyped letters is 20–80% (exact number depends on the alphabet used and difficulty of additional actions). Typing errors occur because the majority of users avoid doing additional actions.
2. The research results have already been implemented on the 26-letter keys keyboard optimized for tablet computers. However, touch screen keyboards are not adapted to languages using alphabets with more letters than the English alphabet has.
3. In this paper, we have described a way of keyboard layout design using an optimized English keyboard as a basis for languages with the alphabet of more than 30 letters. It has been shown that the keyboard with all the alphabet letters on a default alphabetic panel with four rows may be designed. In comparison to the English keyboard, the occupied part of a touch screen does not increase (what is important for small 7–10 inch screens) with a minimum decrease of the key width.
4. The keyboard layout for the Lithuanian language (32 native letters and 3 usually used foreign letters: q, w, and x) has been presented. The solution is not related to the peculiarities of the Lithuanian language alphabet (apart from the number of letters), therefore it is suitable for other languages using a similar number of letters and may be easily adapted for languages using slightly bigger or smaller set of letters.

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Teksto įvedimas mobiliuosiuose įrenginiuose kultūriniu ir edukaciniu aspektais

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Planšetiniai kompiuteriai ir kiti mobilieji įrenginiai yra plačiai naudojami švietime ir kitose gyvenimo srityse. Tačiau tokių įrenginių jutiklinių ekranų klaviatūros nėra adaptuotos kalboms, kurių abėcėlės turi daugiau raidžių negu anglų kalbos abėcėlė. Straipsnyje analizuojamos esamos įvairių kalbų klaviatūros, klaviatūros įtaka teksto rinkimo klaidų darymui, ir siūlomas klaviatūros projektavimo sprendimas. Kaip pavyzdys, pateikiamas lietuvių kalbos klaviatūros išdėstymas (32 lietuvių abėcėlės raidės ir 3 užsienio kalbos raidės). Siūlomas sprendimas nėra griežtai susietas su lietuvių kalbos abėcėle (išskyrus raidžių skaičių), todėl tinka ir visoms kitoms lotynų pagrindo kalboms, vartojančioms panašų raidžių kiekį.