Risk Perception in Domestic Stove: Usability and Security Approach in Product Design

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ABSTRACT

The stove is as indispensable product in residences and at food service places. While there is a better application of a best design in these products, it occurs, still today a great amount of lesions and accidents on handling it, which could be due to various causes. Norris and Wilson (1997) have demonstrated the relevance of ergonomic evaluation methods as helping element on identifying "Designing Safety into Products". They considered that the product must present an expected reasonable level of security for any person that has contact with it, but this security must be extended to further users, passers and even though avoiding a misuse. Lidwell (2010), also agreed with the concept that accidents caused by human errors, could be caused, instead, by design errors but not by human operation. Thus, facing this scenery of risks and accidents caused by domestic stove, we pursued deepen knowledge and methods to obtain perception risk data on using stove. The objective of this article is to survey information about the risk perception on domestic stove use, in order to discuss aspects of security and usability related to design guidelines.

Keywords: Risk Perception, Safety into Products, Usability, Security

INTRODUCTION

Risk perception is the ability to know and manage dangers people are exposed. Difficulties on evaluate the risk perception are demonstrated in studies performed in Sweden (Sjöberg, 2000). It seems to be higher the risk perception by people who are out of the process or who are newcomers in the activity related with the risk. As much people know the activity less are their risk evaluation. This condition increases the accidents probabilities once the users do not perceive the seriousness of the risk as they should.

The stove is as indispensable product in residences and at food service places. While there is a better application of a best design in these products, it occurs, still today a great amount of lesions and accidents on handling it, which could be due to various causes, since user's failure till lack of protection devices in the product. These could lead to lesions or intoxication due to forgetfulness in turn off the flame or in leave the pan over the flame.

Many problems in product use are due to a misunderstanding between the designer's interpretations on how they see

the user's intention trying to make the operation easier and due to unknowing the real needs of the user in a certain moment. In emergency and panic cases, the user will use instinct and intuition to solve the problem he faces. However it is still poor the literature about the systematic and objective association of the real context in using stoves in domestic environment.

In Brazil, while the production of stoves must follow certification standards, established by INMETRO – National Institute of Metrology, Quality and Technology – by means of standards ABNT NBR NM 60335-1, ABNT NBR 13723 -1 and amendments, ABNT NBR 13723 -2, ABNT NBR 14784, ABNT NBR 15076, which deal specifically on the assurance of functional security of these products, they do not assure elimination of accidents in using stoves. In data obtained by INMETRO, till 2011, on 471 denounced cases 60,55% reported the need of medical assistance due to accident on using the stove, and 39,5% of these cases needed work license. In 2010, from the registered cases by INMETRO, 6,4% were accidents related with stove use and in 2012, were 5,26%.

Ergonomy has a fundamental rule on safety of products, studying how people interact with them, with tasks, with environments and with other people. But still are few the studies about human behavior, perception and their meaning in product design, representing a big opportunity for researches related with design, in order to understand users' behavior (Lindwell, 2010). Facing this scenery of accidents and risks related with domestic stoves, this paper deepens knowledge and methods to obtain data on risk perception in order to feedback elements on product design. The objective of this article is to survey informations about usability and security in product design.

THEORETICAL ISSUES

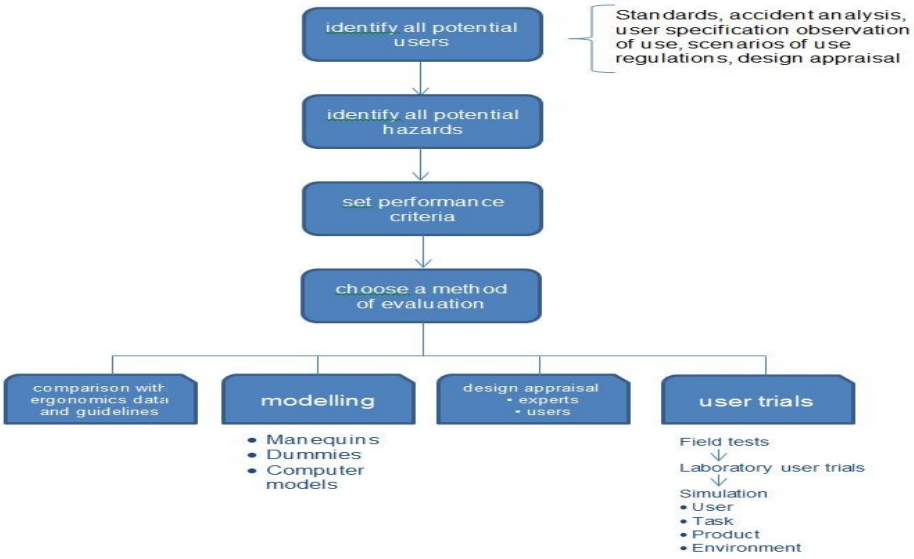
Norris, Wilson (1997) has demonstrated the relevance of ergonomic evaluation methods as auxiliary elements on identification of "designing safety into products". According the authors product safety has two main points to be treated: The first one refer to build the safety of the product, which is related to functional quality, which has to comply with the actual quality standards of a society, and the second one are product design qualities. In designing safety approach, authors consider that product must offer to any person that deals with it, a reasonably expected level of security , and these security should be extended to other users, passers and even though children that could "play" with the product in a dangerous way.

Ergonomics evaluation is a process that incorporates ergonomics data, knowledge and testing within the whole design process. It helps you to:

• ensure your product is reasonably safe for its intended use and its intended users
• extend such safety to include foreseeable misuse, including use by unintended users such as children
• identify those at risk
• identify the likelihood of injury
• quantify the likely severity of any injury
• highlight possible design improvements.

In their handbook, authors encourages designers to see ergonomics evaluation as something which takes place throughout the design process, as presented in Graph 1, below:

Evaluation Process



Graph 1 – Ergonomic evaluation process

Identify potential hazard

Anticipate everything about your product that could go wrong or be dangerous – its hazards. It helps to look at them in a structured way and come up with a considered and thorough list. There are a number of things you can do, and sources of information you can use, to draw up a list of potential hazards:

• review regulations and standards, if these exist for your product, then some potential hazards will already have been identified and minimum safety criteria set for them.
• analyze accident statistics to see what types of accidents are occurring, that is being injured, where, when and how.
• produce a user specification based on your list of potential users
• build up scenarios of how different people might use a product in different circumstances
• observe and analyze how similar products are used.
• carry out design appraisal with people other than the design team who may have an idea about the way the product will be used and its potential hazards.

Set performance criteria

“Once you have a list of potential hazards, you must assess how likely they are. This is known as the element of risk. To do this you must set performance criteria for each hazard. These criteria are effectively design specifications which your product must meet so that hazards do not occur, and which will form the basis of your testing procedures. In cases where a hazard cannot be completely ‘designed out’ and you cannot avoid some level of risk, then make the most of other means of accident prevention such as instructions, labelling and safety education.”

Choose a method of evaluation

There are several methods of evaluation, among them can be seen in Graph 1: the comparison with ergonomic data and guidelines; a modeling using mannequins, dummies and/or computer models; the design appraisal by experts or

users; the user trials that can be at field or in laboratory where can be used simulation. After elected the method, is possible to confirm the results by the use of other method, making a cross review.

METHODS

For the present study we propose the development in three stages. In the first stage we look for to know aspects on risk perception in accidents using domestic stove, by means of on-line questionnaire, on google drive software, sent by Email to the participants. The questionnaire was elaborated with 10 closed questions and 4 open questions, which were answered by 100 people in the Parana state, Brazil. The questionnaire have the following structure: a) invitation to participants clarifying the research goal; b) personal data for identification of user profile (age, genre, schooling and profession); c) stove use frequency; d) type of stove used; e) risk level perception about the risk the product can offer, in a "0" to "7" scale, "0" representing no risk and "7" representing high risk, according figure 1; f) description of type of accident perception associated to the use, by means of open question; g) identification and remembrance of the fact and/or accident with damage or lesion by using the stove; fact or accident frequency; damage or lesion occurred; risk perception level associated with the described fact, in a "0" to "7" scale as described before; identification of accident or damage kind of cause; suggestion to avoid the accident or damage, descriptive open question; h) care taken by user to safe use of the product, descriptive open question. Data collection was done between august 1st and 22th, 2013. Questionnaire data were tabulated and presented as graphs and text referring to open questions.

Figure 1 – Perception scale

Stage 2, Identify Product usability and safety elements and compare them to the risk elements associated with Universal Design Principles presented by Lidwell, Holden e Butler in 2010. Stage 3, the principal accident risk elements on using stove, identified in stages 1 and 2 were analyzed according the proposal of Safe Design (Norris e Wilson, 1997).

RESULTS AND DISCUSSION

For better understanding and objectivity, answers were pooled in graphs or tables, which will be present and discussed ahead. Interesting observe that the reported experience technique, bring more veracity to data (BEVAN, 2008), because the participants while describing textually the events, remember experiences that were not touched in the objective answer.

Thus, when answering objective questions about their involvement in accidents, 53% of participants said that, initially, that had not accidents with lesion, as presented in figure 2, but the after non-objective stage of the questionnaire, 87% of the participants considered that the stove represent a risk between medium and high as shown in figure 5. Remarkable that the great majority of participants are in medium/high degree, showing the need to apply Safe design Techniques, according the second focus of Safety in design studied by Norris, Wilson (1997).

Due to the extensive use all over the world, domestic stove is an appliance that should be considered of low risk by the majority of the users, however, as shown this study, it is a product whose operation risk is between medium and high, which is extremely worrying.

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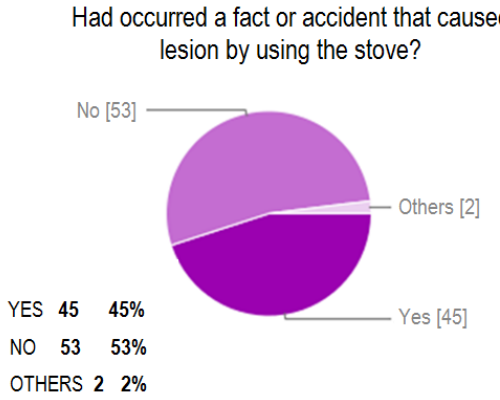

Figure 2 – Accident descriptions

This frame of worrying with product safety is aggravated if considered that more than 70% of the participants use the stove, at least once, fact fully demonstrated in figure 3.

In an unpretentious projection of these data, can be considered that this situation occurs all over the world, with numbers that can be near those presented in this paper, bringing alarming consequences, that should be dramatically minimized by the use of Ergonomy and safe design on creating better products.

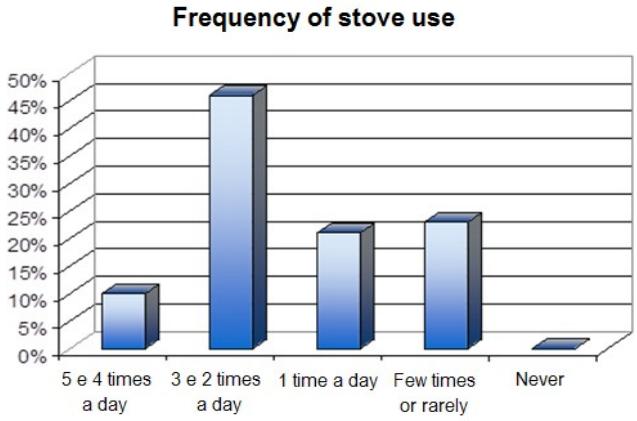

Figure 3 – Stove utilization frequency

Considering collected data can be verified that 94% of the participants use gas or electric stove, which represents the great majority of this kind of appliance. The occurrence of cases associated with gas stoves (80%) is much superior that the occurrences associated with electric stove (14%). Figure 4 shows the frequency of use by kind of stove, used to cook.

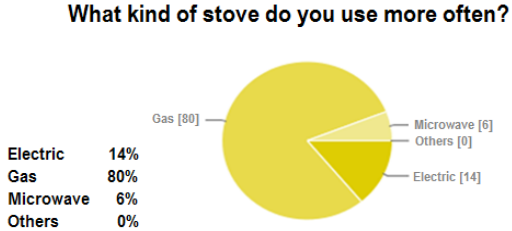

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Figure 4 – Stove kind categories

As shown in figure 5, only 13% of the participants considered the risk level of the stoves between low and very low. It shows the dimension of user perception and denotes the need to deepen the studies in this important matter, in order to reduce the real risk and associated risk perception.

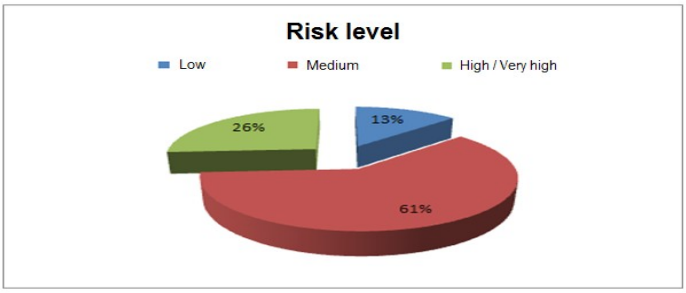

Figure 5 – Participants risk evaluation

When segmented the risks associated with the stove use, is visible that 73% of these risk are associated with explosion and burning, that can produce important material and personal damages and they are related with public health and loss of patrimony – figure 6. In burn cases, prevention represents great spending reduction by correcting the problems that can be avoided improving product creation process.

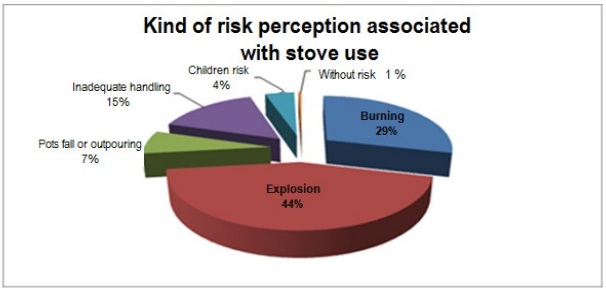

Figure 6 – Real risk and perception

Among the participants that related be involved in accidents during stove use, when questioned about the number of times it happens, more than two third declared that had been at least one accident and almost one third declared that had been involved in “various” accidents – figure 7.

This revelation gives the dimension of the problem involved with the activity of using this appliance; causing questions on the need of deepen the studies of use and techniques to improve the safety on using domestic stoves.

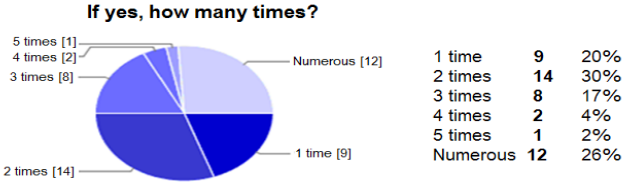

Figure 7 – Amount of accident by positive statement of participants

In order to qualify were made tables of some occurrences associated to the most frequent causes reported. Human failure (table 1) e o utensils handling (table 2) during cooking activity, represent important indicator for the innovative design of these products, to minimize the possibilities of accidents, by human failure or handling utensils. Applying simple building techniques could be possible eliminate causes of accidents like gas leakage. More complex and random causes, like children accidents, demand more sophistication, on using alarms triggered by sensors of height, for example

HUMAN FAILURE

Origin / Cognitive Process	**Generation Source**	**Lesion Qualification**
Forgetfulness	Keep stove working	Intoxication
Desired command handling error	Undesired firing command	Burning
Do not perceive children presence around stove	To lean in door oven	3rd degree burning needing surgery
Attention failure	Touch hot pot	Burning internal side of hand's fingers

Table 1 – User failure accidents: causes and consequences.

Leakage due to melting the hose is one of the accident causes that would demand a minimum effort for solution, by using heat proof materials. No doubt would have a cost increase, but largely justifiable and easily absorbed on product final value. Optimizing utensils design, as pressure cookers, would be great help in accidents reduction, but could be theme of other research.

UTELSILS HANDLING

Origin / Product	**Generation Source**	**Damage or Lesion Qualification**
Utensils	Pressure Cooker	Intoxication
Hot surface	Oven	Burning
Gas leakage	Gas not coupled; To blow out the flame with wind; Oven with gas leakage	3rd degree burning needing surgery

Table 2 – Accidents involving utensils handling: causes and consequences.

After tabulated the causes of reported accidents by participants that had declared having been involved with these kind of occurrence, it was observed that the great majority is motivated by human failure and not product functioning failure. – Figure 8.

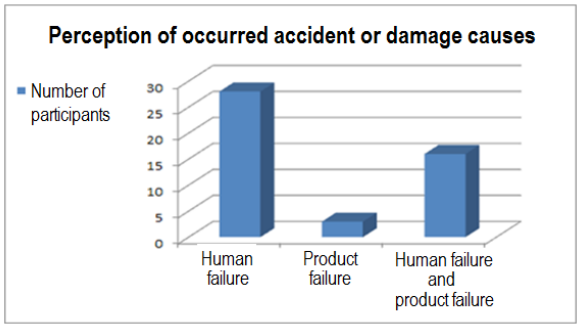

Figure 8 – Accidents causes classification

In order to study, deeply, the subject it was elaborated a table relating data and responses of risk perception with the seven elements or Universal design (UDI, 2011).

Results presented in figure 9, shows that almost half or the risks are related with the element "error tolerance" of Universal Design. This item permits the application of Ergonomy techniques to product design, allowing aggregate improvements that can reduce the occurrence of human failures, by optimizing error tolerance while using stove.

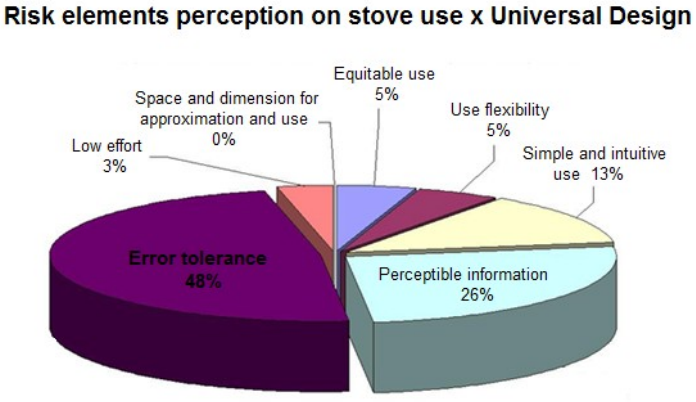

Figure 9 – Relation between risks and Universal Design elements

Still in the scope of the electronic questionnaire, were elaborated questions for which participants were stimulated to suggest possible improvements in the design of the domestic stove, by the simplistic user's point of view. Also this theme would produce deepening by study or direct research, beneath aegis of Ergonomy by using "Designing safety into products".

Below are presented suggestions of improvements that were selected in questionnaire answers:

1. Better alert children about the danger of pots and stoves and paying more attention while cooking food;
2. Redouble the attention while handling utensils and stove;
3. More care while frying frozen food;
4. Do not forget near stove anything that can bring some kind of risk;
5. Take care about the possibility of extinguish flame by wind;
6. Make more frequent, review and maintenance of the stove;
7. After using the stove, verify if all the stove burners are off;
8. Design better signs in product items;
9. Add more rugosity to the superior grille in order to increase the friction with the bottom of pots;

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10. Improve the efficiency of oven burners;
11. Always produce ovens with electrical firing of burners
12. Improve the stove design by adding protection around the burners table, to avoid spot handlers to be out of the area producing fall or spots;
13. Produce stoves with easy access to oven interior;
14. Increase thermal isolation of oven`s door to avoid knee burnings;
15. Add to stove design a device that shut the flame of automatically after a pre-defined time or that produce an alarm sound ;
16. Design burner knobs that could be difficult to be operated by children easily;
17. Develop a way to change the color of the stove parts that are hot;
18. Develop a smoke detector for stoves;
19. Design automatic burners shut-off in the absence of flame;
20. Add security device that avoids the oven door to close by itself;
21. Include a gas leakage detector;
22. Supply stoves with fire proof hoses.

Finally, crowning the on-line consult process, participants were stimulated to answer about the care they took in order to use the stove in a safer way. Figure 10 below shows the elements that catch the attention of user for precautions took to improve safety in using this appliance.

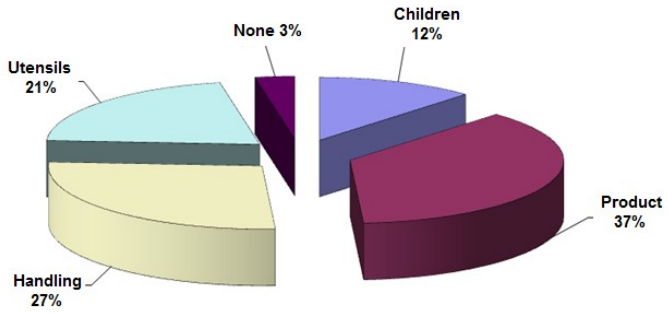

Figure 10 – User attention over risk causes

It shows a balance of user care with the product itself, with handling and with utensils. Children represented lower worries that were expected, reason why seems to be recommendable create additional protections by product design, with the approach or children accidents.

In order to analyze the bigger slice of pizza graph presented in Figure 9 - Error Tolerance - that represents almost half of the Universal Design Elements associated with the risks, Figure 11 shows the segmentation of this element.

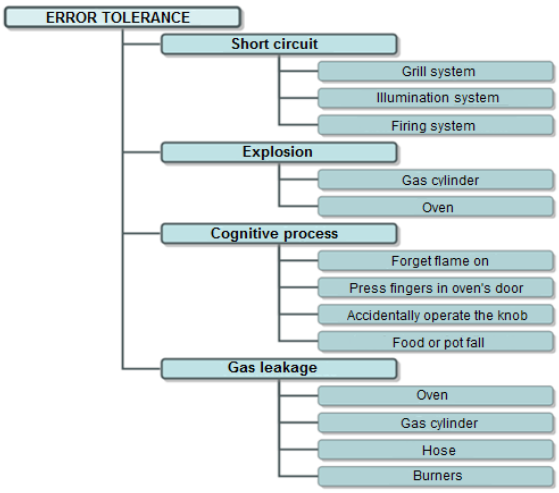

Figure 11 – Causes and places related with accidents involving Error Tolerance

There are four main reasons for accidents that could be minimized using design to improve the error tolerance in stoves: short-circuit; explosion; cognition process and gas leakage. For each one, there is an action or local where accident starts. Short-circuits can be avoided protecting better wires and devices in grill, illumination and firing systems. Leakage can be minimized by taking care of the locals gas is present, like oven; gas cylinder; hose and burners.

Designing signals that show the flame is on; that catch the attention of the user for oven's door; that avoid accidental operation of the knobs and protection to avoid the pot to slip over the burners, could be a simple and cheap task, if well planned and using the ergonomic analysis of safe design (Norris e Wilson, 1997). According with them: "Once you have a list of potential hazards, you must assess how likely they are. This is known as the element of risk. To do this you must set performance criteria for each hazard. These criteria are effectively design specifications which your product must meet so that hazards do not occur, and which will form the basis of your testing procedures. In cases where a hazard cannot be completely 'designed out' and you cannot avoid some level of risk, then make the most of other means of accident prevention such as instructions, labelling and safety education."

In "Designing safety into products" (Lidwell, Holden e Butler, 2010) authors shows that safety is an issue in which, actions can produce a positive or negative result. Some considerations on the approach to use safety into designs are presented in Table 3 below:

Table 3 –

Accessibility	Objects and environments must be designed to be used, without changes, by the greater number of persons that could be possible. So, they do not need modifications or adaptations to serve any person.
Menace detection	Capacity of detect menace stimulus more efficiently than non-menace stimulus.
Errors	An action or omission that produces non-intentional results.
Security factor	Use of more than considered necessary elements to compensate the effects of unknown variables to prevent system failures.
Condescension	Designs must help people to avoid errors and to minimize negative consequences when they occur.
Framework	Technique that manipulates decision-making and the judgment when handling the way informations are presented.
Load and performance	The greater the effort to execute a task, the smaller will be the probability of success in the task execution.

Designing safety into products

CONCLUSION

There are techniques and procedures, well tested that can help the designer to improve de safety into products and this field can be more largely explored. This paper intends to stimulate designers and project engineers that are interested in ergonomics, to use and reach results on creating better and safer products.

Security is one of the fields in which more efforts should be applied, due to the importance and to protect human being and patrimony avoiding lesions, damage and even loss of lives. In the case studied here, children seems to be neglected under the view of participants and attention should be paid, since almost hundred percent of global population handles stoves many times a day, and children are around frequently.
Users could have an important role in the design of products, suggesting solutions under a different point of view, and sometimes innovating with creative improvements.

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