Volume: 3 Issues: 9 [June, 2018] pp.26-36]
Journal of Information System and Technology Management
eISSN: 0128-1666
Journal website: www.jistm.com

THE DESIGN AND EFFECTIVENESS OF PADLOCK WITH CLOSEABLE KEYHOLE IN PREVENTING RESIDENTIAL BURGLARY: A REVIEW

Francis Wa Wee Lee[1]
Abu Bakar Ibrahim[2]

[1]Email: Francis93_@outlook.com
[2]Email: abupsp@gmail.com

Accepted date: 19 April 2018 **Published date**: 1 June 2018

To cite this document:

Lee, F. W.W., & Ibrahim, A. B. (2018). The Design and Effectiveness of Padlock with Closeable Keyhole in Preventing Residential Burglary: A Review. *Journal of Information System and Technology Management*, 3(9), 26-36.

Abstract: *The most common padlocks are also the one of the worst locks in terms of security. In this paper, we perform an innovation of the padlock with a closeable keyhole in order to optimize the padlock security. In particular, we provide a detailed study on comparison of the previous padlock with the proposed padlock. We also highlight the criteria of the residential burglary. The information was collected through previous researches and previous construction of padlocks. Among the main findings, we highlight: (1) there are no previous padlocks invented with the closeable keyhole function; (2) padlock with the closeable keyhole function has the potential to be very useful since the most common padlocks are also the one of the worst locks in terms of security.*

Keywords: *Padlock, Residential Burglary, Autodesk Inventor, 3D Printing*

Introduction

Nowadays there are a lot of burglary incidents in residential areas. Even the door is locked by a padlock, the padlock still opened by thief with certain equipment. A mechanical device that used for securing a door or valuables cannot be opened except by a key or by password or code for digital mechanical device. (Sultan Idris Education University, 2017). However, the thief is breaking this rule and the crime of burglary is unstoppable. One study indicates that young burglars steal out of a desire for fun and excitement, because of truancy from school, or because of a belief in the low probability of apprehension. (Walsh, 1980).

The purpose of this study is to develop a padlock with closeable keyhole. Now, master keys that used to unlock any TSA-recognized locks can be made or created by someone who

know use the 3D printer. (Washington, 2014). Therefore, the padlock with closeable keyhole is trying to protect the keyhole been hacked or cracked.

There are padlocks dating to the Roman Era, 500 BC - 300 AD. They were known in early times by merchants traveling the ancient trade routes to Asia, including China. However, there is a lot of background of the problems of padlocks.

Locks have been designed and constructed with many specialized functions. Basically, locks designed to resist or prevent being blown open. Different locks can be opened or closed by different keys. However, it only can be unlocked by the key that closed them. The most important of the lock parts is the keyhole that prevents a thief from exploring the positions. A thief might try to open the locks with his picking tool slight changes of resistance, then there is a pressure applied to the bolt. (Sultan Idris Education University, 2017).

There are two basic types of padlock locking mechanisms which are integrated and modular. The shackle with the tumblers of the padlock will be engaged by the integrated locking mechanisms. For example, when the correct key is turned on, the disk in the padlocks will rotate and the lever tumblers also affected by the key, where a portion of the bolt that secures the shackle enters the tumblers. (Gleyn, B, 2015).

In today's market, people would like to have a secondary mechanism to open a combination padlock. Especially for lockers in gymnasiums, clubs, workout centers, and the like, it is desirable that the staff could provide a combination padlock to their club-member, where the code for unlocking the padlock is resettable yet, after the member returned the padlocks, the code could be reset. This is especially important when the user sets the code (combination), but it does not tell the staff. Many times, padlocks have to be discarded for this reason, since the padlock cannot be re-coded (even if it can be unlocked with a master key). Some of the existing combination padlock can be opened by a secondary locking mechanism such as a key, however, they can just open the padlock by using the key, but such mechanism cannot help the user (staff) to reset the combination code, which was previously set by a user (club-member). (Karl, 2014).

Recently the padlock is still imperfect and some of the people still worry about using the padlock. The worst thing that can be happened is having that valuables were stolen. It is not just worthless that a padlock does not protect the property but it is dangerous. It is worse that the padlock provides no security and you will always be the last one to know it. If there is a weakness on the padlock that will easily become the target of the theft. There is no such thing as perfect security, but there is a good and bad security. All the locks that fail to live up to their claims are guilty and it might come to a crisis of the user. (Joshua, E. 2016). The weakness on the padlock is included that the keyhole is easily being hacked or cracked by not only the keys, but paperclip, aluminum can and so on.

The most common padlocks are also the one of the worst locks in terms of security. The padlock will be opened in seconds, even the single pin picking. The padlock can be unlocked by paperclip, bamboo shoots, food cans, raking and anything that is fit in the keyhole. It proves that these types of padlock are worst and it is not compromising so many people’s security. It also has special tools which are made for the bypass of the padlock. The locking dogs can be easily released with only two tools which are placed in the lock. It moves all the key pins and back of the lock will be reached. This type of padlock has weak security against any type of

attack. It might nothing more than a decoration for the home gate, bicycle, motorcycle or anything that is valuable. The people who failed to aware this bad security is advised to put more alert on it. (Ralph, G, 2015).

Therefore, a lot of padlocks have been studying and the major objectives are as follows:

1. To design, innovate and simulate a padlock with closeable keyhole.

2. To optimize the padlock security with closeable keyhole function.

3. To assess the effectiveness of closeable keyhole padlock among the residential area.

This research is limited by specific padlocks. We focus on comparison of normal padlock and combination padlock. It means that the proposed padlock did not have any connection with digital padlock or smart padlock.

Literature Review

Theoretical Framework

Figure 1 shows the framework of Theory of Inventive Problem Solving (TRIZ) that applied in this research.

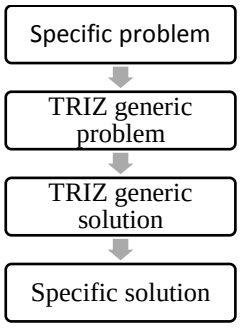

Figure 1: TRIZ Framework

Theory of Inventive Problem Solving (TRIZ), it improves the area for innovation of the product and design process. Based on this theory, it can innovate a high quality product, anticipate future failures and invent next generation. The main objectives to apply this theory in this study are to obtain an ideal design, solve the problems and innovation process can be structured systematically. Also, TRIZ improves the design of the product and it is possible to resolve the contradiction when a problem is structured. (John, Alla & Boris, 1998). Therefore, this research applies TRIZ in order to innovate a new padlock with the new function to solve the residential burglary problem. The innovation of this research is level #1 since it only involved a simple improvement of a technical system. (Lev, 1998). Since it is impossible to test the effectiveness of the new padlock by waiting the robber to break in the house, so it is going to assess the effectiveness of the new padlock after the innovation is completed by using TRIZ.

Residential Burglary

Residential burglary had become one of the critical crime which happens in all countries. Although the crime is reduced during 1990s until the current century, it still happened and it is compulsory to solve the problem. "Stop, question, and frisk" (SQF), one of the policy is used to overcome the burglary and robbery in New York between 2003 and 2010. It recommended that future research should include the impact of SQF on burglary and freedom of the citizens are mostly affected by the policy. (Richard & Robert, 2014). Not only the New York city, Nigerian urban center also having the burglary problem among the residential area. The experience of residential burglary had been tested and examined for the residents in traditional Nigerian urban center. (Adewumi, Deborah & Olanrewaju, 2014). The study found that the residential burglary crime is serious. In the last six months, 54% of this crime are at the core, 72% in the transition and 78% in the suburb during the day time in the weekdays. The data of the residential burglary for the households who had experienced were analyzed. However, the most important issue that must be emphasized is the feeling of insecurity of the households. (Adewumi et al., 2014). Therefore, it suggested that security protection must be maximized.

The residential burglary was studying hard by a lot of researchers and there is a study to prove that the residential burglary not only happened in night time, but also the day time. The data were collected in the city of Enschede and over 851 houses is observed. Multi regression models were used to estimate the forecast of day and night time burglaries. (Lorena, Marianne & Yfke 2014). The findings show that an access control, predict daytime burglary and it strengthen the predict night-time burglary. It concluded that the prevention frameworks not only for night time burglary, but also needed for day time burglars. (Lorena et al., 2016).

A study found that there is a relationship between victims' lifestyle, routine activities and residential burglary victimization. For example, pedestrian and automotive traffic around the residential areas were related to the differential lifestyles. It totally explained that why the crime was happening in specific places at particular times and not others. (Robinson & Matthew, 2012).

The door of the house had become a very common reason that cause the residential burglary. The anti-burglary security devices would increase the security of the house, both individually and in combination. It found that the most effective individual devices are deadlocks, door double locks and external lights. However, the alarms confer less protection than no security. (Andromachi, Rebecca, Louise, Nick & Graham, 2017). Relatively, previous research shows that some burglary incident was deterred by alarms. (Nick, Rebecca, Graham, Louise & Andromachi, 2015). However, the last finding shows that alarms will increase instead of decreased risk of burglary with entry. The findings must be treated cautiously (Nick et al., 2015). The findings were hardly believed and the used of alarms is no suggested. To obtain perfect protection, combinations with window locks and door are suggested because it provides at least 20 times greater protection instead of no security (Andromachi et al., 2017). Further research is needed to improve the security and fix the burglary rates in the long-term.

An analysis about residential burglary from previous researches show that the residential burglary incidents are inexorable because it can't be stopped perfectly. **Table 2** shows the criteria that had collected and analyzed from previous researches.

Table 2: Criteria of the Residential Burglary

No	Criteria	Researchers
1	To further understand the residential burglary in certain areas.	Richard & Robert (2012), Adewumi, Deborah & Olanrewaju (2014).
2	A period that residential burglary happened frequently	Lorena, Marianne & Yfke (2014).
3	Causes of the residential burglary.	Matthew (2012).
4	Methods to prevent the residential burglary.	Nick, Rebecca, Graham, Louise & Andromachi (2015).

Development of the Padlock

Lasaroff (2016) had invented a padlock which the lock cylinder of the padlock can be released. Although the lock cylinder can be released, it still can maintenance the locking balls inside the padlock. It is self-created idea and the invention proved in the independent claim. This design was carried out in order to improve its effectiveness by adding a function which the lock cylinder of the padlock can be released from the body. Since the small parts of the padlock like cam members and the locking balls are very easy to drop and can be easily break or unlock by another person, this design provides a solution which the padlock can release the lock cylinder of the padlock without loosening any cam member or locking balls. It decreases the probability of small parts in the padlock to get lost or break by another person. **Figure 3** shows the padlock which was invented by Lasaroff (2016).

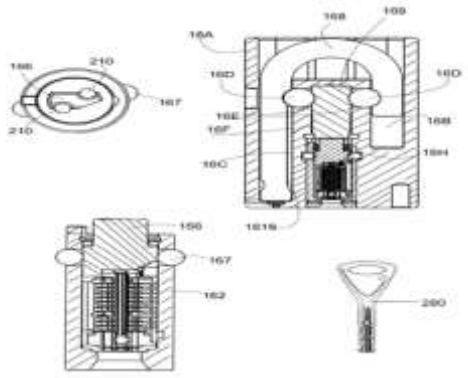

Figure 3: Normal Padlock

Jiaqiang (2004) had invented a new padlock which can be operated either by the key or the cipher. The padlock having a long leg and a short leg with the both sidewalls, which can receive the leg for each other. The basic parts in the padlock are including two bolts, two shackle holes which allow the shackle to pass it, a lock bolt mechanism and a spring. The middle part in the padlock comprising lock cylinder and cylinder housing. A first key can be received by axial or inward. Lastly, there is a drive pin connected to the few parts of the lock cylinder and cylinder housing. This design was carried out in order to improve its effectiveness by adding the reset cipher and a second key function. The second key can be inserted into the padlock in order to lock or reset the cipher. This function is greatly to prevent anyone to unlock the padlock

and reset the cipher without any permission. **Figure 4** shows the padlock which was invented by Jiaqiang (2004).

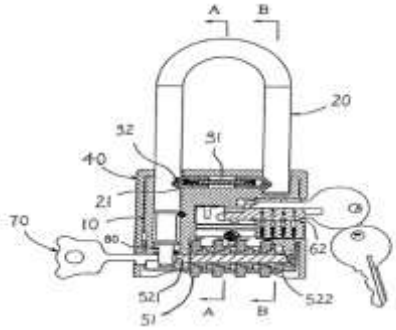

Figure 4: Combination Padlock with Double Key

Innovate a padlock with Closeable Keyhole by Using Autodesk Inventor

This study aims to design, innovate and simulate a new padlock and optimize its security with closeable keyhole function. One of the Computer Aided Design (CAD) software, which is Autodesk Inventor has been chosen to design a new padlock in this study. According to Autodesk (2015), Autodesk Inventor software is a software that enables the user to make excellent products with professional grade engineering solutions. It included tools like simulation, routed systems design, and tooling creation for any advanced products.

Compare to the previous research, this study aims to develop a padlock which can cover the weakness of the padlock in the previous research. This study will innovate a new padlock with closeable keyhole function, which is not found in any previous study. Autodesk Inventor software is a primary software to design a new padlock in this study. A closeable keyhole padlock will be designed and fabricated as a 3D prototype by using the 3D printer machine. The new padlock and the normal padlock will make a comparison to deeply understand the pros and cons for each padlock.

Comparison of the Padlocks

Table 5 shows the comparison of the padlocks which included normal padlock, combination padlock and proposed padlock. Basically, a normal padlock focus on key function and combination padlock focus on both key and code functions. In this research, we proposed a padlock which focuses on closeable keyhole function in order to improve its security. Symbol √ represents the feature is comprised and X represents the feature that do not exist.

Table 5: Comparison of the Padlocks

Type of the padlock	Key	Code	Closeable keyhole
Normal	√	X	X
Combination	√	√	X
Proposed	√	X	√

On external view, a normal padlock comprises a lock bar, lock body and lock insert. The keyhole is not protected by any components. It may unlock by another person with certain tools without any permissions. **Figure 6** shows the normal padlock that usually used in residential area. The figure is drawn by using the software Autodesk Inventor 2017.

Figure 6: Normal Padlock

We proposed a padlock with closeable keyhole which may increase the security by preventing another person unlock the padlock with certain tools without any permissions. We protect the keyhole of the padlock by adding a mechanism which can close the keyhole properly. It can only be opened and closed by using a specific key with unique shape. **Figure 7** shows the proposed padlock that may increase the security of the padlock. The figure is drawn by using the software Autodesk Inventor 2017.

Figure 7: Proposed Padlock

Methodology

In order to achieve the objectives in this research, we apply the ADDIE model innovate a new padlock with the new function and improvement of the security. The ADDIE model contains Analyze, Design, Develop, Implement and Evaluate. As this is a review paper, we are only executing our research until design phase and show the analysis on previous padlocks. However, we also show others phase in our methodology which will carry out after the design phase. **Figure 9** shows the process of ADDIE model which provided by Grafinger (1988).

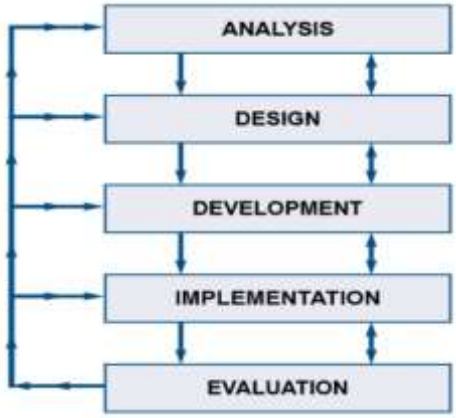

Figure 9: ADDIE Model

In analysis phase, the product development involved the gaps between the desired result and all of the existing skills and knowledges. (Kruse, 2002). The problem that needs to be solved were analyzed clearly. The design and innovation of previous padlocks were analyzed and a proposed padlock was carried out in this research. The requirement of the product development will depend on the desired outcomes and the existing skills and knowledges.

The design phase is directly associated with the learning objectives and assessment instruments. (Kruse, 2002). As the objectives of this study are to design, innovate, optimize and to assess the effectiveness of the new padlock, the design phase will design a new padlock with more security and functionable to achieve the objectives.

The product with actual creation will be completed in the development phase. (Kruse, 2002). The prototype development of the product will be completed in this phase by using the 3D printing technology. The data that required by 3D printing will directly transferred from the software Autodesk Inventor 2017, which is the main design and sketching software that applied in this study.

The developed products are delivered to the study group during the implementation phase. (Kruse, 2002). After the 3D printing proses is done, the prototype of the developed padlock in this study will deliver to the study group. The process of choosing the samples is random and the selected UPSI students are entitled to test the product.

After the developed products are delivered, the effectiveness of the products will be evaluated. (Kruse, 2002). The selected UPSI students are entitled to test the new padlock and they can make an impression between the new developed padlock and the normal padlock. The selected UPSI students are required to fill the questionnaire form. All of the impression and answer in the questionnaire that obtain from UPSI students will be evaluated. It will determine the effectiveness of the new padlock and whether the objectives will be archived.

Analysis

In the design or innovation of the padlocks, mostly the innovations are carried out in order to improve its effectiveness by strengthening the components and cipher. Each inventor shows the parts of the padlock which they are more focus in order to increase its effectiveness. **Table 10**

shows the features of the padlocks that had been invented by the inventors. Symbol √ shows that the feature is comprised and X shows that the feature did not exist.

Table 10: Innovation of the padlocks

No.	Inventor	Components	Cipher	Closeable keyhole
1	Jiaqiang (2014)	√	X	X
2	Jukka (2016)	√	X	X
3	Scott, Michael & William (2014)	√	X	X
4	Tien-Kao (2016)	√	X	X
5	Yao-Kun (2016)	√	X	X
6	Chien (2014)	√	√	X
7	Chun (2015)	√	√	X
8	William (2016)	√	√	X
9	Yung & Renny (2014)	√	√	X
10	Renny & Chun (2014)	√	√	X
11	Glenn (2013)	X	√	X
12	Karl (2016)	√	√	X
13	Karl (2014)	√	√	X
14	Karl (2016)	√	√	X
15	Karl (2017)	√	√	X
16	Proposed	√	X	√

Among the 15 inventors, we found that there are 5 inventors focus on components of the padlock, 1 inventor focus on cipher of the padlock and 9 inventors focus on both. However, there are no inventors focus on closeable keyhole, which is proposed by us in this research. In other words, there are 60% inventors focus on components and cipher of the padlock, 33% inventors focus only on components of the padlocks, 7% inventor focus only on cipher of the padlock and there is no inventor focus on closeable keyhole function. **Figure 11** shows a bar chart with features of the padlocks that had been invented by the inventors.

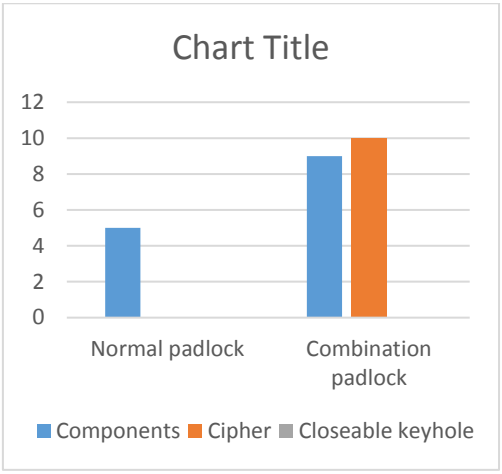

Figure 11: Innovation of the padlocks

Discussion

Our main motivation to innovate a new padlock with closeable keyhole function are to optimize the padlock security, which is important in preventing residential burglary. According to our findings, we found that there are no inventors innovated a padlock with a closeable keyhole function. The closeable keyhole function has the potential to be very useful since the most common padlocks are also the one of the worst locks in terms of security. Considering the factors of residential burglary, the keyhole of the padlock is one of the important parts that need to be strengthened. Thus, we believe that it is considerable to design, innovate and simulate a padlock with closeable keyhole function and proof that its security is higher than common padlock by assess its effectiveness among the residential area.

Conclusions

The innovation of padlocks was studied and the major conclusions are as follows:

1. There are no previous padlocks invented with the closeable keyhole function.

2. Padlock with the closeable keyhole function has the potential to be very useful since the most common padlocks are also the one of the worst locks in terms of security.

3. The innovation will be continued and proceed to the assessment of the effectiveness of closeable keyhole padlock among the residential area.

Acknowledgments

This work was supported by Dr. Abu Bakar Bin Ibrahim, a senior lecturer from Faculty of Art, Computing and Creative Industry at Sultan Idris Education University. A special thanks to Dr. Abu Bakar Bin Ibrahim for performing the project. Last but not the least, assistance provided by Institute of Graduate Studies at Sultan Idris Education University was greatly appreciated.

References

Andromachi, T., Rebecca, T., Louise, G., Nick, T & Graham, F. (2017). The effectiveness of burglary security devices. Security Journal, 30(1), 60–73.

Autodesk. (2015). Make Innovation your Competitive Advantage. Autodesk Product Design Suite 2016.

Badiora, A. I., Oluwadare, D. B., & Dada, O. T. (2014). Nature of Residential Burglary and Prevention by Design Approaches in a Nigerian Traditional Urban Center. Journal of Applied Security Research, 9(4), 418–436.

Gleyn, B. (2015). Proximity Padlock. Retrieved from https://www.google.com/patents/US20150292244

Jiaqiang, R. (2004). Padlock. United States Patent, 2(12).

John, T., Alla, Z., Boris, Z. (1998). Systematic Innovation: An Introduction to TRIZ (Theory of Inventive Problem). Retrieved December 22, 2017, from https://books.google.com.my/books?hl=en&lr=&id=QqPCvdo23dgC&oi=fnd&pg=PA1&dq=triz+theory+innovation&ots=QLPPK4q2En&sig=6DhWayI0XYTRPYTpquDKA9tySE&redir_esc=y#v=onepage&q=triz theory innovation&f=false

Joshua, E. (2016). Why hackers are so obsessed with picking locks. Retrieved December 22, 2017, from https://www.csmonitor.com/World/Passcode/Security culture/2016/0815/Why-hackers-are-so-obsessed-with-picking-locks

Karl, L. (2014). Combination Padlock with Secondary Opening Mechanism. United States Patent, 2(12), 12–15.

Kruse, K. (2002). Introduction to instructional design and the ADDIE model.

Lasaroff, J. (2016). Padlock. United States Patent, 2(12).

Montoya, L., Junger, M. & Ongena, Y. (2016). The RelationBetween Residential Property and Its Surroundings and Day- and Night-Time Residential Burglary. Environment and Behavior, 48(4), 515–549.

Nick, T., Rebecca, T., Graham, F., Louise, G., Andromachi, T. (2015). Do burglar alarms increase burglary risk? A counter-intuitive finding and possible explanations. Crime Prevention and Community Safety, 17(1), 1–19.

Ralph, G. (2015). 10 Locks That Provide the Illusion of Security. Retrieved December 22, 2017, from https://unitedlocksmith.net/blog/10-locks-that-provide-the-illusion-of-security

Robinson & Matthew, B. (2012). Lifestyles, Routine Activities, and Residential Burglary Victimization. Journal of Crime and Justice, 22(1), 27–56.

Rosenfeld, R., & Fornango, R. (2014). The Impact of Police Stops on Precinct Robbery and Burglary Rates in New York City, 2003-2010. Justice Quarterly, 31(1), 132–158.

Shulyak, L. (1998). Introduction to TRIZ. 40 Principles: TRIZ Keys to Technical Innovation, 40, 15–22.

Universiti Pendidikan Sultan Idris. (2017). Development of modern types.

Walsh, D. (1980). Break-Ins: Burglary from Private Houses. Retrieved December 22, 2017, from https://www.ncjrs.gov/App/Publications/abstract.aspx?ID=80188