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From Self-efficacy to Human-Computer Interaction Design

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Abstract. This article mainly focuses on how to improve the existing Human-Computer Interaction (HCI) design by considering the methodology of self-efficacy to let the users be more willing to interact with a novel system. The discussion is based on the fact that the proliferation of internet enterprises brings higher demand for better user experience because pleasant user experience could contribute to the promotion of their products. The question is that the existing principles of HCI design (especially display design) are based on the designers' understanding of how to improve user experience instead of the users' point of view. So this article has reviewed the theory of self-efficacy and the existing display design principles. Then the paper makes suggestions to improve the design of the user interface by increasing users' level of self-efficacy and evaluates the change of users' feeling during the interaction. At last, this article has concluded that considering users' level of self-efficacy could make the users more willing to try new products and increase their user experience.

1. Introduction

Since the Graphic User Interface has appeared, the users of computers started to switch from "expertise only" to the ordinary people. Thanks to the open-ended usage of personal computers, people found that they could solve different problems by using different software. Moreover, the popularisation of the portable devices makes the usage scenario of computable devices from in-door to anytime and anywhere, which encourages people to use their smart devices instead of the backward tools for higher efficiency and less error. However, even these intelligent devices could reduce people's working load, the increasing complexity of them brings higher demand for the learning process. For example, mobile payment is more efficient compared with cash or credit card, but the trade-off between the learning cost and the benefit of it could affect the users' aspiration of using the advanced technology in their daily lives. As a result, having better user experience with less learning cost while using new technology is essential to the spreading speed, which could also speed up the development of the technology and bring higher commercial value to the market. As the principle of Human-Computer Interaction (HCI) design, simplicity and consistency could help with reducing the complexity of the layout and lower the learning cost by providing similar experience to different functions. This article is to induct how the users' experience has been affected while interacting with software or system, from the perspective of the theory of self-efficacy. And we will also explore how to raise users' self-efficacy through the HCI design principles.

2. Literature review



Psychologist Albert Bandura has come up with the definition of self-efficacy as one's conviction that one can act and get the expected outcome successfully [1]. As a part of Bandura's social learning theory (also called the social cognitive theory), self-efficacy highlighted four major sources of efficacy expectations which could influence people's behaviour while facing tasks and challenges. After about fifteen years of research, Bandura has proved that self-efficacy could contribute to students' level motivation and academic accomplishment in their learning [2]. Similar to the students' case, users are also trying to learn how to use new technology while interacting with a computer system, and self-efficacy may contribute to their motivations and accomplishments.

Based on Bandura's theory of self-efficacy, K. Rajeswari and R. Anantharaman have proved that stress and HCI variables have main effects on the work exhaustion by analysing people's self-efficacy [3]. Their research has shown that the relation between HCI design and self-efficacy could affect some of the sources of efficacy expectations. In another word, considering users' level of self-efficacy while designing interactions could help reduce users' stress and exhaustion.

Furthermore, Jane I. Gravill and Deborah R. Compeau [4] have tried to explain the internal relation between the knowledge gap and users' level of self-efficacy in several ways, where the gap between users' self-assessed knowledge and the knowledge the system required is essential to the research of Knowledge-driven HCI. Jane I. Gravill and Deborah R. Compeau distinguished the required knowledge to interact with a new system into declarative knowledge ("what" element users need to understand) and procedural knowledge ("how" to interact with this element). They found that the higher the overlap between users' self-assessed knowledge and the join set of Declarative Knowledge and Procedural Knowledge is, the higher General Computer Self-efficacy (General CSE) they will have, which is shown in the Figure 1.

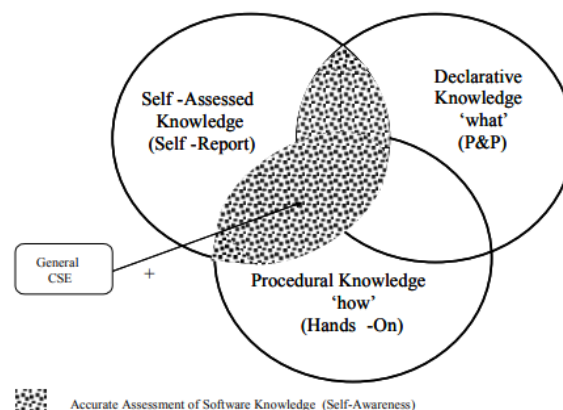


Figure 1. The model of users' General CSE [4]

The above two types of research have all mentioned that a complicate interaction system will affect users' level of self-efficacy. However, in the experiment of Henk Herman Nap, H. Paul De Greef and D. G. Bouwhuis, they found that except of the degree of complexity of the interaction, the feedback the system provided to the users could also influence their self-efficacy. Therefore, they suggested that it is important to support users during computer interaction with positive performance feedback [5].

3. The factors of Self-Efficacy

Based on the previous researches, people found that users' level of self-efficacy could influence their performance and perceived stress. Therefore, an appropriate design of the interaction which helps raise users' self-efficacy could bring a better user experience and encourage them to explore the system. As a result, we need to understand the factors affecting self-efficacy first. The detailed factors are shown as following.

- Performance accomplishment is based on the personal experience and the major factor of ones' self-efficacy. Successes will enhance people's personal experience while failure will decrease it. But when someone has a strong personal experience, the effect of failure will be minimised. However,

there is another case in which the failure will strengthen self-motivated persistence if people find she or he could get over the obstacle through a sustained effort by experience. As a result, the impact of failure is based on the time point it happens and the total pattern of experiences.

- Vicarious experience is based on other's experience people observed. By observing other people perform threatening activities and not getting disadvantages, the observer will think she or he could also succeed by doing so and generate expectations. Comparing with the personal accomplishment which is the direct evidence of one's performance, the vicarious experience is a less dependable source of information about one's capabilities [1]. So, the efficacy expectation will be less strengthen and more vulnerable to change.

- Verbal persuasion might be the simplest and most widely used way to enhance one's self-efficacy without practice. Through insinuations, people would believe that they could handle the work they used to fail. Since the "abstract" experience, the efficacy expectation of verbal persuasion provides less than what the personal accomplishment could provide. Especially while facing threat and long-term failure, the efficacy expectation provided by verbal persuasion will be undermined by unpredictable experience easily.

- Emotional arousal is the last source of information which could influence one's efficacy expectation. It is triggered by pressure and will affect the perceived self-efficacy as a consequence because high arousal usually debilitates performance. People are more likely to believe they could have succeeded when the threatened situation does not surround them. It is no surprise that when people feel anxious, they will doubt their abilities to get things done correctly. At this moment, their self-efficacy has dropped. Moreover, by arousing people's fear of ineptitude, individuals could suffer from a higher level of anxiety which far exceeds the actual situation.

4. Display design principles in HCI research

As one of the most common fields of study in HCI, display design will be the major topic of this article. To apply the methodologies of self-efficacy to improve the display design, we need to understand the existing principles of display design firstly.

An Introduction to Human Factors Engineering [6] by Christopher D. Wickens in 1998 has introduced 13 principles of display design which have been known as excellent references for designers in the industry. These principles guide us to reduce errors and training time, increasing efficiency and user satisfaction while designing an interactive user interface.

4.1 Perceptual principles

- Principle of legible displays – The displayed texts or objects should be clear and easy to read;
- Principle of avoiding absolute judgment limits – Not to use single sensory variable while demonstrating the level of a variable;
- Principle of Top-down processing – The signal provided to the user should be according to user's experience;
- Principle of redundancy gain – A signal is more likely to be understood correctly if it can be presented in alternative physical forms (e.g. Red represents the stock rise, and Green represents stock decline);
- Principle of avoiding similarity – Similar signals will likely be confused, so remove unnecessarily similar and highlight dissimilar features;

4.2 Mental model principles

- Principle of pictorial realism – A character should present the variable it represents. For example, a higher bar or a larger circle always represents a higher value;
- Principle of the moving part – Similar to the previous principle, the movement of the moving objects should reflect the change of the value;

4.3 Principles based on attention

- Principle of minimising information access cost or interaction cost – Frequently used element should be located as close as possible to minimised users’ cost of time and effort after considering the legibility of the context;
- Proximity compatibility principle – Visual elements which have similar function should follow consistency. For example, while browsing a website with multiple pages, the buttons to the previous page and next page should share similar visual features (usually same colour or same shape);
- Principle of multiple resources – Providing multiple sources of information to the users could help them to process the signals more easily. As an example, while providing a warning to users, designers could use both red colour and alarm ring to inform the users;

4.4 Memory principles

- Principle of replacing the memory with visual information: knowledge in the world – A better display design should not require users to remember important information in their working memory or long-term memory. For example, a Multiple-Choice Question (MCQ) system should provide both the question and the choices in the same page to make sure users will not need to remember the question while making choices;
- Principle of predictive aiding – Designer should use more proactive actions (perceptual task) instead of reactive actions (cognitive task) to reduce the requirement of users’ mental resources. By way of illustration, designers should use a progress bar to represent the current time stamp in a video more than the exact time which may require users to calculate between seconds, minutes, and hours;
- Principle of consistency – Transferring the interaction from an older version to a new one with consistency could reuse users’ long-term memory.

5. Discussion

The display design principles we have discussed above focused on helping user to understand the patterns in the graphic UI, reducing users’ cognitive workload, and avoiding too many working memories. We find that some of the goals have positive effects on users’ self-efficacy. Replacing the memory with visual information could reduce users’ stress (emotional arousal) during the interaction. However, the other three factors of users’ self-efficacy have not been considered in these display design principles. Since we know that a higher level of self-efficacy could improve users’ performance and user experience, this article makes the following suggestions to improve the existing display design principles.

- Reusing users’ common experience while designing new interactions – Performance accomplishment is the major factor of self-efficacy. And high level of self-efficacy could reduce users’ stress. Also, bringing personal experience to users is essential for display design. However, personal experience is enhanced by users’ successions which need users’ effort. As a result, bringing users’ existing personal experience from daily life, or another interaction system could maintain a decent of self-efficacy at the first time they interact with the display, which could reduce users’ cognitive work. For example, the “Sign out” button in most of the social media websites is located under the drop-down menu of users’ avatar, as shown in the Figure 2;

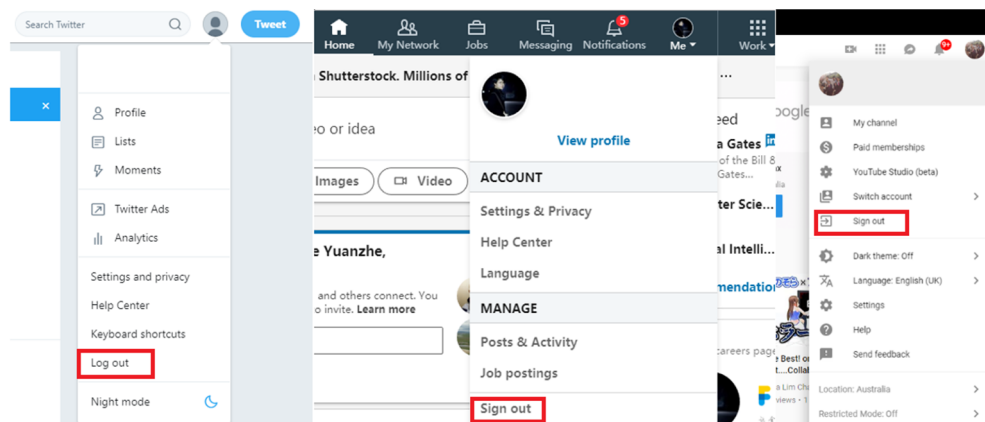


Figure 2. The drop-down menu of Twitter, LinkedIn, and YouTube

- Providing conspicuous feedback when an action has been made – Users get performance accomplishments through successions. As designers, we need to make sure user could realise their interaction to get the expected outcome. Therefore, we need to provide conspicuous feedback to users (like visual message and tone of success) when a correct interaction has been made, as shown in the Figure 3. A combination of this information would be even better in some case;

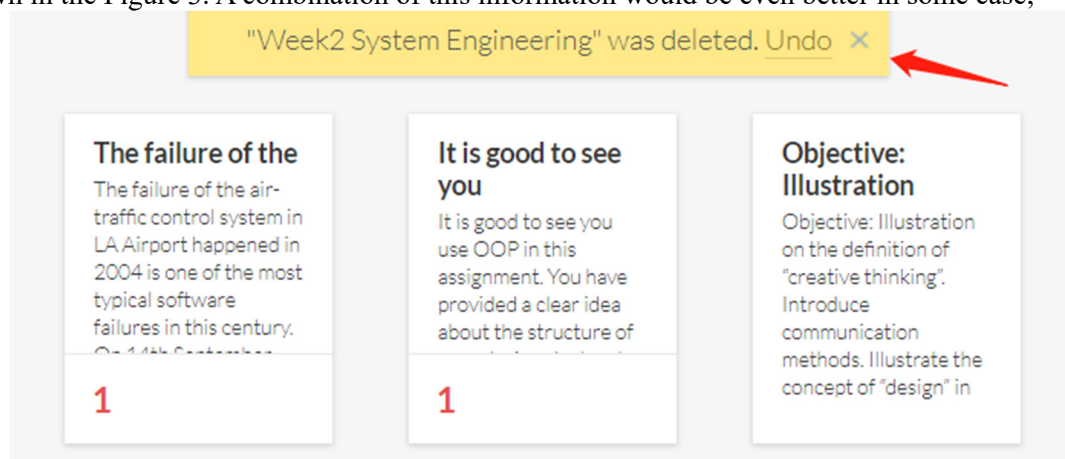
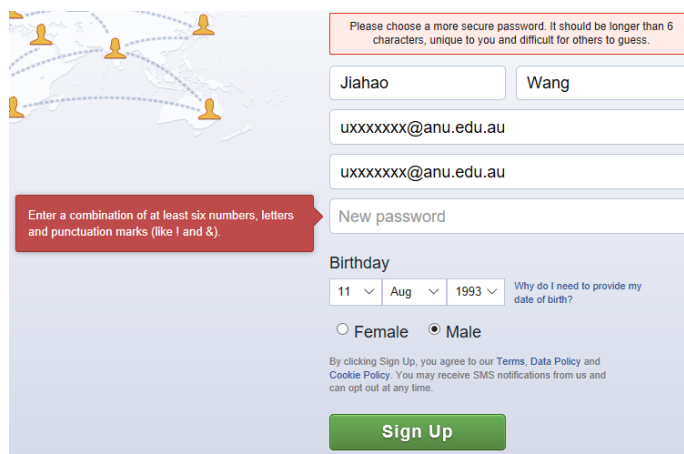


Figure 3. The bubble message while deleting a file from Grammarly

- Thinking twice while providing warning and error information – According to users point of view, a warning or error information usually is recognised as a failure of their action which might undermine their self-efficacy in some cases. Especially when the warning information contains a complex error message where most of the users could not understand, a sharp alarming may make users feel annoying, or even simply freezing. Accordingly, designers need to find a balance while deciding what kind of error message could both make users notice the error, while not giving them too much stress (to avoid emotional arousal which is the last factor of self-efficacy);
- Providing constructive feedback instead of the error message – The Previous principle suggested that negative feedback will demonstrate a failure experience to users which could weaken their self-efficacy. So, designers may try to use constructive feedback instead of error messages if possible. Providing useful feedback could not only avoid affecting users' performance accomplishments, but also transfer this negative effect into a positive vicarious experience which is the second factor of one's self-efficacy through demonstrating the correct interaction to the user. For example, when user use an invalid password while signing up an account, the website will provide detailed suggestions about what should a valid password looks like instead of a simple error message, as shown in the Figure 4;



Please choose a more secure password. It should be longer than 6 characters, unique to you and difficult for others to guess.

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New password

Enter a combination of at least six numbers, letters and punctuation marks (like ! and &).

Birthday

11 Aug 1993

Why do I need to provide my date of birth?

☐ Female ☒ Male

By clicking Sign Up, you agree to our Terms, Data Policy and Cookie Policy. You may receive SMS notifications from us and can opt out at any time.

Sign Up

Figure 4. Facebook's feedback when the user provides an invalid password

- Reducing the complexity of the interactions – A complex user interface will trigger users' feeling of stress and ineptitude, which will debilitate users' performance (mentioned as emotional arousal in the last factor of self-efficacy). As a result, a less complex interaction could reduce the negative effect of emotional arousal by reducing users' physical work and memory work;
- Providing advanced interaction for professional users – As mentioned in the first factor of self-efficacy, users' level of self-efficacy is not only based on the number of failures or successions, but also depends on users' pattern of experience. Also, the negative effect on users with strong personal experience will be minimize. Therefore, providing advanced interactions which will need more learning cost while have better performance for professional users, which will not undermine their level of self-efficacy. As an example, many search engines provide an advanced searching feature for users who are familiar with the kind of information they are looking for, as shown in the Figure 5.



Google

Advanced Search

Find pages with...

all these words: google

this exact word or phrase:

any of these words:

none of these words:

numbers ranging from: to

To do this in the search box.

Type the important words: tri-colour rat terrier

Put exact words in quotes: "rat terrier"

Type OR between all the words you want: miniature OR standard

Put a minus sign just before words that you don't want: -rodent, -"Jack Russell"

Put two full stops between the numbers and add a unit of measurement: 10..35 kg, £300..£500, 2010..2011

Figure 5. The "Advanced Search" feature on Google

6. Conclusion

During the review of the display design principles, we could find that designers usually not consider the theory of self-efficacy intentionally. Even some of the display design principles could help enhance users' level self-efficacy. For example, the principle of top-down processing is one of the display design principles which could help users to shift existing experiences from previous interaction or daily life, which could increase one's performance accomplishment. By considering the methodology of self-efficacy, the design of the interaction could base on how to make the user more confidence about the interaction and focus more on the evaluation of users' level of self-efficacy during the interaction which is the gold of the human-centred design.

The previous article has mentioned six improvements of existing display design principles. These suggestions could serve as the new-generation design philosophy for designers. And designers could

utilize them to perform better solutions to the HCI design issues systematically. But it does not mean that considering these six points is the end of the improvement of the display design. Designers still need to apply them based on the use case. For example, providing constructive feedback may be impossible in some case like an online exam, but we could focus on reducing people's stress while taking an online exam for better performance. Also, since the way people interact with the computer has evolved these days quickly, further improvements of the existing display design are expected in the future.

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