Iron Prototype for Domestic Safety with Green Technology

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Abstract. Electrical fault is one of the causes of fires, and its potential hazard is increasing as more electrical appliances were found in each household unit nowadays. This is due to the number of fire cases arising from electrical appliances (i.e., iron), whereby the existing iron system unable to automatically turn off when idles for more than 30 second and missing green technology characteristics. Thus, the purpose of this project is to develop a smart iron prototype with security features and energy saving properties. The main objective of this project is to develop intelligent smart iron prototype using vibration and temperature sensor to get input for an automatic control. The Design Thinking Model was used to guide the development process through five phases namely; Empathize, Define, Ideate, Prototype and Test. The system was developed using Arduino Uno R3 microcontroller. The product testing indicated that the smart iron prototype has automatically supply cut off after 30 second without vibration and when the temperature exceeded 79 ° C to save energy. Therefore, application of this potential product could prevent major accident caused by iron and simultaneously save more energy when the iron left unattended, especially for the targeted users.

Keyword: Innovation, product safety, green technology, microcontroller, smart iron

1. Introduction
Electricity accidents has been the focus around the world and it usually involve short circuit cases, and it may cause fire due to the spark of the current. For example, in United States fire departments reported to an estimated 1,342,000 fires in 2016. These fires resulted in 3,390 civilian fire fatalities, 14,650 civilian fire injuries and an estimated $10.6 billion in direct property loss (Haynes, 2015). In Sweden, the number of fire fatalities has not changed significantly during the last two decades, in spite of information campaigns and an increased use of smoke detectors and fire extinguishers in homes (Winberg, 2016). In China, the design for high rise building has become the hot topic that causes to 85% death of the victim from fires (Qu, Wang and Cao, 2019). This indicated that fire was caused by many factors such as by the building design and its contents, vehicles, machines, electrical tools, petrol, chemicals, gas stoves and others. Increase in electrical loading might give potential fire hazard. Electrical fault seems to be the most possible cause of fires (Lee, Chow & Hung, 2016). Therefore, society should take a serious look at this, because electric appliance is always used at home, especially with high power tools. Furthermore, the problem faced by electrical appliance users is that they have to press the switch manually when it wants to turn off or turn on the electrical equipment.

The negligence of users in the use of electrical appliances may also contribute to fire hazard (Ganapathy, 2003). If seen in the press or in the news, the occurrence of frequent fires is caused by the negligence of users who handle electric equipment. Iron is one of the electrical appliances that can cause a short circuit. This also causes anxiety to users if they forget to turn off the socket switch. This
is why there is an initiative in improving existing iron control systems to more systematic and user-friendly. According to (Meyerson, 2008) proposes a multilevel approach to initiating a change. Power saving means a reduction of power used by any electronic device (Narayan, Mahadevan, 2012).

In addition, the correct use of the iron is also not practiced by consumers who can carry out electricity wastage. Selection of electrical appliances such as washing machines, air conditioning and fans play an important role in saving electricity for a home (Pierce et al., 2010). The use of an unmanned iron is one reason why the cost of electric bill payments increases every month. Consumers are comfortable with very low electricity rates in the country (Singh, Alqawi & Espiritu, 2010). They argue that the use of electricity is a non-essential facility. Thus, based on the problem the investigator produces a cut-off system on the iron which can disable the circuitry’s own connection from the socket and also live if there is a movement on the iron.

Improper use of the electrical appliance is a major reason causing quite a number of electrical fires (Lee, Chow & Hung, 2016). Many users, particular children and elderly, used to ignore the proper procedure of using electrical appliances as many of them never read the user manual. Therefore, this study is based on one of an electrical appliance that been use regularly at home which is clothes iron. A clothes iron which also call iron is a small appliance that, when heated, is used to press clothes to remove creases and help prevent the spread of infectious disease. Middle class of users owned an existing iron system that is mostly using the conventional system that can only be turned on and does not have a security system that can automatically turn it off. Many iron users often experience minor accidents when using it either during or after completion. Consumers who work at home were also likely forgot to shut down the switch when doing other work. The heat that accumulates may cause fire and burn of the user or any person who will wait for the iron to heat up in no time. Iron also use high electricity and cause wastage on daily bills. For example, there will be a waste of electricity in changing clothes process or doing other work and the iron still operating. Therefore, this research and development focuses on three main objectives as follows:

i) Designing a smart iron prototype that devours safety system and energy saving.

ii) Developing a smart iron prototype that consumes safety system and energy saving.

iii) Evaluating the functionality of the smart iron prototype.

2. Related products

Table 1 shows the difference of 3 irons available in the market. Each iron has its own characteristics. The first is about cost price, iron A is the cheapest at RM 62.00 and iron B (RM 168.00) while iron C (RM 1556.60). The power used is, the C-machine uses the highest power of 2400W, the iron B (2000W) and the lowest is the iron A (1000W). However, these three irons have their own design and function. Based on table 1, iron A has manual temperature control as well as iron B. But iron C is not necessary because the temperature control is automatic. The difference between these three iron, iron B has a water spray to smooth the movement while rubbing. While the other iron does not have water spray. The price of iron C is most expensive than the other because the iron does not need a long time to heat the iron base and have security controls for electricity savings. Lastly, about weight, iron A is the lightest 0.72kg compared to that. Based on the researcher’s research, most consumers use iron A as a daily use as it is easily adapted and cheap.

| Specification | Iron A | Iron B | Iron C |
|---------------|--------|--------|--------|
| Specification |        |        |        |
| Cost Price    | RM 62.00 | RM 168.00 | RM 1556.60 |
| Power used    | 1000W  | 2000W  | 2400W  |
| Design        | Manual | Manual | Automatic |
| Function      |        |        |        |
| Water Spray   | No     | Yes    | Yes    |
| Weight        | 0.72kg |        |        |
3. Methods

Design and development research (DDR) provides an alternative to conduct rigorous and systematic design research based on solid theoretical foundations. The developer will focus on this methods throughout this study. This study involves every phase in the Design Thinking Model namely empathize, define, ideate, prototype and test. This research also presented a feedback that was completed with specific assumptions on the functionality of the smart iron prototype. The use of feedback in the facilitation of research was examined extensively according to various historical and paradigmatic views of the past feedback literature (Mory, 2004).

Phase 1: Empathize
Preliminary studies were conducted to understand users’ problem in handling domestic iron while doing daily routine. The works started by document and literature study to actual place observation. In this phase, the major aim was to seek for problems that occurred namely the source of fire and accident caused by electrical equipment. The scope of the study needs to be set to enable the project to be developed and produced systematically without leaving the project's objectives. In this study, questionnaires use to obtain feedback from users. The result, it helps to understand the problems that occur to the iron user. Hence, it also easy to develop, designs and prototype software according to user defined specifications.

Phase 2: Define
In this process, the researcher determines the user’s need to find the problems that arise against them. As a result of a questionnaire survey found that the needs of the consumer are the need for a security system that can help them deal with the problems. The idea of producing this smart iron prototype is

|                      | Sharp Dry Iron AM-04 | Philips Steam Iron PLP-GC1440 | Iron Philips Amway |
|----------------------|-----------------------|-----------------------------|-------------------|
| Price (RM)           | 62.00                 | 168.00                      | 1556.60           |
| Power (W)            | 1000W                 | 2000W                       | 2400W             |
| Design / function    | -Have manual temperature control. | -Have a water spray tool to reduce heat and smooth the movement while rubbing. | -Stainless steel sheeting. |
|                      | -The base of the iron base is non-stick | -Stainless steel sheeting. | -The Calc clean grease will easily remove the scale. |
|                      | -The light (The light automatically switches to indicate that the desired temperature is reached) | -The Calc clean grease will easily remove the scale. | -Stim ready for use within 2 minutes and can be refillable at any time during ironing. |
|                      | -Have a temperature control manually. | -Has OFF automatic safety function for energy saving. | -Has OFF automatic safety function for energy saving. |
| Weight               | 0.72 kg               | 0.8 kg                      | 4.5 kg            |
also based on a newspaper readers report and a fire source report from statistical data. The power consumed by the iron is extremely high and may have adverse effects if not monitored according to the designated period. Therefore, researchers choose this security system to be developed by consumer needs. The summary of the result during define stage as indicated in Table 2:

**Table 2.** summary of issues pertaining to iron usage

| Problem highlight from survey study and observation |
|-----------------------------------------------------|
| i Iron left unattended more than 3 minutes while users doing multi-tasking (engaging in communication gadgets, entertain children, etc…)
| ii Forgot to switch off iron
| iii Overheat iron (no maintenance for old iron)
| iv Issue on high power consumption

**Phase 3: Ideate (Design)**

There are three major focuses in this phase, namely to determine components and parts of the circuitry hardware, the part of the software to be used and the project overview. In the design that is to be implemented, several aspects to be taken into consideration that are the consumer safety, functionality of a project and something of a reality. The circuit and physical design as indicated as in figure 1 and figure 2:

i) The design of the circuit

![](image)

**Figure 1.** Design circuit
ii) The design of overall project

![Front view](image1)
![Left view](image2)
![Top view](image3)
![Bottom view](image4)

**Figure 2.** Design smart iron prototype

**Phase 4: Prototype (Development)**

The components were carefully selected right after completing the prototype sketches and schematic selected schemes. The major influences of the component selection are the right and accurate function based on circuit requirement and the cost, is not too expensive to reduce cost. Finally, the thermocouple sensor, vibration sensor (SW-420), buzzer and LED were used. Priority is given to the development of system controllers because this part is the most important part which determine the successful of the intended functions. Arduino Uno R3 is appropriate for the simple function and thus was used to reduce cost. The final circuit simulation was tested using Fritzing software.

In the production of this iron safety system, there are several work procedures need to be done. The procedures are like designing the circuit and designing printed circuit board layouts (PCBs). In this phase, researchers also divide into two stages, namely the development of hardware and software. The flow (restricted: reveal upon request) of the system design was coded into Arduino according to the intended operation. Then, all units that have been developed will be tested separately to test the functionality of each unit. Final prototype is indicated in figure 3:
Figure 3: Final prototype

Phase 5: Testing
In this phase, the testing was conducted using two methods. Testing on built-in components and user acceptance tests. Testing is also carried out to ensure that the system run accurate to the parameters needed. The prototype was confirmed by expert validation from technical specification expert from external researcher, user and industry personnel.

4. Result and discussion
The input for the sensors were tested and notification from output were also confirmed. Input testing include the input for the vibration sensor and thermocouple heat sensor and output for LED and buzzer. The testing used was using appropriate equipment including oscilloscope and multi-meter. The result as figure and table below.

Table 3: Result vibration sensor

| Vibration Sensor Time (S) | Iron Operation System | Buzzer |
|---------------------------|------------------------|--------|
| 2                         | ON                     | OFF    |
| 6                         | ON                     | OFF    |
| 10                        | ON                     | OFF    |
| 12                        | ON                     | OFF    |
| 16                        | ON                     | OFF    |
| 20                        | ON                     | OFF    |
| 24                        | ON                     | OFF    |
| 26                        | ON                     | OFF    |
| 30                        | OFF                    | ON     |

Table 3 shows an analysis of vibrational times performed to indicate the operating system of the iron or stop. When the vibration detector unable to detect the vibration for 30 seconds, the buzzer will produce a sound signal indicating that the circuit operating system cut off.

The following figure 4 and figure 5, shows the results output for thermocouple heat sensor. The results of the test are as stated in the figure. Functionality for this temperature sensor can be performed perfectly when the thermocouple heat sensor can detect temperature at three level which is (0 - 49 °C), (50-79 °C) and 80 °C.
Expert validation of the prototype had been conducted involved five expert personnel. Expert selection was based on expertise and experience in the field of electric and electronics. The developer performs an analysis based on the feedback or answers given by the specialist selected in the field of expert validation using checklist. Each expert's validation was divided into three parts which are design, functionality and commercial potential. As the result, this product achieved good average level for all parts. The results as in table below.

**Table 4: Finding of expert feedback confirmation on design of smart iron prototype**

| No | Item                                                                 | Agreement | Agreement percentage |
|----|----------------------------------------------------------------------|-----------|---------------------|
| 1  | This product has an interesting design                               | 5         | 100%                |
| 2  | This product has a neat array of components                          | 5         | 100%                |
| 3  | The circuit casing size corresponds to the components used           | 5         | 100%                |
| 4  | Circuit box positioning is appropriate                               | 5         | 100%                |
| 5  | Fulfilling safety features                                           | 5         | 100%                |
| 6  | User friendly:                                                       |           |                     |
|    | i. Have automatic switch control                                     | 5         | 100%                |
|    | ii. Has information display about temperature and operating system level either ON or OFF. | 5         | 100%                |
| 7  | The material used is durable                                         | 5         | 100%                |
As a result of the table 4, out of seven (7) questions assessed that the three experts gave 100% consent and positive feedback on the questions assessed under the suitability aspect of the model. This proves that the suitability of this smart iron prototype is acceptable and is applied by an iron users.

**Table 5**: Finding of expert feedback confirmation on functionality of smart iron prototype

| No | Item                                                                 | Agreement | Agreement percentage |
|----|----------------------------------------------------------------------|-----------|----------------------|
| 1  | This iron can work properly.                                         | Yes      | 5                    |
|    |                                                                       | No        | 0                    |
|    |                                                                       | Percentage| 100%                 |
| 2  | Thermocouple temperature verification is used in accordance with     | Yes      | 5                    |
|    | high temperature.                                                    | No        | 0                    |
|    |                                                                       | Percentage| 100%                 |
| 3  | The vibration detector works in parallel with the vibration input.    | Yes      | 5                    |
|    |                                                                       | No        | 0                    |
|    |                                                                       | Percentage| 100%                 |
| 4  | The buzzer will sound after 30 seconds when there is no vibration.   | Yes      | 5                    |
|    |                                                                       | No        | 0                    |
|    |                                                                       | Percentage| 100%                 |
| 5  | The buzzer will sound when the temperature exceeds 79 ° C            | Yes      | 5                    |
|    |                                                                       | No        | 0                    |
|    |                                                                       | Percentage| 100%                 |
| 6  | The LED light goes on to indicate the temperature level.             | Yes      | 5                    |
|    | - 0 - 49 ° C, green LED is on                                        | No        | 0                    |
|    | - 49 - 78 ° C, blue LED is on                                        |           |                      |
|    | - 79 ° C, red LED is on                                              |           |                      |
| 7  | The developed software coding can run circuit operations              | Yes      | 5                    |
|    |                                                                       | No        | 0                    |
|    |                                                                       | Percentage| 100%                 |

Table 5 shows the results of functionality of smart iron prototype points. The finding above shows all of the experts are agreed 100% that smart iron prototype is a user-friendly where they did not have any problem in using it.

**Table 6**: Finding of expert feedback confirmation on commercial potential

| No | Item                                                                 | 1 Disagree | 2 Not sure | 3 Agree |
|----|----------------------------------------------------------------------|------------|------------|---------|
| 1  | I will use this smart iron prototype for daily use.                  | 1 (25%)    | 4          |         |
| 2  | I am willing to buy this iron at the stated cost price.              | 2 (40%)    | 3 (60%)    |         |
| 3  | I'm ready to make this iron for family use.                         | 1 (25%)    | 4 (75%)    |         |
| 4  | I recommend that this iron be marketed in the world market.         | 5 (100%)   |            |         |
| 5  | I will use this iron as a step to save energy.                      | 1 (25%)    | 4 (75%)    |         |

As a result of the analysis carried out in table 6, out of five (5) questions assessed that the majority of experts had given positive feedback, which they agreed with the question of value to be analysed for the smart iron prototype. About 75% of experts agree to use this smart iron prototype used in daily use while another 25% is uncertain.

On the cost price, 60% of experts agree on the stated cost price of RM 84.57 because of its reasonable price with the built-in iron security system, compared to iron type A, B and C as in Table 1. For mass production, the cost most probably can be reduced and thus comparable to the regular iron type A. Next, the third thing is to make this iron for family use of 75% agree while the remaining 25% is uncertain. For the fourth question, the majority of experts agree to recommend that this iron be marketed in the world market it benefits the middle-income consumers of iron. Finally, for the fifth question, 75% agree to use this iron as a measure for electricity savings. This proves that this smart
iron prototype can be marketed and can help consumers avoid electricity wastes and avoid small accidents.

5. Conclusion
Smart iron prototype was developed with intention to add more safety measures with green technology for iron, especially for middle class users. The development of smart iron prototype with functions tested in term of accuracy of functionality could have high potential for commercialization, supported by the expert. Testing also indicated that the automatic cut-off for unattended iron can contribute to energy saving initiative by the authority. This product was developed according to the design thinking model, which is closed to meet the users’ need product.

Acknowledgments
Authors wishing to acknowledge assistance or encouragement from colleagues, and special thanks to Universiti Tun Hussein Onn Malaysia for funding this research.

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