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A Learning Platform for Cultivating Learner's Self-Awareness on Human Decision-making in an Emergency Situation

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Doctoral Dissertation

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ABSTRACT

Self-awareness is an important skill that each individual needs in daily life. It is even more important in a critical situation. However, it is difficult to be aware of one's own thinking process. A person may have useful knowledge for a certain situation; however, they may fail to apply it to solve a problem they encounter. For example, people may know that competing with others for a single exit immediately causes the evacuation flow to become clogged. However, many of them may still behave improperly and emotionally when they confront the actual situation. One of the possible reasons is that ordinary people may not have many opportunities to realize how their decision-making affects their behaviour. Unlike the emergency services, such as the police, fire fighters, and rescue teams who have been trained to cope with emergency situations, ordinary people tend to behave inappropriately. It is therefore important for people to be able to apply the right knowledge to a situation and to improve their self-awareness of their thinking process. However, self-awareness is very difficult to cultivate, because mental processes are implicit and vague.

With regard to learning about self-awareness, authors believe that *surprise* caused by self-awareness could be a good activator for learning. We are not aware of how we can think or behave to cope with a situation and we often believe that we can think appropriately, although there may be not any evidence of this. If we can observe our thinking process and realize that the result of our thinking is not reasonable, we will be "surprised" to find that we are not good at thinking and then we will be motivated to cultivate our self-awareness of our thinking process.

The role of surprise is a trigger that makes learners have a deeper realization of their own thinking process. This dissertation has two objectives: 1) to motivate learners to cultivate self-awareness of their thinking process in an emergency, and 2) to propose a learning platform using surprise as a trigger for learning.

The proposed learning platform consists of three phases. 1) The Anticipating Phase: its objective is to let learners collect information in a learning environment, interpret it in terms of parameters, analyse information and make a prediction of the behaviours of agents in the microworld. These activities would allow the learners to present their current thinking process. 2) The Evaluation Phase: the objective of this phase is to let the learners evaluate their prediction results and observe the outcomes generated by a simulation system. The learners can compare the two results to find out which are similar or different. 3) The Self-monitoring Phase: if the comparison results from Phase 2 are different, it implies that the thinking process of the learners and the simulation's mechanism are different. The learners might feel surprised at this and they would then like to know what caused the different results. In this way, the learners start to monitor their own thinking process. They can modify the simulation's parameters to test their hypothesis. Thus, the awareness of their thinking process has begun. Our research hypothesis is that surprise will be a good learning trigger to deepen self-awareness of a person's thinking process and will cause them to reflect on their own behaviour if they are ever in an actual emergency situation.

Keywords: self-awareness, emotion-based decision-making model, microworld, surprise, learning platform

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Table 6-14 Rules for categorizing alternative in to categories. There are four categories: top candidate path, candidate path, ignored candidate, and the rest candidate categories. For the *top candidate path* category, this category represents alternative paths that are accepted for both escaping and helping risk estimations. For the second category, the *candidate path,* this category represents alternative paths that are accepted only either the escaping or helping risk estimations. For the third category, the *ignored candidate path*, this category represents too dangerous or useless candidate paths. Too dangerous path means a path that there is a fire right next to current location. Useless path means a path that there is neither any exit for escaping, nor handicapped for helping. For the forth category, the *rest candidate path*, this category represents the leftover of the *top candidate path, candidate path,* and *ignored candidate path* categories. These categories are ranked from the most to the least preferable as *the top candidate path, the candidate path, the rest candidate path,* and *the ignored candidate path* categories, respectively. 67

Table 6-15 Criteria for an agent to select its best alternative when there are multiple alternatives. If the agent has escaping intention, the criterion is to select the alternative that has the least distance to exit. On the other hand, if the agent has helping intention, the criterion is to select the alternative that has the least distance to the handicapped. 69

Table 7-1 Overview of the learning course. It is divided into three phases: pre-learning, main-learning and post-learning phases. The pre-learning phase aims to shape the mutual understanding of the scenarios of emergency we used in this research, and seed the curiosity about their behaviors if they were in the emergency themselves. The main-learning phase aims to let the learners explicitly express their prediction toward the given phenomenon. Questionnaires are used to guide the learners to think deeper. The post-learning aims to motivate learners to realize of their thinking process. A set of questionnaires are carefully selected to guide learners to question their thought. 73

Table 7-2 There are seven factors that are required the learners to make their predictions. The factor no1 and 2 is number survivors and deaths representing number of agents that successful and failed to escape to an exit, respectively. The rest factors, no.3-7, are better to be described with Figure 7-6 86

Figure 7-6 Example situation that an agent tends to help a handicapped. The counter of *helping intention* factor*,* factor no.3 in Table 7-3, is increasing whenever there is an agent have an intention to help a handicapped. If the agent can reach to the handicapped, the counter of *accessible help* is increased (factor no.4.) Moreover, if the agent and the handicapped manage to escape to an exit successfully, the counter of *success escaping* is increased (no.5.) On the other hand, if the agent cannot reach to the handicapped, the counter of *failed access* is increased (no.6). If the agent can reach to the handicapped (no.4), but they are failed for escaping (no.7), the counter of *failed escaping* is increased. 87

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Table 8-1 Overview of the whole processes in this learning course. There are three phases: 1) pre-learning phase, 2) main-learning phase, and 3) post-learning phase. The purpose of the pre-learning phase is to describe overview of learning tasks and describe the simulated emergency scenarios to the learners. The purpose of the main-learning phase is to let the learners make their predictions of the simulation. The purpose of the post-learning phase is to evaluate whether the learners are motivated to be aware of their thought. 98

Table 8-2 Setting for the *simple scenarios*. Learners are requested to set number of each type of agent as showed in the table and make their predictions from question no.5 to no.10. Each situation there are only two types of agent at a time. 107

Table 8-3 Setting for the *complex scenarios*. Learners are requested to set number of each type of agent as showed in the table and make their predictions from question no.11 to no.18. These scenarios consist of all types of agnet. 112

CHAPTER 1 INTRODUCTION

Self-awareness is an important skill that an individual requires in daily life. It is even more important in a critical situation since it may imply the difference between life or death. However, it is difficult to realize the nature of one's own thinking process without help. It is true that people may have knowledge which is useful for a certain situation; however, they may fail to apply the knowledge to solve the problem they are encountering. For example, people may know that competing with others trying to exit at the same time clogs up the evacuating flow (Fahy R. F., 1997; Kobes M. a., 2010); closing doors and windows in a building during a fire evacuation are a good method for stopping a fire from spreading (Kobes M. a., 2010; Hasofer, 2006). However, many people may still behave improperly and emotionally when they confront an actual situation. There is a term to describe this phenomenon which is known as "knowledge-to-action gap (Tanaka, 2015)." To reduce the knowledge-to-action gap, it is important for people to be aware of how they think or behave, and try to lessen mistakes caused by these gaps.

One of the possible reasons for the knowledge-to-action gap is that ordinary people may not have many opportunities to understand their decision-making process, and how their decisions affect their behaviour. Unlike the emergency services, such as the police, fire fighters, and rescue teams who have been trained to cope with emergency situations, ordinary people tend to behave inappropriately in such situations. In this research, we make the assumption that emotion can affect decision-making and behaviour. Figure 1-1 presents concepts showing that people may have important knowledge (solid-oval A), for a certain situation. Based on this knowledge, a person is expected to perform an *expected action 1* (solid-oval B.) However, with too much emotion in the emergency (dash-oval C), the emotion causes a person to behave emotionally as *actual action 1* (dash-oval D.) The knowledge-to-action gaps in this figure is the difference between *expected action 1* (solid-oval B), and *actual action 1* (dash-oval D).

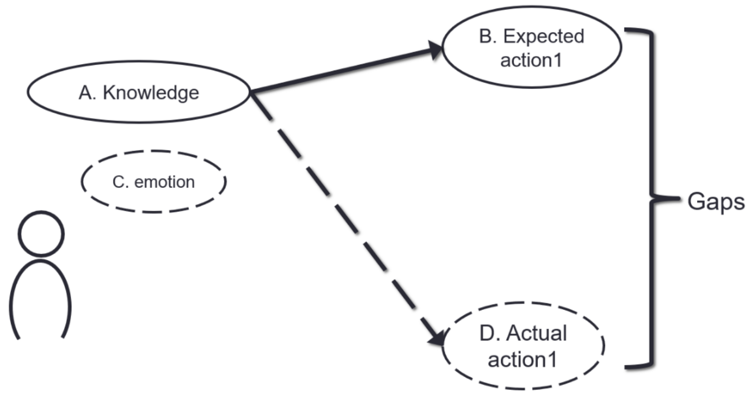


Figure 1-1Knowledge-to-action gaps. A person has knowledge (solid-oval A) to solve a problem in a certain situation. He is expected to perform expected action 1 (solid-oval B) to handle that situation. However, with too much emotion (dash-oval C), that person perform actual action 1 (dash-oval D) instead. The knowledge-to-action gaps is the difference between *expected action 1* and *actual action 1*

We hypothesize that awareness can be used to balance the emotion. We use the term "balance" since emotion does not always imply to cause inappropriate performance. For example, in an indoor fire emergency, we often hear that evacuees may be stronger than usual in moving obstacles or carrying heavy objects during their escape. If a person can balance their emotion so that it does not reach an extreme level, they can balance their decision-making by taking into account what is a rational response and also what is an appropriate level of emotion. Thus, their actions which are the result of their decision-making process may not lead them into a dangerous situation.

Figure 1-2 shows the research hypothesis of how gaining the self-awareness ability could reduce the knowledge-to-action gaps caused by too much emotion. From the figure, suppose that a person has *knowledge* (solid-oval A) to solve a specific problem. With this knowledge, he is expected to perform *expected action 1* (solid-oval B) to handle that situation. However, with too much *emotion* (long-dash oval C), that person emotionally perform an *actual action 1* (long-dash oval D) instead. Our hypothesis is to gain *self-awareness* (short-dash oval E) for making that person to have better controlling his emotion. As a result, the person may perform an *actual action 2* (short-dash oval F.) The *actual action 2* is more similar to the *expected action 1* (solid oval B) than the emotional *actual action 1* (long-dash oval D) which influenced by emotions. As a result, the figure shows the idea of how self-awareness less the knowledge-to-action gaps.

It is important for people to be able to apply the right knowledge for the situation and also to improve their self-awareness which is part of the thinking process. However, self-awareness is very difficult to cultivate, because mental processes are implicit and vague.

Thus, our objective is to cultivate self-awareness in order to lessen the knowledge-to-action gaps.

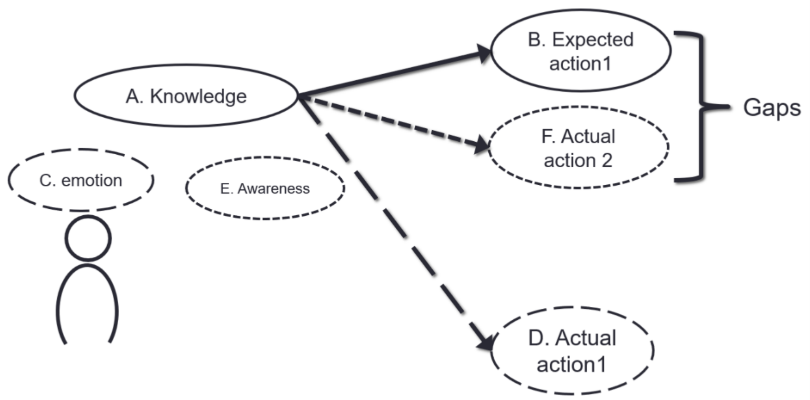


Figure 1-2 Gaining self-awareness ability (dot-oval E) to reduce the knowledge-to-action gaps caused by too much emotion (dash-oval C). With awareness, a person can apply his knowledge while balancing it with his emotion. As a result, the person performs *actual action 2* (dot-oval F.)

1.1. Research motivation

This research aims to reduce the knowledge-to-action gaps. Our belief is that by increasing self-awareness these gaps will be reduced if we are aware of our thoughts and if we do not let too much emotion affect the decision-making process. This research makes the hypothesis that *surprise* could be a good trigger to increase self-awareness. The definition of *surprise* in this research is a representation of difference between expectations and reality (Casti, 1994; Lorini, 2007). Based on this definition, there are two personal reasons to support this hypothesis and to enable this research to be conducted: 1) an unexpected situation can cause us to be more aware of what we are doing and to help us use the right knowledge when we encounter a particular problem, and 2) an unexpected situation can enhance cognition which is closely related to self-awareness.

1.1.1. An unexpected situation can motivate awareness

The author's mother experienced an indoor fire when she was young. That indoor fire incident could be considered as a negative surprise for her. As a result of this experience she is very aware of the risk of fire, even if there is nothing to be worried about. She is always ready to face an unexpected fire incident. Unlike the emergency services such as fire fighters, those people have been trained repeatedly to make them to be aware to cope with the emergency fire situation. Moreover, there are stories of people or animals that they have lesion learns from their unexpected failure experiences. These experiences can make people aware of possible risks and how to respond to similar situations effectively. They may even repeatedly imagine a particular problem, and try different ways to solve the problem in their mind. As a result, they may have a better idea of how to find the best solution to cope such a problem in advance.

If the stories mentioned above are considered as negative surprises, positive surprises could motivate people to be aware of their thinking processes as well. Such an awareness of our thinking processes is not only limited to only solving problems. People can learn and improve themselves every day. For example, people may feel impressed by being treated nicely by others unexpectedly as, for example, when a person is cheered up and encouraged when they feel depressed. Consequently, that person may become more aware of the power of speech. Thus, that person may be more careful about how they use words and try to encourage others to share their experience.

1.1.2. An unexpected situation can enhance cognition

This reason is based on a common phenomenon which is people have difficulty to recognize the common matters. For example, how many people can recognize what they ate for breakfast a week ago? How did it taste? However, many people may be able to recognize the taste of a particular dish that surprised them a long time ago. Another example is if you are walking along the street. Suddenly, a car honks its horn at you. This will make you remember this day for some time. Biological and medical studies show that this phenomenon is caused by the adrenaline hormone. It affects to our memory (FRANCISCO, 2013; William J. Cromie, 2004).

Cognition may not be directly related to self-awareness; however, it is related to improving self-awareness. If we define self-awareness as conscious knowledge of oneself or comparing our self-current status with our internal values (Duval, 1973), cognition is the important capability of retrieving information or knowledge for comparison. Without cognitive ability, we would be less able to be aware of ourselves since we would lower our ability to retrieve information or knowledge for the purpose of evaluation.

1.2. Research objectives

Based on the research question 'how to motivate self-awareness', this research makes the hypothesis that surprise could be a good activator to realize one's self-awareness. Individuals are often not aware how they will be able to cope with a particular situation and they often believe they can think appropriately without having any evidence for this. If individuals can observe their thinking process they will realize that the results of their thinking are not always reasonable; they will be surprised to discover that they are not good at thinking and then they will be motivated to cultivate their self-awareness of their thinking processes.

To evaluate the hypothesis, this research has set the following objectives:

1) To motivate learners to cultivate self-awareness of their thinking process in an emergency situation.
2) To propose a learning platform that uses *surprise* as a learning trigger for learners to be aware of their thinking processes.

As mentioned earlier, our hypothesis is that when individuals observe their thinking processes they may discover that the results of their thinking are not reasonable, then they will be surprised and motivated to develop a greater awareness of their thinking processes. The proposed learning platform provides a simulated emergency phenomenon. The phenomenon is a simulation of a human being in an emergency. There are four types of agent: rational, emotionally brave, emotionally selfish, and handicapped agents. Different types of agent behave differently based on the decision-making process. Learners are requested to make a prediction based on their reasons for their expected results of the phenomenon. This process will lead the learners to express their thoughts explicitly. After making their predictions, they run the simulation and observe the simulated results. Thus, learners can make a comparison between their predictions and the simulated results. Both similar and different comparisons will make learners rethink their thinking processes, especially when the comparison shows a difference. In this learning environment, learners will hopefully be motivated to become more aware of their thinking processes.

1.3. Research plan

The research proposes a learning platform using surprise as a learning trigger to motivate learners to be aware of their thinking process. In this research, the surprise is defined as a representation of the difference between expectations and reality (Casti, 1994; Lorini, 2007). The learning platform provides a set of learning scenarios to represent a simulated version of a certain phenomenon. In this research, the simulated phenomenon is human behaviors in an emergency. This research is limited to consider only two types of behavior as cited in Pan X.'s studies (Pan X. , 2006; Pan X. a., 2007). The behaviors are 1) escaping to the nearest exit or 2) helping others before escaping. However, the simulated phenomenon is designed to achieve our learning purpose. It aims to motivate learners to be aware of their thinking processes. The simulated phenomenon is designed with limited and controlled factors. It does not represent actual human behaviors in an emergency which is much more complex than this simplified simulated behaviors.

1.3.1. To use an indoor fire emergency as learning scenarios

An indoor fire emergency is selected over other natural emergencies: earthquakes, tsunamis, floods or other manmade emergencies: wars, car crashes, since an indoor fire shares mutual understanding more than others. People live and pursue their daily activities in buildings such as living at houses or apartments, working at office buildings and shopping at department stores more than ever since the massive development of cities. It is a global phenomenon. People may not have direct experience of an indoor fire emergency; however, most can imagine what an indoor fire would be like. Unlike other emergencies or disasters, people in some areas may not have experienced earthquakes, tsunamis or wars for generations. They may know those emergencies' definition; however, it is hard for them to imagine the exact circumstances of such emergencies. As a result, an indoor fire emergency was selected as our learning scenarios since learners are able to imagine how they would cope with such situation. On the other hand, earthquakes, tsunamis or wars are not suitable for our learning scenarios since the gap between knowing the actual situation and our experience is too large.

In an indoor fire emergency, we can assume that evacuees want to escape through an exit to find a safe place as soon as possible. However, many behaviors could occur in such a situation. For example, altruism, competitive, and leading-following behaviors (Pan X. a., 2007). Helping others could be considered as a form of altruistic behavior. This type of behavior is selected since it can represent a critical situation in which we have to make a decision to help others or to escape. This kind of situation is not limited to indoor fire emergencies, but also occurs in daily life. Moreover, it is simple enough to understand the feeling of preferring to help others who need help. This preference for helping others can be defined as a factor in the simulation. The helper goes to one who need help, then both of them escape together. Learners will be able to accept this concept easily. Other types of behaviors such as competitive behavior or leading-following behavior are more complex than helping behavior. Learners may have diverse opinions of competitive activities. For example, what would be the outcome of competition: fighting, running away, or leading-following behavior. Therefore, helping behavior is a better option since learners are more likely to have a mutual understanding of the learning phenomenon.

Other behaviors might be considered for motivating learners' to be aware of their thinking processes. For example, most people know that we should lower our head to avoid smoke while escaping from a fire in a building. However, this kind of behavior relies largely on our senses of smell and vision. Without those senses it is difficult to conduct a learning scenario to motivate the learners' awareness.

1.3.2. To provide a learning platform aiming to let surprise occurred

As mentioned previously, the objective of this research is to propose a learning platform using surprise to motivate learners' self-awareness of their thinking processes. The learning platform uses simulation to provide learning scenarios. The learning scenarios for this research are helping or escaping behavior by simulated agents in an indoor fire emergency. Learners are requested to predict and observe behaviors of three types of simulated agent: 1) a rational agent, 2) an emotionally brave agent, and 3) an emotionally selfish agent. The rational agent represents those who balance their emotions of preferring to help others or to escape. In other words, a rational agent is considered as an ordinary person and is used as a reference for other emotional agents. An emotionally brave agent represents a person who confident and optimistic. They may accept a bit more risk than a rational agent. An emotionally selfish agent represents a person who is more concerned about their personal safeness. They would help others only if they consider the situation is safe. However, they carefully estimate risks more than the other types of agent. The learning scenarios represent phenomenon for which all types of agent have the same knowledge of how to solve the problem: to help others or to escape. However, with different abilities to control their emotions, they let their emotions affect their decision-making processes differently. Since each type of agent has different criteria to make a decision, as a result, they behave differently even if they are in the same situation. However, the agent's decision-making process does not represent how an actual human being make a decision. These decision-making processes on the part of the agent are designed to allow different types of behavior to occur in order to achieve our learning purpose.

Learners are given an overview of the scenarios such as how many members there are for each type of agent. They are requested to predict the simulated outcomes and to explicitly describe the reasons for the prediction they made. Examples of prediction outcomes are: which type of agent attempts to help others the most, which has the highest number of successful escape, and so on. In this process, learners play a role as a simulated agent in the given scenarios. For example, if they imagine themselves as a rational agent and what decision would they make. On the other hand, if they are an emotional agent, brave or selfish agent, **what decision** would they make and **what reasons** do they give for their predictions. This process is designed to reflect their thinking processes.

Once the learners have made their predictions, they run the simulation and observe the simulated results. The learners are requested to compare their predictions with the simulated results. These comparisons may be similar or different. It is expected that the difference in the results between expectations and reality will surprise the learners. As a result of such surprises and carefully selected questions designed for guiding learners to be curious about why their predictions and simulated results are different, learners are expected to be motivated to questions their thinking processes by themselves. They can modify the simulation parameters to test their hypotheses and try to answer questions in their minds. As a result, they are expected to be motivated to realize on their thinking processes and ask themselves **why** they made the predictions as they did. More information is presented in chapter 3, methodology, and in chapter 7, learning material.

1.3.3. To expect learners being motivated to become more aware of their thinking processes

The expectation of this research is to provide a situation which leads learners to ***be motivated*** to realize on their thinking processes. It is not expected that every learner can fully and clearly realize how they thought or be able to explicitly describe their own thinking model. Our goal is to change learners' thinking status from not realize of their thought, to be curious and start making question on their thinking process by themselves.

Considering on our motivation of reducing knowledge-to-action gaps, the knowledge-to-action gaps means people may have knowledge to solve a problem, but they may fail to apply it to solve the problem when they are in the actual situation. This research assumes that too much emotion may affect one's decision-making process. For example, extreme emotional thinking may lead to a dangerous situation if a person fails to apply their knowledge to solve the problem.

Why does the failure happen? It could be because they are not aware, or they ignore their knowledge of how a certain action may lead to some situation. Why are they not aware of this? It is possible that they lack the self-awareness ability, or emotion may take place at the time they have to make a decision. The research selects learning phenomenon representing rational-emotional decisions/behaviors in an emergency situation. Learners observe the simulated agents which have a rational- emotional decision-making process, then reflect on how they would react themselves. As a result, they are expected to be motivated to increase their own self-awareness.

The correspondence between our designed learning scenarios and knowledge-to-action gaps are as follows: first is the corresponding of the knowledge. In this research, it is the perception of the learner toward being a rational, brave or selfish person, respectively. They can imagine that they have different degree of self-awareness which will allow their emotions to control their decision-making processes. For example, if the learner is a selfish agent, they may imagine that fear can control their decision-making process. As a result, they prioritize their safety-safeness first. Second, the corresponding of action, the learner makes a set of prediction results according to the given scenarios. The predictions could be considered as actions based on their perceptions toward different types of agent. Third, the corresponding of the gaps, as presented in Figure 1-1, the expected action (solid-oval B in Figure 1-1) represents the rational agent's behavior in the learner's mind. On the other hand, the behaviors of emotionally brave or emotionally selfish agents represent how emotions take control of the decision-making process (dash-oval B in the Figure 1-1.) As a result, learners can imagine the knowledge-to-action gaps between rational and emotional behaviors by themselves. With the comparison between their predictions and simulated results, they are expected to be motivated to realize of their own thinking process.

For example, if a learner believes that a brave person is one who tends to help others if possible, then typically, in that learner's mind, the more brave persons there are in the scenario, the more survivors there will be. If this learner expects more survivors in the actual emergency, this learner may emotionally take action to help or even ask others to cooperate with him/her to help those ones who need it. However, in some of our case studies, the results are not in accord with the learner's prediction. The greater the intention to help does not always result in a higher number of survivors. Thus, the learners are motivated to question their thinking processes to try to find out the possible reasons for themselves. As a result, the learners can find the reasons for this different comparison result and be considered as be motivated.

1.4. Significance and originality of the study

To achieve the objectives mentioned above, this research prepared simulated emergency scenarios for helping learners to cultivate their self-awareness. The scenarios involve a mixture of agents, who are rational and emotional, trying to escape a simulated emergency situation to reach a safe place. Learners try to describe their thoughts explicitly as predicted results, and then compare the actual simulated outcomes with their predictions. The comparisons will develop learners' awareness of their thinking processes. There are three major novelties in this research.

1) A novel learning platform: This learning platform uses surprise as a learning trigger for cultivating self-awareness. It encourages learners to question their thoughts. As a result, they will be motivated to develop a greater awareness of their thinking processes.
2) A Rational Emotional Decision-making model (RED model): The model describes how emotion has an impact on the decision-making process. It is used to represent how rational and emotional agents make decisions in given scenarios. However, its mechanism is hidden from learners since the objective is to cultivate self-awareness, not to judge its correctness. More detail of this model is presented in chapters 5 and 6.
3) A soft-half-baked microworld: this provides a simulated environment which is designed to follow a theoretical concept of a microworld. Its innovative points are described in chapter 4.

1.5. Dissertation overview

This dissertation will be divided into eight chapters. The chapters of this dissertation are presented as follows:

Chapter 2 describes the literature related to the research. The literature is reviewed according to various aspects: psychology, pedagogy, sociology, emergency behavior and computer science. The content will be described in terms of the relationship between self-awareness and learning, surprise and learning, emotion and decision-making, human behavior in an emergency, human behavior modeling, and software library packages for implementing the simulation system of this research.

Chapter 3 discusses the research methodology. The aim of this chapter is to propose a learning platform using surprise as a learning trigger for motivating self-awareness. It starts with analyzing the necessary components for the proposed learning platform and then explains the design of the learning platform itself and the design of the experimentation of the research. The learning platform is divided into three phases: the anticipating phase, the evaluating phase, and the self-monitoring phase. Then the design of *learning materials* is described. The context will give learners a better understanding of the learning tasks of the experiment they are going to be involved with. Finally, the design of the questionnaires is discussed.

Chapter 4 introduces the term microworld and its family. Next it describes the role of the microworld and its correspondence with learning. Then there is a discussion of the scope and limitations of the microworld. Finally, we propose our new category of microworld called the soft-half-baked microworld which will be used to handle the limitations of the microworld which is one of the original contributions of this research.

Chapter 5 presents our rational-emotional decision-making model (the RED model). This is a simplified emotion-based decision-making model. The role of this model is to perform as if it is the brain of each agent in the simulation. The model is a core concept to control the agent's behavior in the simulated environment. The structure of this chapter is an introduction of the RED model, objectives of the model, design of the model and design of the decision-making rules used with the model.

Chapter 6 focuses on describing how the RED model is related to the microworld and the correspondence between the RED model and its decision-making rules. Examples of many decision-making rules are presented in this chapter. The RED model and its rules represent a rational, an emotionally brave, and an emotionally selfish agents' thought. All agent types have the same decision-making mechanism, except for some criteria which rely to concepts of emotion. However, when emotion is involved in their thinking process, the agents may behave differently and, finally, the phenomenon of emergency behavior is presented.

Chapter 7 presents learning material that is used for the trial use case. It describes the content that learners received to participate in this research. Various contexts are presented to introduce learners to the problem, to seed curiosity toward the emergency scenarios in the learners' mind, how to use the agent-based simulation, how to modify the parameters, and how to interpret the educational information generated from the simulation. This chapter also include the questionnaires.

Chapter 8 discusses the experiment. It starts with describing the target respondents. Next is the setting of the experiment. The experiment is divided into three phases: pre-learning, main-learning, and post-learning phases. These three phases are divided into seven sub-processes. Finally, the results of the experiment are presented.

Chapter 8 is a summary of this dissertation. The significance of the research outcomes, the limitations of the study and the possibilities for future work are discussed, respectively.

CHAPTER 2 LITERATURE REVIEW

Literature reviews are divided into seven sections. Section 2.1 describes on definition of self-awareness and relation between self-awareness and learning. Section 2.2 discusses definition of surprise from different aspects, how the surprise happens, and how surprise could relate to learning. Section 2.3 describes on decision-making studies, summarization on decision-making modeling, and how emotion affects to decision-making process. Section 2.4 presents facts of human behavior under emergency, especially indoor and building fire emergency. Section 2.5 reviews on studies that focus on human behavior modeling. Section 2.5 presents software library packages which are used to implement a simulated system of this research. Section 2.7 is a conclusion and discussion.

2.1. Self-awareness and learning

Self-awareness is a conscious knowledge of one's own character, feeling, motives and desire; it happen when we focus on our attention on ourselves, we evaluate and compare our current behavior to our internal standards and values (Duval, 1973). It could be considered as one of metacognition. Flavell (1979) defined metacognition as knowledge about cognition and control of cognition. However, in another sense, self-awareness can be defined as a capability to identify oneself as an individual (Gallup Jr, 2002; Rochat, 2003; Boccia, 2006; Prior, 2008). For example, studies about animal to be able to identify itself with their reflection in a mirror. This research considers self-awareness from the former definition. Self-awareness does not occur suddenly through one particular behavior. It develops gradually through a succession of different behaviors all of which relate to the self (Bertenthal, 1978).

From the learning aspect, studies showed self-regulated learning is highly related to effective learning (Pintrich, 1990; Zimmerman, 2001; Ridley, 1992). Winne (1998) divided it into four-stages of studying: task definition, goal setting and planning, enactment, and adaptation. For the last stage, adaptation could be considered as self-awareness, learners evaluate their performance, may be motivated to change their belief, determine how to modify their strategies to achieve the higher performance. Applying self-awareness and self-monitoring is to develop independent learners who can control their own learning and learn how to learn for life (Papaleontiou-Louca, 2008). Thus, motivating self-awareness could keep one to be conscious and improve learning.

Authors believe that surprise caused by self-awareness could be a good activator for learning. We do not aware how we can think/behave to cope with a situation and often believe we can think appropriately without evidences. If we can observe our thinking process and realize that the result of our thinking is not reasonable, we will "surprise" that we are not good at thinking and will be motivated to cultivate the self-awareness of thinking process.

2.2. Surprise and learning

Surprise can be considered in various aspects. Some studies considered surprise as belief-based experience that one may feel toward unexpected events (Lorini, 2007). Other studies viewed surprise as one of emotion (Gendolla, 2001; Maguire, 2011; Ekman, 1983). It could be considered as a physical response of emotion like startle (Lewis, 2012). On the other hand, some studies proposed it is a bridge between cognition and emotion (Mellers, 2013). Casti (1994) defined surprise that it represents difference between expectations and reality. In this research, surprise is an unexpected matter and not relate to physical response such as startle.

Based on Expectancy Violation Theory (EVT), surprise occurs due to a violation of expectancies (Burgoon, 1976). Whenever it is occurred, it often affects our life. Surprise could enhance credibility, power, attraction and persuasiveness in both positive and negative approach (Burgoon, 1976). People are often more persuaded by surprising argument (Petty, 2001). People even learn more with surprising information (Rescorla, 1988).

Considering from learning aspect, incidental learning is highly related to surprise. The learning is often the result of a significant or unexpected event (Carter, 1996; Menard, 1995; Marsick, 2001). Surprise is also considered to make people aware of their own ignorance, and the acknowledgement of the ignorance can lead to new knowledge (Gross, 2010). The concept of surprise, as inconsistencies between known and unexpected matter, can be applied to surprise-based learning for robotics (Ranasinghe, 2008). Moreover, surprise could be considered to enhance cognition. When ones experience a new event within a familiar context, ones would store this event in memory easily (Fenker, 2009). Based on these studies, they showed that surprise is a promising factor for enhancing learning and cognition.

2.3. Emotion and decision-making

Rational could mean a formal process based on optimizing utility (yotard, 1994). Rational thinking is considered that there is no room for emotion (Livet, 2010). In this research, rational thinking means a thinking process that is not biased by emotion or feeling. An individual makes a decision based on maximizing the result that is set by its criteria. On the other hand, emotional thinking is often considered irrational occurrences that may distort reasoning (Barnes, 1996). Research studies showed that emotions affect decision in many ways. For example, fearful person makes pessimistic judgment of the future events (Lerner J. S., 2000) while frustrated anger person makes optimistic and more likely to choose high-risk (Leith, 1996). Happy people tend to decide against gamble since they would like to maintain their happiness feeling (Isen, 1983). Last but not the least, emotion may not always affect decision in the same approach. Raghunathan (1999) showed effect of negative emotion toward decision-making. They found that different types of negative mood affect decision-making differently. Unhappy or sadness caused people to prefer high-risk, but anxiety caused people to prefer low-risk. With these examples, we can realize that emotion and decision-making are related to each other; on the other hand, they are complex and difficult to be defined as equations or rules. We can model them as concept instead.

There are research studies have tried to model decision-making process. Firstly, we will focus on what is a model of general decision-making process. After that we will focus on how emotion can engage decision-making model. A general decision-making model, a well-known one is GOFER (Mann, 1988) which was based on the earlier research conducted with psychologist Janis (Janis, 1977). GOFER is divided into five-step process as following:

1) **G**oals clarification – for setting objectives considering to making a decision
2) **O**ptions generation – for considering available alternatives
3) **F**acts-finding – for retrieving or searching for related information
4) Consideration of **E**ffects – for weighting positive and negative for each alternative
5) **R**eview and implementation – for planning how to implement and implementing them

Similarly, in 2008, another general decision-making model was proposed. It is named DECIDE (Guo, 2008). This model is divided into six-step processes.

1) Define the problem
2) Establish all criteria
3) Consider all alternatives
4) Identify the best alternative
5) Develop and implement a plan of action
6) Evaluate and monitor the solution

There are other research studies proposing similar general decision-making model with more details. (Pijanowski, 2009) proposed a model which is divided into eight-step processes.

All of them share many commonalities. However, these models present on regular decision-making model. None of them consider emotion into the model. In psychological domain, (Lerner J. S., 2015) proposed a model of how current emotion and incidental factors affects the traditional rational decision-making. Other studies in both psychology and cognitive sciences showed that emotion could change a person's decision-making and behavior (Barnes, 1996; Leith, 1996; Lerner J. S., 2000).

2.4. Human behavior under emergency

Emergency is a critical situation. It can harm lives and properties. Emergency can be considered in wide range. Natural, manmade, etc. This dissertation would focus on indoor emergency, especially on building fire since it relates to our daily life the most which is the domain this research trying to attack.

In building fire, the most injuries and fatalities occurred since evacuee were not aware or overlooked vital information (Hasofer, 2006). Many tragedy cases happened because restricted information. For example, ones might not notice the emergency exit sign nearby, then tried to use the familiar path which was more dangerous (Kobes M. a., 2010). They could not access necessary information while escaping (Grosshandler, 2005; Kobes M. a., 2010). However, there were cases that even the evacuees had that vital information, but they decided to ignore the information since they believed it was abused (Wilson, n.d.). This kind of behavior could be considered as they were not aware how important of that information.

In the past, there were arguments about whether evacuees were panic in the emergency or not. Research studies investigated on these issues and found out that there is no proof the presence of panic in case of major disaster (Sime, 1980; Heide, 2004). People were rational under emergency. The irrational behavior caused by lacking essential information in hand at that time. As a result, people had a tough time to make a good decision (Kobes M. a., 2010). Based on interviewing, the studies show that people were rational even they thought they were panic (Fahy, 1997; Kobes, 2010; Fahy R. F., 2012). They reacted based on information they had at that time.

2.5. Simulated emergency and decision-making implementation

This section would like to mention and give them credit on related software packages. The simulation system was created through concept of Microworld. It will be described in detail in chapter 4. The simulation system was implemented by Python programming language (Python, 2017). It was relied largely on two main library packages named Mesa and PyKE. Mesa package is an Agent-based modeling package (Mesa: Agent-based modeling, 2016). It was first introduced in PyCon 2016. Mesa, in this research, is a core engine for implement Microworld. Its role is to create simulated space and agents, control timing, and display of visualization, PyKE package is a knowledge engine package (PyKE, 2010). Decision-making rules were defined with PyKE for implementing our emotion-based decision-making model. The decision-making model was considered as a brain of agent in Microworld. Different types of agent - rational, brave and selfish agent - behaved differently since they had different criteria defined in the decision-making rules.

2.6. Modeling of human behavior

This section aims to describe 1) facts of human behaviors that would be useful for ones who intend to model them, 2) literatures on research studies which are related to human behavior modeling.

Human behavior under emergency, from psychological and sociology, is considered into three levels: individual, interaction among individuals and group (Pan X. , 2006; Pan X. a., 2007). For the individual level, ones could make a decision by instinct, experience or rational thinking. However, decision-making in emergency is difficult. The situation is considered as higher stakes, higher uncertainty and limited time (Proulx, 2002). Females generally move slower than males, adults move faster than children (Fruin, 1971; Bryan, 1999). For the group level, if the group are separated i.e., family, the individual members may seek to reconstitute the group before exiting which is make contrary movements and impeding the evacuating flow. Group with hierarchically organized such as partents and child probably behave differently than those who are not (Pan X. , 2006).

This section concerns on human behavior modeling in two aspects: 1) observing human behavior for creating a model, and 2) implementing a model for simulating a phenomenon. From the first aspect, there are many appraoches to observe human behavior. Drill can be one of them (Kobes M. a., 2010). Even though, observation by drill approach can get the result similar to the actual situaion, unless there is announcement in advance. However, drills require a lot effort to setup the environment concerning safety of participants, labor intensive (Kobes M. a., 2010). As a result, it is difficult to repeat the experiment. Computer-based simualtion is an alternative approaches. Virtual Reality (VR) could be a promising approch (Reznek, 2002; Tang, 2009). Researchers can ask ones to participate and obsesrve their reaction from using the system with less risk, and the experiment is repeatable. However, reaction would depend on how realistic the model is. It highly relies on modeler's skill. On the other hand, for the second aspect, implementing a model to simulate the phenomenon, mostly are in computer-based appraoches. Helbing (1992) modeled an evacuating behavior to simulate a situation that a crowd of people try to exit the building as fluid particle. However, human behavior is not as fluid, it is more complex and cannot represented by mathematic (Still, 2000). Pan X. (2006) conceptually modeled human and social behavior from philosophy point of view. Agents can interact by single individual, interact between individuals and social interaction.

2.7. Conclusion and discussion

This research presents literature reviews on various related research domains such as psychology, pedagogy, sociology, emergency and computer science. From the studies, section 2.1, self-awareness is discussed of its definitions from various aspects. Relations between self-awareness and learning are presented for supporting our hypothesis that surprise could be a learning trigger. Section 2.2 discusses about surprise. Studies showed that surprise would relate to learning and cognition. Section 2.3 is about relation between emotion and decision-making. This section begins with two parts. The first part describes on studies related to regular decision-making models. The latter part describes on how emotion could impact on regular decision-making process. Section 2.4 describes facts on human behaviors in emergency, especially indoor and building fire emergency. Section 2.5 presents studies that relate to human behavior model. There are human behavior modeled from psychological point of view; research activities trying to capture human behavior, such as drill or virtual reality, for designing model; and simulation that focuses on represent emergency phenomena. Section 2.6 describes software packages used for implementing the system of this research.

CHAPTER 3 RESEARCH METHODOLOGY

This chapter describes outline of research methodology. It shows overall processes of the research conduction. Figure 3-1 shows an outline of research methodology. There are divided into four major steps. First step is to state problem. The problem can be considered as research problem and learning problem. The research problem is *“whether surprise can motivate self-awareness”*. The learning problem is *“people are not aware on their thought.”* Second step is to setup research goals regarding the problem defined in the first step. The research goal is to propose a learning platform using surprise as a learning trigger to motivate self-awareness. Thus, it can verify that whether surprise can motivate self-awareness or not. The learning goal is that learners are motivated to realize their thinking process on to topic of human behavior under emergency. Third step is designing of experiment. This is the main idea that will be described in this chapter. Finally, the forth step is designing how to evaluate the experimentation.

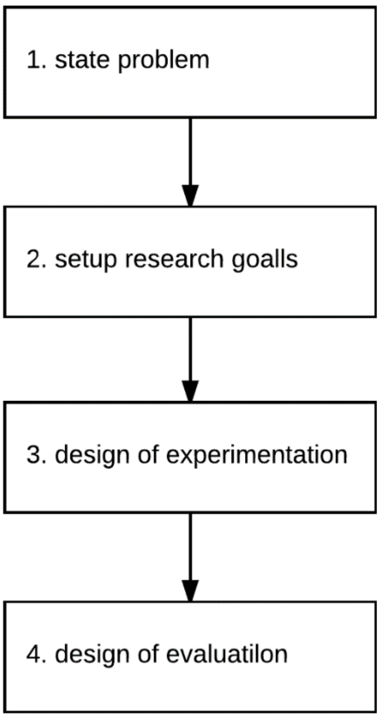


Figure 3-1 Outline of research methodology

3.1. Designing of the experiment

This section would like to describe an experiment design in mixture of top-down and bottom-up style. It will start with analyzing necessary element to achieve the goals. This is presented in section 3.1.1. This step is described in the top-down style. It starts with the objectives or goals, next is to tracks down what pieces of information that are required. Next is how to design the learning platform that uses surprise as its learning trigger. This step assembles components analyzed from section 3.1.1 to generate the learning platform, as bottom-up style. Finally, the design of the whole experiment including the designed learning platform mentioned earlier.

3.1.1. Analyzing necessary components for design an experiment

According to the first and second steps in the methodology outline in Figure 3-1, the research goal is to propose a learning platform using surprise as a learning trigger to motivate self-awareness. It is the learning platform that will be described in this section. First of all, the necessary component is ***the scenarios that learners can observe*** for performing the experiment. This research selects a scenario of building fire emergency. The reason to select emergency is that many people have knowledge-to-action gap in this domain. They may have knowledge to handle the emergency situation. However, when they have to encounter the actual emergency, they may not perform well as the knowledge they have. The scenarios show phenomenon of agents trying to escape the building as soon as possible. However, since there are various types of agent in the building, each of them may behave differently.

The research goal stated that it would like to motivate self-awareness. It means there is an expectation that the motivated learners know or realize the reason why they have a thinking process as they are. It is a meta-thinking. That means it is necessary for the learners ***to know what the results of their thought is*** first. Without knowing it, they cannot trace back to find reasons why they have thinking process as they have.

To propose a learning platform using surprise as a learning trigger, surprise means unexpected matter as mention in chapter 1. That can be considered that ***there is a comparison*** between the learners' thought and another alternative. Thus, this ***alternative opinion*** is a necessary component as well.

In conclusion, the pieces of information that the experiment required is: 1) phenomenon scenarios for learners to observe, 2) what is the result of their thought regarding to the phenomenon, 3) alternative thought or opinion toward the same phenomenon, 4) comparison between learner's thought and the alternative one.

3.1.2. Designing a learning platform using surprise as a learning trigger

According to the necessary components referred in the last section 3.1.1, the learning platform could be as depicted in Figure 3-2. The learning platform is divided into three phases: 1) anticipating phase 2) evaluating phase and 3) self-monitoring phase (Damrongrat, 2017).

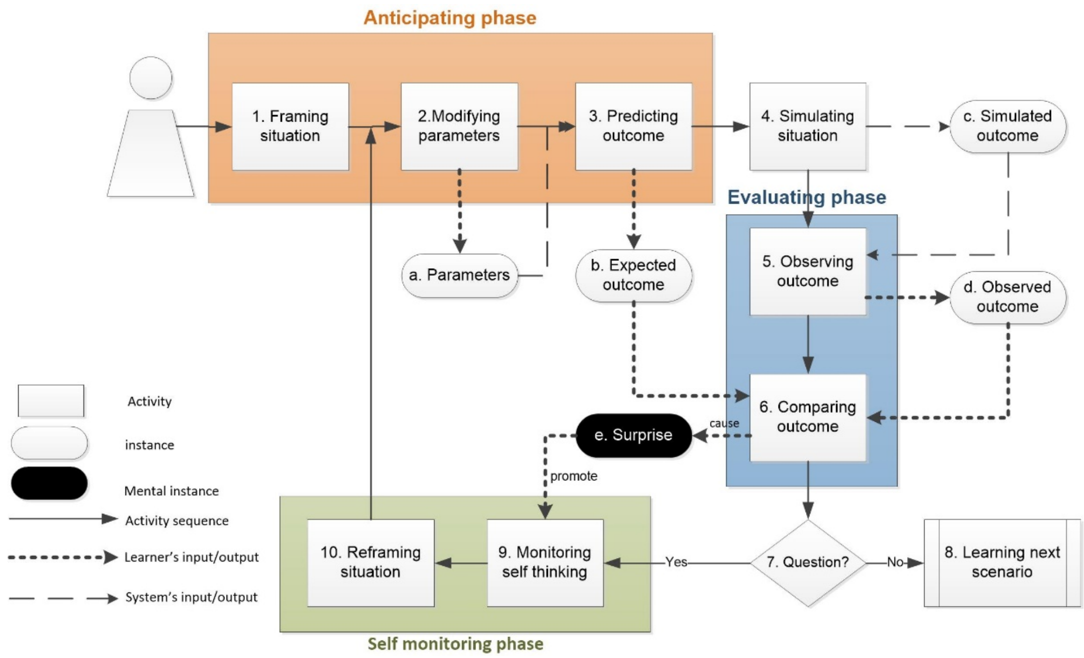


Figure 3-2 Outline of the proposed learning plat form using surprise as its learning trigger for motivating self-awareness

Regarding to describe correspondence between the necessary components mentioned in section 3.1.1, and the outline in Figure 3-2, phenomenon scenarios are generated by simulation as the component no.4 in the figure. The result from the learner's thought regarding to observe the phenomenon is learners' prediction about how the does simulation go based on their opinion. It is presented with b) expected outcomes in the figure. Alternative opinion of the same phenomenon is presented as d) observed outcomes. Finally, the comparison between the learner's thought and the alternative is presented as module 6) comparing outcome in the figure.

The anticipating phase is to allow the learners to express their thought toward the phenomenon explicitly. This phase will make them know what the result of their thinking process is. The evacuating phase is to allow the learner to compare their opinion with the alternative opinion or simulated outcomes in this research. Learners could find out what the differences are and what the similarities are. Surprise is considered happened if those comparisons are different since the surprise here is defined as unexpected matters. We wish the surprise could promote learners to deepen their thought to find out why the comparisons are different. As the result, it motivates learner's self-awareness.

3.1.3. Designing an experimentation

The learning platform in section 3.1.2 alone cannot make the experiment complete. Table 3-1 shows the outline of the research methodology. It is divided into three phases: pre-learning, main-learning and post-learning. Each phase has its own goals, learning contents and learning activities.

Table 3-1 Outline of research methodology.

Phases	Order	Goal	Learning material	Learning activity
Pre-learning	1	a) Introduce objective of the learning b) Introduce concept of rational and emotional decision making c) Seed curiosity on self-awareness	a) Video and text of emergency scenarios: to seed curiosity in the learner's mind	Motivate learner to realize loss in emergency (15 mins)
Main-learning	2	d) Explicitly describe learner's prediction e) Let surprise happens to trigger learners to be aware of their thought f) Reflect learners thinking process	b) Explanation of using the simulation (microworld) with example	Understand how to interact with the microworld (10 mins)
	3		c) Run the soft-half-banked microworld with the RED Model	Set parameters and express the expected results (15 mins)
	4			Run the simulation (the microworld) (10 mins)
	5		d) Questionnaires I: to guide learners to give reasons for their predictions	Compare expected results and actual results (15 mins)
	6			Aware difference and similarity and expected surprise happened (20 mins)
Post-learning	7	g) Evaluate results of learning	e) Questionnaires II: to guide learners to be aware of their thought	Reflect on self-awareness (25 mins)

For pre-learning phase, its goals are to introduce the objective of the learning, introduce concept of rational and emotional decision-making since it is related to the experiment contents, and to seed curiosity about self-awareness to learners' mind. To achieve these goals, some learning contents are prepared. For this phase, the learning contents are content describing about the emergency. These contents are important since learning outcomes achieved through Microworld depend largely on the surrounding instructional activities

(Miller, 1999). The content can be mixture of text, photos and videos. With these contents, learners are expected to understand what kind of emergency look like and be motivated to realize about loss in the emergency.

For the main-learning phase, this phase mainly applies the learning platform described in the last section 3.1.2. Goals of this phase are to allow learners to explicitly describe their prediction about how the simulation would be based on their own opinion. Then observe the simulation outcomes and compare them with their prediction. If the comparison is different, we expect surprise could happen at this step and motivate them to realize on their thinking process. The learning contents could be an explanation about how to use the simulation (term Microworld could be considered as a simulation at this time, it will be described again in detail in chapter 4. The explanation includes how to modify parameters relating to the simulation. Learners can modify parameters and observe the phenomenon changes as they please.

For the post-learning, the goal is to evaluate the experimentation. It can be conducted by questionnaires. As a result, learners are expected to reflect their thought by themselves.

3.2. Designing of learning materials

Learning materials can be considered as an introduction of the experiment. It offers a big picture of the research topic to learners. In the experiment, we have to carefully select the content to make sure that learners can understand the topic they are engaging. In this section, the learning materials of pre-learning and main-learning, order 1 and 2,3 in Table 3-1, are presented.

3.2.1. Learning materials in pre-learning

It is a content presented in Table 3-1, order 1. We selected two news that relate to helping behaviors. The first one is a short video clip about a son notice that his mom got an electric shock. He tried to help his mom; however, both of them were dead at the end (see Figure 3-3). The objective of the first news is careless behavior may cost your life.

Figure 3-3 the learning material to allow learners to understand stand how important of self-awareness. The content of this news is a son noticed his mom got an electric shock, he tried to help her but both of them were dead

Another news is about a young cameraman felt guilty that he did not go and safe an old man who escaping Tsunami on 3/11. Instead, he filmed the event. However, after the video became well-known, a son of the old man made a contact to this cameraman. The son wanted to thank to the cameraman that did not go helping his father otherwise the cameraman may not be survived too. Moreover, at least the son knows what happened to his father (see Figure 3-4).

Figure 3-4 Learning materials to allow learners to understand how important of self-awareness. The content of this news is a young cameraman felt guilty that the did not help an old man escaping Tsunami on 3/11. He filmed the event instead.

This second news will pass to learners by narrative since the length of the video was too long which is not suitable for the experimentation. Moreover, the news is difficult to understand for the Thai respondents. The objective of the second news is to show that there are many aspects for the same event. Thus, we should not conclude thing too early.

In total, it approximately takes15 minutes for passing the learning material to respondents.

3.2.2. Learning materials in main-learning

This is a content presented in Table 3-1, order 2 and 3. In this phase, the main activities are: 1) explanation how to use the simulation system, 2) start the experimentation and ask learners to explicitly describe their predictions toward the given scenarios, 3) run the simulation and ask learners to observe the simulation outcomes, 4) compare their predictions and simulated outcomes, and 5) describe their opinion toward the differences and similarities of comparison.

1) Explanation to use the simulation system: the demonstration page was launched to allow the learners to understand how the simulation works (see Figure 3-5). Learner can modify parameters at the left-side bars. Red colour block represents fire. Fire will spread to neighbour area as time flies. Green colour block represents exit. If an exit is covered by fire, its colour becomes brown. Blue circle, orange circle and yellow circle represent rational-, emotional- and handicapped person, respectively. In this demonstration, there is no obstacles or wall for make it as simple as possible. Learner can modify parameters and observer how the simulation goes.

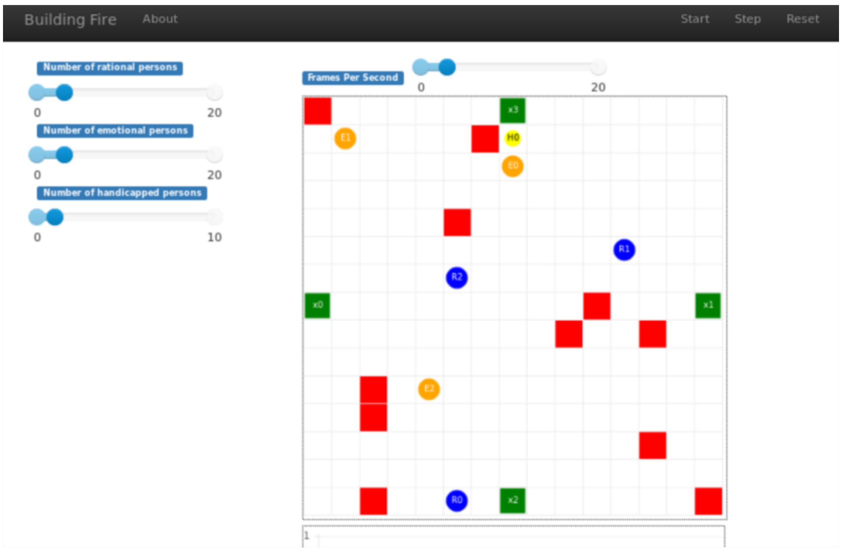


Figure 3-5 Demonstration's interface to allow learners to understand how the simulation work

2) Start the experimentation and ask learners to explicitly describe their prediction toward the given scenarios: the experimentation starts from this step. The simulation will open another version, not the demonstration (see Figure 3-6). The environment is bigger than the demonstration one. There are walls and more types of agent. The emotional agent will be classified as brave and selfish agent. Brave and Selfish agents are represented by orange and light blue colour, respectively.

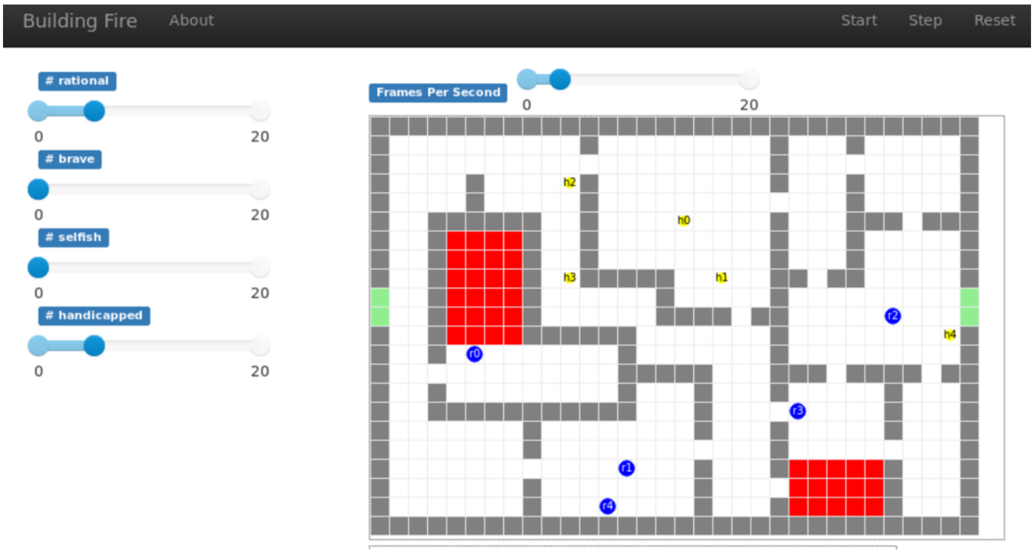


Figure 3-6 The experiment version's interface. There are obstacles and more types of agent

At this step, the tasks are divided into two sections. The first section considers on a single type of agent staying with handicapped (H.) The second section considers on mixture of agents together.

3.3. Designing of questionnaires

The questionnaire is designed to observe learner's thought and self-awareness. Its objectives are to allow learners to predict results of phenomena by given set of situations. Learners are requested to describe what their expected outcomes are and explicitly explain reasons behind those predictions. However, human being has limited capacity of cognition or working memory (Anderson, 2013; Miyake, 1999); especially, when engaging on rational processes (Barrett, 2004). By considering this constraint of working memory capacity, number of questions should be considered to prevent the respondents' interest drop. The questionnaire is divided into four sections.

- **The first section**: to collect general information such as age and gender.
- **The second section**: to monitor image of each agent type. Learners are requested to descending order agent types from ones who tend to have helping intention the most

to the least; and descending order agent type from ones who tend to have escaping intention the most to the least.

- **The third section**: this section is divided into two subsections. The first section, named Prediction 01, requests learners to modify parameters to create simple scenarios. There are three scenarios which each of them only allow handicapped type stays in the building with only another type. The objective of this setting is to make the scenario simple (see Table 3-2). Then learners are requests to make a prediction regarding given questions with reasons behind those answers. The prediction answers show what the learners are thinking, and reasons make the learners to think about their thinking. Questions in this section are as follows:
    - o Based on the given scenarios, please descendent order of the scenario that has the highest survival rate
    - o Based on the given scenarios, please descendent order of the scenario that *the handicapped* probably has the highest survival rate
    - o Based on the given scenarios, please descendent order of the scenarios that has the highest *helping intention* rate. (having helping intention does not mean the helping is success)

Table 3-2 Tasks Prediction 01 which aim to make the scenario simple. Handicapped agents stay with another agent type foe each time.

	Rational	Brave	Selfish	Handicapped
1	5	0	0	5
2	0	5	0	5
3	0	0	5	5

After finish prediction on the first section, then begin the second section, named Prediction 02. The second section requests learners to modify parameter again (see Table 3-3). There are two scenarios which each of them present scenario that mixture of all agents. The objectives of this setting is to make complex situation. Learners are requested to make a prediction regarding given question with reasons behind those answers. Questions in this section are as follows:

- o Based on the fourth scenario, please descendent order of the agent type that has the highest *accessible help* rate. (*accessible help* means that agent type can reach to the handicapped for helping, but it does not mean the helping is success)

- Based on the fourth situation, please descendent order of the agent type that has the highest *success escaping* rate to handicapped (*success escaping* means that agent can reach to the handicapped and they both can go to the nearest exit safely)
- Based on the fourth situation, please descendent order of the agent type that has the highest *failed access* rate (*failed access* means that agent can reach to the handicapped, but they are failed for escaping)
- Based on the given scenarios, increasing number of agents does matter to survival rate?

After learners answer the question, they can run the simulation and observe the simulated results.

Table 3-3 Tasks Prediction 02 which aim to make the scenario a bit more complex. All types of agent are in the map.

	Rational	Brave	Selfish	Handicapped
4	5	5	5	5
5	10	10	10	10

- **The fourth section**: it is to compare learners' prediction outcomes and the simulated outcomes. Its objectives are to allow learners to notice the similarities and differences between their thought and alternative opinions, and to allow them to think about their thinking process. The questions are as follows:
    - Please check the list of prediction that similar to simulated outcomes
    - Did you agree on the similarities? Why did you think like that?
    - Did you agree on the differences? Why did you think like that?
    - According to the comparison, please check the list of questions that make you curious to know the reasons behind
    - What did you feel toward those questions?
    - With the feeling from the last question, did it make you think about your thinking process?
    - Based on the experimentation, which steps motivate you to remind on your thought the most? (see Figure 3-7)

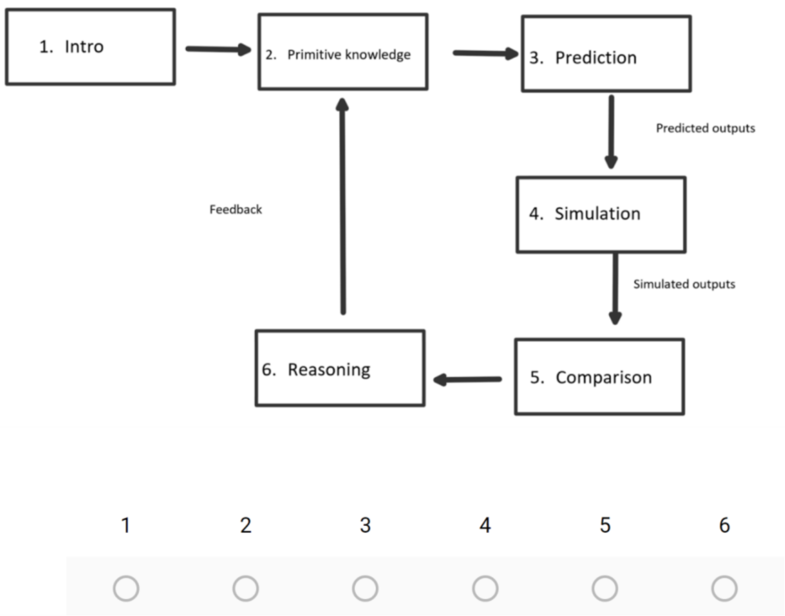


Figure 3-7 The outline of the experimentation process.

3.4. Conclusion and discussion

This chapter focuses on described how to design the research methodology. It starts with analyzing what are the necessary information required for making the experiment. Next is to describe how to cook those set of information to generate a learning platform using surprise as its learning trigger. Finally, the whole design of the research methodology.

Since this research related to many domain, there are some terms that are new in this chapter. However, it will be described in detail in latter chapters.

CHAPTER 4 MICROWORLD

4.1. Introduction

Microworld was first introduced 1980s (Papert S. , 1980) for simulating a programming for children. Microworld can be considered as a learning playground. It is well accepted for learning especially on physics and business domains (Miller, 1999; Smyrnaiou, 2012). Microworld always requires a learning model to achieve its learning goal. Learning subject always embedded into this learning model. Learners achieve the learning subject by try to understand the learning model mechanism. They would start learning by setup parameters, run a simulation and allow the specific phenomenon to take place. After that, they would observe that phenomenon and guess how the model mechanism works. The learners are allowed to modify learning parameters for testing their hypothesis, observe the phenomenon's changes. They can repeat these steps as much as they want to figure out how the model works.

The following contents in this chapter are as following. Section 4.2 is to describe the role of Microworld toward learning aspect. Section 4.3 is to describe on how many existing categories of Microworld family since 1980s until now. Section 4.4 is considering on the limitation on current Microworld family. Section 4.5 introduce our Soft-Half-Baked Microworld, which design to overcome the limitation mentioned in section 4.4. Finally, conclusion and discussion about Microworld in section 4.6.

4.2. Role of Microworld in the learning aspect

Microworld could be considered as a small, controlled space for a specific learning subject. It always requires a well-designed learning-subject model to guide learners to explore alternatives, test their hypothesis and discover learning content by themselves (Rieber, 1996; DiSessa, 2001). The learning-subject model in Microworld is a factor that makes the Microworld is different from game. A model-based inquiry learning is simulations that allow learners develop knowledge about a specific domain by using specific tools and methods, while games seem to bring forward intuitive knowledge since the learning goals usaually do not include systematically exploring and defining the underlying scientific model. Finally, learners tend to lose their learning goals to game goals while playing game (de Jong, 2008)

The role of Microworld is to provide a conceptual simulation representing a specific phenomenon. The learning subject will be difined as equations or rules and embedded into the model. Microworld would generate a simulation represeting a specific character based on those equations or rules. Learners can observe the phenomenon and guess mechanism that embedded into the model. Learners can modify learning parameters for testing their hypothesis, and observe the phenomenon chages. They can repeat the modification and observation as much as they want. With this method, learners deepen their thought for understanding how the model work. As a result, the learner can understand the learning subject by themselves. For example, (Miller, 1999) introduced Electric Field hockey (EFH) Microworld to undergrad students. The research team embedded equations of electric field into the model. Learners learned how the electric field works by observing phenomenon and modifying parameterrs.

For this research, Microworld represents human behavior under an emergency situation. Learners are expected to reflect their thinking process and to be motivated to improve their self-awareness after observing the phenomenon and modifying parameters. However, human behavior is subjective and difficult to be defined by euqations. It is a limitation of traditional Microworld. We will discuss about this limitation again in section 4.4. We also propose an solution, Soft-Half-Baked Microworld to overcome this limitation, which is described in section 4.5. Finally, the experimentation setup is described again in detail in chapter 7.

4.3. Category of Microworld

Until now, there are two types of Microworld. Each type has its unique characteristic and its own purpose of learning. More detail will be described in following sections.

4.3.1. Traditional Microworld

As mentioned previously, Microworld was introduced since 1980s. The learning subject are defined as equations or rules embedded into its learning model. Microworld would present a phenomenon regarding the equations or rules designed in the model. Learners are expected to understand the mechanism inside the model that makes the phenomenon happens. Learners can modify learning parameters for testing their hypothesis. Learners also observe changes of the phenomenon regarding the parameter modification. To understand how the model works, learners have to notice the relation between the phenomenon changes and parameter modification.

The key factor of this Traditional Microworld is the model has to be defined correctly since the equations or rules are the learning goals itself. Activities that learners can do are modified learning parameters, observing the phenomenon changes and guess how the model works.

In this Traditional Microworld, the role of a learner is an observer. Learners observe and guess on the mechanism of the model. They can try to test their hypothesis by modifying parameters and observing the results.

4.3.2. Half-Baked Microworld

If the Traditional Microworld is expecting a correct model, the Half-Baked Microworld is expecting an incomplete or incorrect one, intentionally (Kynigos C. a., 2007). Learners are also expected to understand the learning subjected embedded inside the learning model, the same as Traditional Microworld. As a result, the learning model is a well-defined by equations or rules, but they are allowed to be incorrect intentionally and let the learners correct them later.

The key factor for learning in the Half-Baked Microworld is the learners learn the subject by trying to figure out their understanding by operating and/or modifying the embedded incorrect model. There were research studies showed that the learning could be more effective if the learners change their role from an observer to a modeler. The deeper thinking process happened when they try to share their discovery to others (Harel, 1990; Papert S. a., 1991; Kafai, 1996).

The role of a learner for Half-Baked Microworld is a modeler. Whether or not they share their discovery to others, they have to think as a modeler to figure out the mechanism of the incorrect model. To achieve that, they can modify learning parameters to test their hypothesis as the same as Traditional Microworld.

4.4. Limitation of the existing Microworlds

Figure 4-1 shows shared character among Traditional- and Half-Baked Microworld. The learning subject is the equations embedded into the model itself. Learners are expected to understand it through observing phenomenon and modifying parameters of the model. Thus, the equations or rules should be well-defined. As a result, learning subject such as physics is suitable for both type of Microworld.

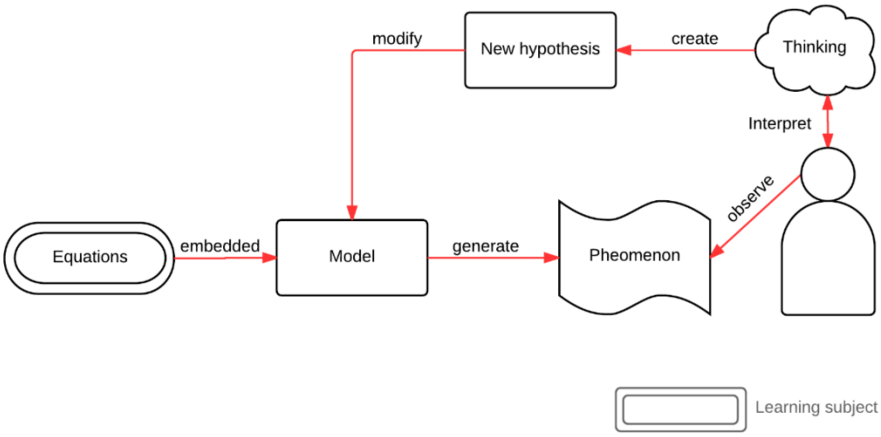


Figure 4-1 In Traditional- and Half-Baked Microworld, the learning subject is the equations which the learner is expected to understand. Thus, the model is required a well-defined equations or rules.

However, the learning subject might not necessary be limited only well-defined equations. For example, learning subject about human being's thinking process or decision-making process. These subjects are extremely complex and are difficult to model since there are many factors involves. Moreover, it may be different depend on person-to-person. This research would like to overcome this limitation. As a result, we propose Soft-Half-Baked Microworld which would be able to handle this limitation. It will be describe in more detail in the next section 4.5.

4.5. Soft-Half-Baked Microworld

We propose Soft-Half-Baked Microworld for overcoming the limitation mentioned in the last section. The learning goals of the Soft-Half-Baked Microworld is not that the learners can understand relation between phenomenon and equations behind the model, but it is the learners aware on their own thinking toward that phenomenon. It is focus on self-awareness because thinking process is different from person-to-person. Unlike physics subject which is related on a certain set of equations or rules.

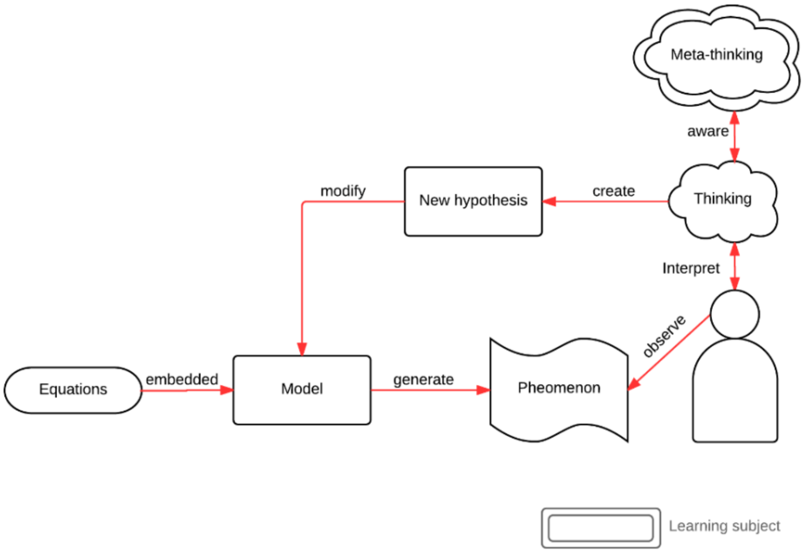


Figure 4-2 In Soft-Half-Baked Microworld, the learning subject is meta-thinking. Thus, the learners are expected to aware their own thinking process, not the equations embedded into the model.

As showed in Figure 4-2, the goal or learning subject is to be aware on self-thought. Learners are expected to realize on their thinking process by themselves through observing the phenomenon. Thus, Soft-Half-Baked Microworld prioritizes on allowing the phenomenon to take place. The learning model could be vague, since it could be representing an abstract subject. Learners are expected to observe phenomena and reflect something on their thought. For example, reflect on their thinking process related to the phenomena that are observing.

The key factor for learning in Soft-Half-Baked Microworld is a vague model. The phenomena generated by the model could be a specific phenomenon that is concerned. Real world phenomenon might be happened differently. Learners are expected to observe this phenomenon, monitor their thought toward that phenomenon and aware on self thinking process instead of understanding the model's mechanism. To enhance self-thought monitoring, learners could be asked to show their thought explicitly. For example, describing what they are thinking toward the observed phenomenon, and what the reasons that make they think as they claimed. For the learner's role, they play a role as reflector. They are expected to observe their own thought and to design their own new thinking if necessary. The learners are not expected to well-understand on the model's mechanism work.

In this research, we use "surprise" as a learning trigger. Our hypothesis is that "surprise" or "unexpected matter" could make learners make question to themselves and investigate on their own thinking process. As a result, they are aware on their thinking process better.

In conclusion, Table 4-1 shows the differences between these three types of Microworld. From the goal aspect, Traditional Microworld focuses the learner's understanding on how the model work. Half-Baked Microworld focuses on understanding the mechanism of the model as well, but the model is allowed to be incomplete or incorrect. For Soft-Half-Baked Microworld, it focuses on motivate learners on self-awareness instead of understanding the model's mechanism. From the learning model's aspect, Traditional- and Half-Baked Microworld are focus on a correct model and incorrect model, respectively. While Soft-Half-Baked Microworld allows the model can be vague or ambiguous. For the learner's role aspect, in Traditional Microworld learners play a role of an observer. They have to find relation between parameters modification and phenomenon's changes. For Half-Baked Microworld, learners are modeler. They try to figure out how to correct the incomplete model. If necessary, they might design their own model and share to others. For the Soft-Half-Baked Microworld, learners are reflector. They observe phenomenon, reflect on their own thought and redesign the new one if necessary.

Table 4-1 Aspects' comparison of Traditional-, Half-Baked- and Soft-Half-Baked Microworld

	Traditional Microworld	Half-Baked Microworld	Soft-Half-Baked Microworld
Goal	To understand how the model work	To understand the learning subject by an incorrect model	To motivate self-awareness by surprise without concern the correctness of the model
Keys of the learning process	• Correct model • Observe relation between parameter modification and phenomena • Guess how the model work	• Intentionally incorrect model • Deepen learner's thought by correcting the model to present correct phenomena	• Vague model • Explicitly show learner's thought • Create surprise by comparing learner's thought and simulation results • Use surprise to motivate self-awareness
Role of the learner	Observer – to observe relation of parameters and phenomenon	Modeler – to figure out how to correct the model	Reflector – to observe their own thought and to design their own new thinking

4.6. Conclusion and discussion

This chapter is focusing on describing the story of Microworld. It was first introduced since 1980s. Microworld is well accepted and used in learning domain especially on physics and business. It always requires a learning model to represent its learning subject. Learners are expected to understand the model's mechanism to achieve the learning goals. Based on this concept, the learning subject has to be defined by equations or rules. Otherwise, learners cannot verify whether they understand the model's mechanism or not.

There are two major categories of Microworld: Traditional Microworld and Half-Baked Microworld. The former one allow learner to guess on how the model work. Learner can modify parameters and observe the changes of phenomena. The latter one designs its model a bit difference. The model is intentionally designed to have some mistakes. Learners have to understand the model's mechanism to correct those mistakes. As a result, learners have chance to deepen their thinking process. Similar to the Traditional Microworld, Half-Baked Microworld's model has the same limitation that has to be defined by equations or rules.

To solve this limitation, this research proposes Soft-Half-Baked Microworld, a new category of Microworld. Instead of expecting a learner to understand how the model work, it is designed for expecting the phenomena happened. Its goal is to let learners to be aware on their own thought rather than well-understanding the model's mechanism. For this research, the expected phenomena are "unexpected matters" and "feel surprised." These would make learners make question to themselves and motivate them to develop a greater awareness of their thinking process.

CHAPTER 5 DESIGN OF THE RATIONAL-EMOTIONAL DECISION-MAKING MODEL

In chapter 4, we presented the difference between the traditional microworld and our soft-half-baked microworld. Generally, a microworld is a small and controlled simulated environment designed for a specific learning purpose. It always requires a learning model representing the learning of a subject. In the traditional microworld, the learning model is limited to the learning of a subject that can be well-defined by equations or rules. Learners interact in a microworld, which is considered as a simulation system, by modifying the parameters of the simulator and observing changes of the simulated phenomena. Learners are expected to understand the learning model's mechanism that causes the phenomenon changes when the parameters are modified. As a result, learners are expected to understand the equations that are embedded in the learning model. Thus, the traditional microworld is well-accepted in an educational situation, especially in physics since the learning content can mostly be presented in equations. On the other hand, our proposed soft-half-baked microworld aims to allow learners to become aware of their own thought. It is not prioritized on clearly understanding of the equations or rules embedded in the learning model. Since the aims are different, our soft-half-baked microworld is able to accept a learning model embedded with incomplete equations or rules. The goal of a learning model in a soft-half-baked microworld is to let the simulated phenomena occur. Learners observe the simulated phenomenon and reflect on them to become aware of their own thought.

This chapter presents the model we have designed for use with our soft-half-baked microworld. Since the learning scenarios of this research is a simulation of agents' behaviors in an indoor fire emergency, it is necessary to model how an agent would behave in such a situation. In this research, an action or a behavior is the result of a simulated agent making a decision. However, different simulated agents may make different decisions since emotions may influence its decision-making process. Thus, we model how a simulated agent makes a decision instead of directly modeling its behavior. This chapter presents an emotion-based decision-making model which is a key component to control how a simulated agent behaves.

5.1. Introduction

This section aims to provide an overview of the information about our rational-emotional decision-making model. The rest of this dissertation will refer to this model as the RED model. The RED model is not an emotion-based decision-making model. It presents our concepts which are designed to represent how a human being makes a decision both rational and emotional approaches. It is intended to present the design in more detail in section 5.5 (Design of the RED model.) To describe the RED model briefly: it consists of six modules representing a rational decision-making process which included making goals, collecting information, making criteria, making alternatives, predicting outcomes for each alternative, and selecting the best alternative. However, human beings are emotional creatures. We cannot eliminate our emotions. Thus, emotions may have an effect on any of the modules mentioned above. As a result, a decision could occur based on a person's emotions.

This research proposes a learning platform using surprise as a learning trigger to motivate learners to become more aware of their thoughts. We use a simulation of a human being's behavior in an indoor fire emergency as our learning environment. With regard to the behavior, we are only focusing on a behavior of helping others, and a behavior of escaping to an exit. Other types of behaviors such as cooperating with other peers, or competition with others are not taken into account so that we can minimize the complexity of the scenarios and focus on modeling the target behaviors. We assume that a type of behavior has been selected from various alternatives. It is the result of a particular decision. In other words, such a decision results in a certain type of behavior. These decisions can be affected by our emotions. Thus, an emotional decision take place. As a result, we have designed our RED model to represent concepts of how one makes a decision in order to perform a certain type of behavior. We have also designed decision-making rules following the RED model concepts to represent how a simulated agent make a decision to perform a helping or an escaping type of behavior and how emotions may affect to the agent's decision.

This research provides a simulated learning phenomenon using the soft-half-baked microworld described in chapter 4. Figure 5-1 depicts a general concept of the soft-half-baked microworld. The soft-half-baked microworld is designed to promote learners' self-awareness (module no.6 in the figure), while the traditional microworld aims to let learners to understand equations or rules (module no.1) that causes a specific phenomenon to happen. According to Figure 5-1, the RED model can be presented as module no.2. The model itself is a conceptual model. However, with embedded equations or rules designed follow the conceptual model, it could generate a designed phenomenon to happen. The equations in module no.1, in this research, are decision-making rules. The rules are described in detail in section 5.6, decision-making rules, and section 6.2 correspondence between RED model and decision-making rules, respectively.

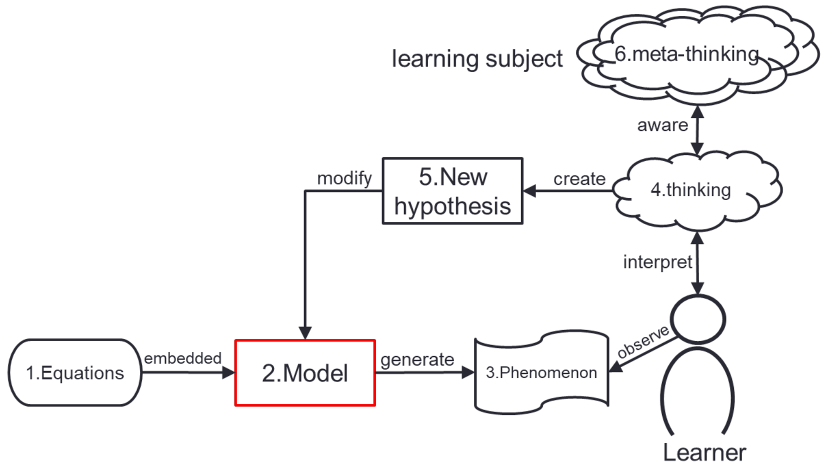


Figure 5-1 This figure presents a general concept of the soft-half-baked microworld. It consists of modules. The RED model is represented as module no.2 with a red colored rectangle. Decision-making rules, module no.1, are embedded in the RED model to generate a simulated specific phenomenon, module no.3. A learner is expected to be aware of their thought, module no. 6, by comparing its own thoughts in module no. 4, and results of the simulated phenomenon are observed in module no. 3. A new idea might occur while the learner compares their thoughts with the simulated results. The learner may test their hypothesis, module no. 5, by modifying the simulation parameters and repeating the simulation to observe how the newly simulated results should be evaluated the test if the hypothesis make sense or not.

This research only considers behaviors of helping others and behavior of escaping to an exit in a simulated indoor fire emergency. The decision-making rules are designed to handle these behaviors following the concept of the emotion-based decision-making model, the RED model. The remaining sections of this chapter describe the RED model in more details, the objectives of the RED model, the role of the model from a learning aspect, the design of the RED model, and its decision-making rules, respectively.

5.2. What is the rational-emotional decision-making model (RED model)?

This research is designed to motivate learners to be more aware of their thoughts about their own behavior in an emergency situation by means of a simulation. The simulation represents the simulated phenomena of behavior in an indoor fire emergency. Learners can obverse the phenomena and reflect on the simulated behavior to themselves. However, actual behaviors in a real-world emergency are too complex so to simplify the scenario, we focus on only helping and escaping behaviors instead. According to this concept, we design our simulation to present behaviors of simulated agents in an indoor fire emergency. Each simulated agent can perform behavior of helping others by helping handicapped agents and escaping to an exit. Based on our assumption that a person may be too emotional and lack necessary self-awareness to control their emotions may fail to apply their knowledge to solve the problem they are encountering (see Figure 1-1, knowledge-to-action gaps.) To represent this phenomenon, we have designed an emotion-based decision-making model which we call a rational-emotional decision-making model (RED model.) This RED model represents the conceptual processes that cause ones to make rational or emotional decision. The details of the RED model are described in section 5.5, designing of the RED model.

As mentioned earlier, this research uses the soft-half-baked microworld to represent a simulated learning phenomenon. The phenomenon represents behaviors of simulated agents in an indoor fire emergency. The soft-half-baked microworld inherits some properties of the traditional microworld. One of these is the requirement of using a learning model to present the phenomenon for learning as mentioned in chapter 4. The learning model of our soft-half-baked microworld is represented by this RED model. The RED model is a crucial component which cause the phenomenon to occur. However, the soft-half-baked microworld aims to allow learners to become more aware of their thoughts, but not to understand how the model's mechanism works. Thus, the RED model, in this research, is defined by the decision-making rules which are designed to represent only helping and escaping types of behaviors. More details about the decision-making rules is presented in section 5.6.

The RED model should be considered as the core component that controls how a simulated agent behaves in simulated scenarios. It performs like the brain of an agent. The simulated agent perceives the surrounding information such as how many alternative paths it has, distance of the nearest exit, the distance to the nearest fire and the distance to the nearest handicapped agent that is requesting help for these alternative paths. The RED model processes all these items of information and estimates the risks involved in the various aspects. For example, the risk of escaping, the risk of helping and the effort the agent would require if it decides to help a handicapped agent. Once the risks have been estimated, the RED model selects the best alternative action for the agent, which are helping a handicapped agent or escaping to an exit. In summary, the RED model is like the brain of an agent. It causes the agent to behave responding to the situation the agent is encountering.

In summary, the RED model is a simplified emotional-based decision-making model. It is a model that is embedded to our soft-half-baked microworld to generate a specific phenomenon to happen for our designed learning purpose. The phenomenon is scenarios representing behaviors of simulated agents in an indoor fire emergency. The RED model can be considered as a brain of a simulated agent. It controls how an agent behaves in a given scenario. In this research, the RED model presents only two behaviors: helping others to escape and escaping oneself to an exit.

5.3. Objective of RED model

There are two objectives of creating the RED model: 1) to allow the designed simulated phenomenon to happen, and 2) to represent simulated behaviors of helping others and escaping to the nearest exit. The first objective can be considered as a general objective of the learning model for the soft-half-baked microworld. Since the main objective of the soft-half-baked microworld is to provide opportunities to allow learners to reflect on the content of the simulated phenomenon to their thought. Moreover, the learning model could be incomplete. Since real-world phenomenon may be too complex to be modeled, only a part of the phenomenon can be selected for use in the model. As a result, the incomplete model generates a simplified version of the expected phenomenon. However, the partial phenomenon provides sufficient for the learning purpose in the soft-half-baked microworld. The second objective can be considered as a specific objective for this research. The expected phenomenon shows a situation in which simulated agents perform helping or escaping behaviors. Many complex events such as cooperation between the simulated agents, or competition between the simulated agents are not considered. The decision-making rules which are embedded in the RED model, for this research, focus only on handling helping and escaping types of|| behaviors.

5.3.1. Objective 1: To allow the designed simulated phenomenon to occur

This objective is considered as a general objective of the learning model used in the soft-half-baked microworld. Since the goal of the soft-half-baked microworld is to encourage learners to be aware on their own thoughts, the leaning model, in general terms, is designed to achieve this goal. Learners are given tasks to guess or predict the simulated phenomenon based on the given simulation parameters. They can modify the simulation parameters to test their idea on how to figure out the mechanism of the learning model. The soft-half-baked microworld is designed to motivate the learners to become more aware of their thoughts by allowing them to compare their predictions with the observed simulated phenomenon. The comparison of the results between the learners' predictions and the simulated phenomenon results are expected to trigger the learners to questions their thinking processes, especially when the results of their comparisons are different. The learners may feel curious to find out the reasons for these differences. New ideas with regard to the simulated phenomenon may occur to them in this process. The learners may modify the simulation parameters and repeat the simulation to test their hypothesis. As a result, the learners are expected to have a better understanding of their thinking process. However, it is not claim that the simulated results are what would actually occur in a particular incident. The simulated phenomenon is generated based on limited and controlled factors in the environment. They are designed to present a simplified phenomenon for learning purpose. While the actual emergency situation is more complex and there are many more factors and conditions involved. In summary, the objective of the learning model used in the soft-half-baked microworld, the RED model in this research, is to allow specific phenomenon to occur. The simulated phenomenon allows the learners to observe and reflect on its content in their thinking processes.

5.3.2. Objective 2: To represent simulated behaviors of helping others and escaping to the nearest exit of and simulated agent

This objective is considered as a more specific one in this research. Even though the RED model is designed to represent a general concept of the rational-emotional decision-making process, this research is limited on a simulated phenomenon of helping behavior and escaping behavior in an indoor fire emergency. The objective of the RED model in this research is to show how a simulated agent makes its decision in scenarios in which it is engaging. Different agents may have different emotions involved. As a result, different agents may behave differently in the same situation. All simulated agents apply the same decision-making mechanism described in the RED model, but because of the different emotions they may have, they have different criteria for making a decision. Thus, those agents will behave differently in the simulated indoor fire emergency. As a result, the specific phenomenon of helping and escaping behaviors in an indoor fire emergency, is presented. This simulated phenomenon occurs as a result of the decision-making rules which were designed according to the concept of the RED model. Once the simulated phenomenon of helping- and escaping-behaviors in an indoor fire emergency are presented, learners can observe the phenomenon and reflect on their its content to their thought. As a result, the soft-half-baked microworld can provide a useful environment for the learners.

5.4. Role of the RED model from learning aspect

The role of the RED model in software development aspect is to allow the specific phenomenon to occur. The phenomenon is an occurrence of the helping and the escaping behaviors from simulated agents in an indoor fire emergency. On the other hand, from learning aspect, the RED model's role is to providing chances for learners to realize their own thinking process. Figure 5-2 depicts relation between the RED model, presented as module no.2 with red rectangle, and modules of the soft-half-baked microworld for motivating the learners to be aware on their own thought. Learners could observe the specific simulated phenomenon, no.3 in the figure, generated by the RED model. They can compare the results of simulated phenomenon with their expected results. The learners' expected results are the predictions which are made by their current knowledge and mindset toward the simulated scenarios, module no. 4 in the Figure 5-2. This research expects the learners would be triggered and be aware of their thought, module no. 6, through comparisons of the observed simulated phenomenon and their predictions. Comparison results, especially the different ones, are expected to cause the learners to feel *surprised* since the differences can imply that their logics during making predictions are different from logics, module no.1, of the emotion-based decision-making model, RED model. The learners may feel curious to find out how the differences happen. Learners may have questions to themselves such as "is there any missing criteria during the prediction process?", "is there other alternative that I overlooked during the prediction?", "do my predictions make sense?" or "why I have these reasons to support my predictions?" The learners may have new reasons to explain the phenomenon. They may test their hypothesis by modifying the simulation parameters and repeating the simulation, module no. 5. In other word, the *surprise* may cause the learners starting to make questions themselves about why they have the thinking process as they did. As a result, they are motivated to be aware of their thought. In this research, we carefully prepare questionnaires, module no.7, to guide the learners to be motivated to make questions to themselves.

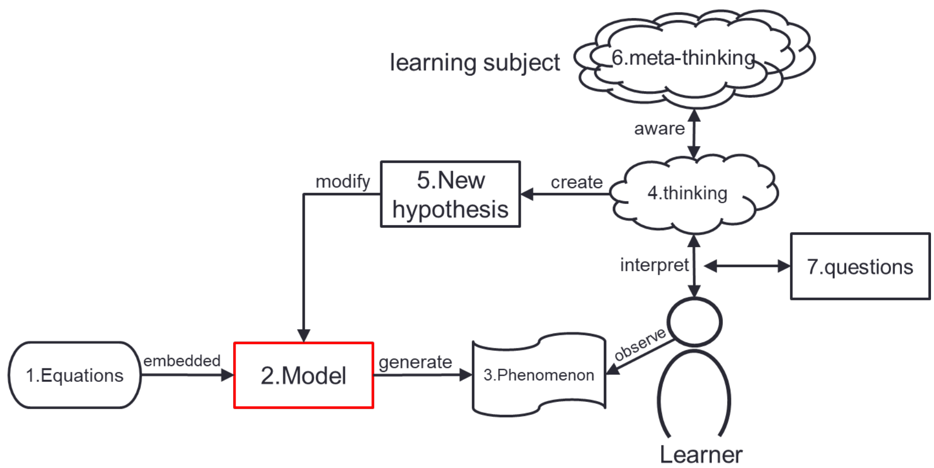


Figure 5-2 From learning point of view, the role of the RED model, presented as module no.2 with red colored rectangle, is to provide chances for learners to realize their own thought. Learners can obverse the simulated phenomenon, module no.3, generated by the RED model, and compare the simulated results with their predictions. Prediction results, especially the different one, are expected to cause the learners to feel surprised and curious to find out reasons that make the differences happen. They may

question themselves about their thought, module no.4. They may even try to modify simulation parameters to test their new hypothesis if they need, module no.5. We carefully prepare questionnaires to guide the learners to question their own thought, module no. 7. As a result, learners are motivated to realize their own thought, module no.6.

However, we do not claim that the simulated results can represent the actual outcome in real emergency. The actual situation is complex and have many more factors to be considered, while the simulated phenomenon in the research is limited and controlled by only few necessary factors to achieve our learning purpose.

5.5. Design of the RED model

It is challenging to figure out how to model human being decision-making process. There are many related studies tend to model the human being's decision-making process. Many studies related to psychological and cognitive research domains (Mann, 1988; Guo, 2008; Janis, 1977; Lerner J. S., 2015; Pijanowski, 2009). However, there are no single agreement or a complete model of it. The design is based on its objective. For example, Mann (1988) proposed a model named GOFER. It models a decision-making process into five steps. Its objective is to train adolescent learners to become effective decision makers; while Guo (2008) proposed a decision-making model named DECIDE. It models a decision-making process into six steps. Its objective is based on health care management.

In this research we propose our emotion-based decision-making model to represent a simple decision-making process. It is named rational-emotional decision-making model or RED model (Damrongrat, 2017). This model also presents how emotions could have impact and cause an emotional decision. Figure 5-3 depicts conceptual modules of the RED model. The intention for designing the RED model is to apply to a typical use. Its main concept is to make a decision by selecting the best alternative corresponding to available conditions with emotion engagement. Unlike other studies which designed their decision-making model for training its user to become an effective decision maker (Mann, 1988) or designed from health care management point of view (Guo, 2008).

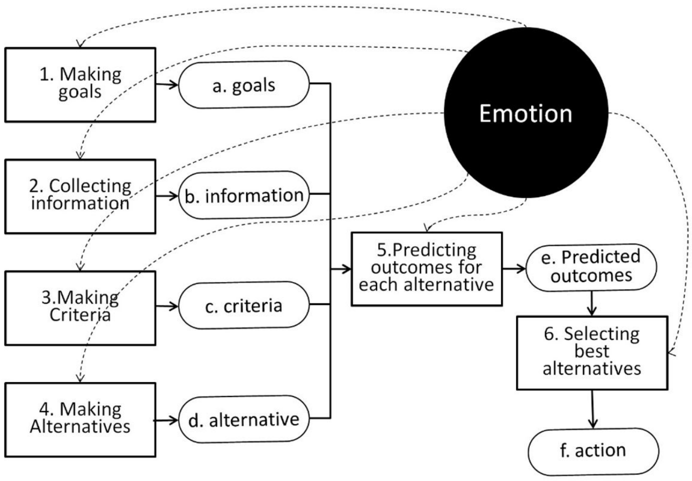


Figure 5-3 The RED model consists of 6 submodules for making a decision. Without emotion, it can be considered as a rational decision-making model. However, emotion could take place and cause impact to any submodule. As a result, the decision becomes an emotional decision-making.

Based on Figure 5-3, the RED model is divided into six-step processes. In this dissertation, we will describe the design intention of each step for both typical use of the model, and for implementing the behavior of helping and escaping which is used in this research.

Before overviewing intention of each step, we would like to briefly describe the specific simulated phenomenon we have designed. In this research, the designed simulated phenomenon has three types of simulated agents. 1) rational agent representing one whose decision process are not biased by emotions. As a result, this agent type is making decision based on external conditions, not its own emotion. 2) emotionally brave agent representing one who may feel optimistic. This agent type can accept a bit higher risk than other agent types. As a result, while others may think the considering alternative is too risky, the emotionally brave agent may consider it is possible. 3) emotionally selfish agent representing one who prioritize on self-safeness. This agent type would consider helping others when it has a confidence that the condition is low risk. All agent types have to make a decision of helping a simulated handicapped agent who cannot move by itself, or go straightly for escaping to an exit.

1) Making goals – in typical use aspect, its design intention is to represent a list of possible actions or behaviors that the simulated agent could perform. For example, the goal to help others or to escape to the safest exit. In a specific use in this research, we present an adjustable parameter representing *chance* for a simulated agent to set its intention (goal.) When the agent has multiple best-conditioned alternatives to select, it will select the best alternative based on its basic intention. Different agent types have

a different chance. For example, the rational agent, emotionally brave agent and emotionally selfish agent have 50%, 70% and 30% to have *helping intention,* respectively. This setting shows that a brave agent is not always trying to help others. On the other hand, a selfish agent also has chance to help other as well, even though its chance is lesser than others. this process presents *intention* of the simulated agent. It is intention to help others, and intention to escape to an exit. The rational agent is set to have balance of helping and escaping intentions. While the emotionally brave agent has helping intention more than escaping intention. On the other hand, emotionally selfish agent has escaping intention more than helping intention. This setting represents how emotions may make impact to the decision-making process.

2) Collecting information – in typical use aspect, its design intention is to represent how one collects information surrounding itself to process this information later. For example, the simulated agent processes the information to predict risks for escaping to the nearest exit or helping others. Emotions could make impact to this process as making one to ignore, overlook or interpret the information incorrectly (Fahy R. F., 1997; Kobes M. a., 2010). In other words, it presents chance that one may perceive distorted information. The emotional one has more chance to perceive distorted information than the rational one. In a specific use in this research, we can set an adjustable parameter to present chance that the simulated agent may perceive distorted information. For example, the rational agent and emotional agent may have 5-10% and 10-15% chance to perceive distorted information, respectively. However, in this research we set all agent types are able to perceive correct information as its default.
3) Making criteria – in typical use aspect, it is to represent a list of considering criteria used for estimating situation for each alternative option. For example, in the building fire emergency, criteria could be distance from current location to nearby exits; how far of the distance will be considered as too far or too close; the possibility to use a considering path to escape; criteria to select the best alternative. Emotion may cause different people to have different criteria, or have the same criteria but different evaluation. For example, in the same situation, a brave person considers the distance to an exit is acceptable, while a fearful person may consider it to be too far and too dangerous. In a specific use in this research, the criteria to evaluate distance as *near* or *far* are different. For example, if the nearest fire from current location is three-unit distance away, a brave agent may consider this distance is possible to use for escaping,

while a selfish agent, with high of fear emotion, may feel this distance the fire is too close, and it is too dangerous to use this path for escaping.

4) Making alternatives – in typical use aspect, it is to represent a list of possible options that one can select. For example, list of actions to perform: helping or escaping, or list of possible escaping paths to use. Emotion may make one to drop some possible alternatives off. For example, in emergency evacuation, people tend to escape through an entrance they used for entering the building, and ignore alternative options such as emergency exits which may be nearer than that entrance (Kobes M. a., 2010). In a specific use in this research, it is possible to set an adjustable parameter to present chance that simulated agent may drop each alternative off. The emotional one has higher chance than the rational one. However, in this research, we set zero chance to drop any alternative off. The alternative behaviors are *to help* and *to escape*. The alternative of possible paths to use are all available paths surrounding the simulated agent at that time.
5) Predicting outputs for each alternative – in typical use aspect, it is to represent how one assesses situations based on combination of goals, collected information, criteria and alternatives it has in the previous steps. Emotion may cause the situation assessment different from person to person. For example, in a scenario of helping a handicapped person to the nearest exit, a brave person may estimate the situation and value the helping effort is low, while a fearful person may consider the same situation as it requires high effort for helping the handicapped person. In a specific use in this research, there are three risk estimations in each alternative path to be concerned. 1) escaping risk, 2) helping risk and 3) helping effort. There are three level for each risk estimation: low, medium and high. Different simulated agent types may estimate the same situation differently since its criteria caused by emotions are different.
6) Selecting the best alternatives – in typical use aspect, it is to present how one utilizes the assessed results from the fifth step. For example, escaping risk of alternative *A*, *B* and *C* are *low, medium* and *high*, respectively. That one would select the alternative *A,* which has the lowest risk among the three. In a specific use in this research, a simulated agent would prefer the alternative that has the lowest risk. However, it is possible that there are multiple alternative candidates with the same lowest risk, in this case, the *intention* of each agent takes an account for selecting the best alternative among the candidates.

5.6. Decision-making rules

The RED model is just a concept representing how one makes a decision. It means that only the RED model itself cannot make the designed phenomenon to happen. Decision-making rules play a key role to make the designed phenomenon to happen. However, the rules have to be designed following concept of the RED model. In this research, the simulated phenomenon is expected to represent helping behavior and escaping behavior of simulated agents in an indoor fire emergency. Thus, the decision-making rules will focus on making those behaviors happen. The decision-making rules have to be able to create or assess the necessary information for each module corresponding to in the RED model. For example, to generate what is the intention for each simulated agent, to assess the considering path is low risk for escaping or not.

The decision-making rules in this research are implemented by using a python package named PyKE (Frederiksen, PyKE: python knowledge engine, 2010). PyKE is a knowledge engine introduced to academic society since 2008 (Frederiksen, Applying expert system technology to code reuse with pyke, 2008). PyKE knowledge based is divided into Fact bases and Rule bases. Fact bases are considered as statement of fact. Table 5-1 is an example of fact bases. The first statement refers to the nearest fire has distance equal *infinity*. It implies to the fact list that there is no fire in that path. If the distance to the nearest fire is a valid number, the second statement, then it implies that there is fire in that path. Rule bases are considered as a collection of rules. Table 5-2 shows example rules of risk estimation for helping others. These rules are corresponding to the predicting outputs for each alternative, module no. 5 of the RED model in Figure 5-3. For example, rule no.3, the helping risk is considered as *seems dangerous* (high level) when the considering path has both a target-for-helping handicapped, and fire; moreover, the distance to that fire is closer than the distance to that handicapped. More example about rules bases are presented at section 6.2.

Table 5-1 Example of fact bases. The first statement shows that if the distance to the nearest fire is infinity, then it means there is no fire on that path. If the distance is a valid value, then there is fire in that path.

	statement	fact
1	nearest_path_to_fire(?path, Inf)	there_is_no_fire(?path)
2	nearest_path_to_fire(?path, ?f_dist)	there_is_fire(?path, ?fire)

Table 5-2 Example of risk estimation for helping others in the predicting outputs for each alternative module of the RED model.

	corresponding module	rule's name	conditions
1	prediction	risk_helping_low(?path)	possible_to_help(?path) NO handi_fire_similar_distance(?path, ?handi, ?fire)
2	prediction	risk_helping_a_bit_dangerous(?path)	possible_to_help(?path) handi_fire_similar_distance(?path, ?handi, ?fire)
3	prediction	risk_helping_seems_dangerous(?path)	there_is_handicapped(?path, ?handi) there_is_fire(?path, ?fire) fire_closer_than_handicapped(?path, ?fire, ?handi)

In total, this research conducts 65 knowledge bases: 19 fact bases and 46 rule bases, with PyKE. More details of these knowledge bases are presented in APPENDIX A.

5.7. Summary

The RED model is a conceptual emotion-based decision-making model. It represents processes that one may take for making a decision. The model is divided in to six steps: making goal, collecting information, making criteria, making alternatives, predicting outcomes for each alternative, and selecting the best alternative. Emotion can engage any of those step, and cause an emotional decision. As a result, emotion cause simulated agents behave differently even though they are in the same condition. The reason is the emotion has impact to decision-making processes. For example, it causes each agent type to have different criteria when making its decision. The RED model is designed to generate a specific simulated phenomenon following the concept of soft-half-baked microworld which aims to motivate learners to be aware of their thought. The expected phenomenon is to represent simulated scenarios of simulated agents performing helping behavior and escaping behavior in an indoor fire emergency. Its role is to let the expected simulated phenomenon to happen. Thus, learners can observe the phenomenon and reflect its content to their thought, making question to themselves whether their thought is reasonable or not. As the result, the learners may realize on their thinking process and be motivated to be aware of their thought. However, the RED model itself cannot make the expected phenomenon to happen, since the model itself is just a concept. A set of decision-making rules designed following the concept of the RED model plays a key factor to make the expected phenomenon to happen.

CHAPTER 6 CORRESPONDENCE OF THE RED MODEL TO THE SOFT-HALF-BAKED MICROWORLD AND ITS DECISION-MAKING RULES

This chapter aims to illustrate a relation of the RED model toward other components. The relations we are focusing are 1) correspondence between the RED model and the soft-half-baked microworld, and 2) correspondence between the RED model and its decision-making rules made following the RED model's designed concept. Section 6.1 describes relation between the RED model and the soft-half-baked microworld. What is the role of the RED model as a component of the soft-half-baked microworld, and what is the role of the RED model from the learner aspects Section 6.2 describe relation between the RED model and its related decision-making rules. Since the RED model is divided into six modules, some decision-making rules corresponding to each module are selected to present their correspondence.

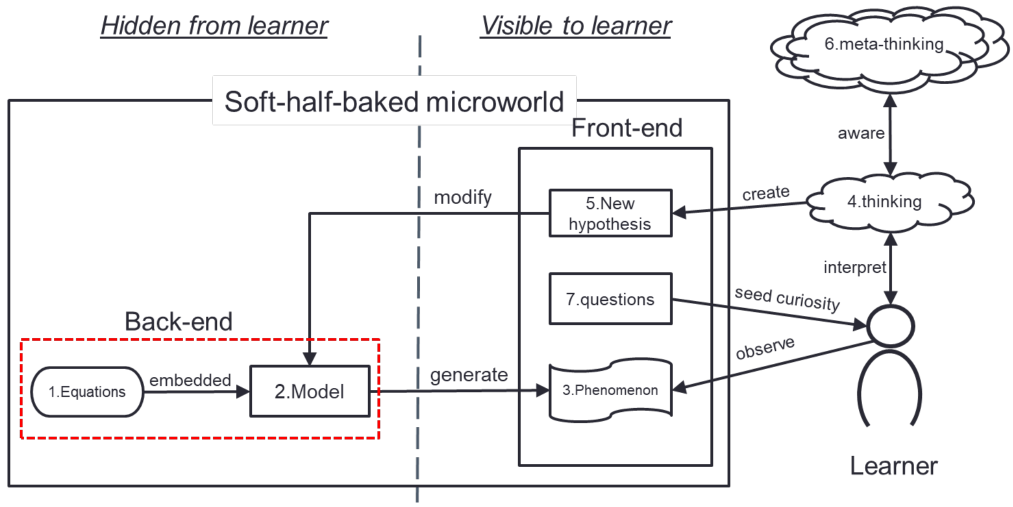


Figure 6-1 Overview of the solf-half-baked microworld shows relation between the RED model (no.2) and other modules. The soft-half-baked microworld is divided into front-end and back-end. The front-end is user interface that a learner can interact with. The back-end unit consists of the RED model (no.2) and a set of decision-making rules (no.1) designed following the RED model's concept. The back-end unit is hidden from the learner. However, the learner may guess how the mechanism of the RED model and its decision-making rules work through observing the simulated phenomenon (no.3.) The RED model works together with its decision-making rules to make the soft-half-baked microworld a specific designed learning environment for the learner.

6.1. Correspondence between the RED model and the soft-half-baked microworld

In chapter 4, we describe that the soft-half-baked microworld is as a small and controlled simulated environment designed for a specific learning purpose. That learning purpose is to motivate learner to be aware of their thinking process through a simulated phenomenon of helping and escaping behaviors of simulated agents in an indoor fire emergency. The learning course aims to motivate learners to have better realization of their thought toward the designed phenomenon, but not aim to justify which actions are right or wrong. The actual emergency situations have many more factors to be concerned and the situation are more complex than our simplified and controlled learning environment. In chapter 5, we introduce our emotion-based decision-making model representing simplified concept of how a rational or an emotional thinking are conducted. In this research, the RED model is used in the soft-half-baked microworld to present a phenomenon that simulated agents performing helping and escaping behaviors in an indoor fire emergency. This section aims to describe how the RED model and the soft-half-baked microworld are cooperating.

Figure 6-1 presents the overview of how a learner interact with the soft-half-baked model, and what the key components in the soft-half-baked microworld are. From the learner's point of view, the learner can interact with only the front-end module. The learner is not informed about the back-end which is a mechanism causing the designed simulated phenomenon to happen. The learner can observe the simulated phenomenon (no.3 in the Figure 6-1) at the front-end, and uses it to compare the results with the learner's prediction results. Questions (no.7) are used to seed curiosity about the learner's thinking process, and increase chances for the learner to make question of its thought by oneself. If a new idea is happened, the learner can test their hypothesis by modifying the simulation parameters and run the simulation again (no.5.) The learner can repeat these steps as many as he or she wants. As a result, the learner is motivated to be aware of how its thought toward the simulated phenomenon (no. 8) is. Based on objective of the soft-half-baked microworld, the back-end unit, the RED model and its decision-making rules, play a role to make a specific simulated phenomenon to be happened.

From the learner's point of view, even though learners are not informed to know what the mechanism of the back-end unit is; however, the learners can guess and figure out how it works the by observing the simulated phenomenon. They may compare the observed phenomenon results with results they have predicted based on their current knowledge and opinion. The comparison results between the observed results and the learner's predictions may cause them to feel surprised. The definition of *surprise* in this research is a representation of difference between expectations and reality (Casti, 1994; Lorini, 2007). The surprise is happened since unexpected comparison results imply that their thought and the designed mechanism from the back-end unit are different. These differences and a set of carefully selected questions (no.7 in the Figure 6-1) promote curiosity to the learner mind. The questions are designed to guide them to remind of their thinking process: is there any overlooked or missing information during they predictions were made. As a result, the learners are motivated to be aware of their current thinking process toward the simulated phenomenon of helping and escaping behaviors in an indoor fire emergency. This awareness may be useful to the learners if they have to encounter an actual emergency in the future.

In summary, from the development of the soft-half-baked microworld point of view, the RED model and its decision-making rules play a role to make a specific phenomenon to be happened. It is designed for learning purpose following concepts the soft-half-baked model. From the learning point of view, the learners observe this phenomenon for reflecting its content to be motivated to realize their thinking process.

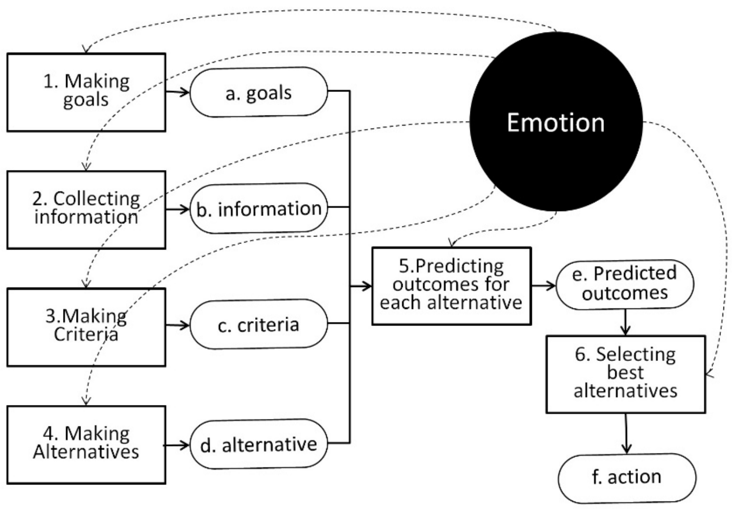


Figure 6-2 The RED model consists of 6 main modules: making goal, collecting information, making criteria, making alternative, prediction outcomes of alternatives, and selecting the best alternative, respectively. Without emotion, this model can be considered as rational decision-making model. However, emotion could be engage to any module, and cause an emotional decision-making.

6.2. Correspondence between RED model and decision-making rules

This section describes correspondence between the proposed RED model and its decision-making rules, and how emotion has effects to each module in RED model. Figure 6-2 shows that RED model consists of 6 submodules: 1) making goal, 2) collecting information, 3) making criteria, 4) making alternatives, 5) predicting outcomes for each alternative and 6) selecting the best alternative. This section shows some example of designed decision-making rules corresponding to each module for illustrating a better understanding of how the RED model and its rule are able to cause the simulated phenomenon to happen. More decision-making rules are presented in APPENDIX A.

Before describing how each module of the RED model correspond to the decision-making rules, we would like to describe our assumption about the designed phenomenon first. The phenomenon we designed is a set of scenarios that each simulated agent may behave differently to respond the situation it is encountering. Every simulated agent is assumed to have the same knowledge to cope with the emergency, and has the same decision-making process described as the RED model in chapter 5. What make them behave differently is the different emotion that is involving their decision process. As a result, it causes them to behave differently. In this research, simulated agents are categorized into three types: 1) rational agent, 2) emotionally brave, and 3) emotionally selfish. A rational agent type represents ones who have a balance of using its emotion for escaping or helping others. It accepts moderate level of risk for its escaping or helping behavior. An emotionally brave agent type is ones who may have too high confidence. This brave agent would accept a bit riskier situation than the rational type for escaping or helping others. For example, considering a path to the nearest exit, a rational agent considers it as dangerous and should be avoid to use, but the brave agent may consider this path is possible for escaping. On the other hand, an emotionally selfish type is ones who may feel too fear to the situation. They prioritize on their safeness first. However, they help others when they have confidence that the situation is safe enough.

However, brave agents are not always go and help others, and selfish agents are not always abandon to others who require help. We design a preference of agent as its intention. The intention, in this research, is *escaping* or *helping* intention. For example, there are two brave simulated agents. One of them has *escaping intention,* and another one has *helping intention.* Both of them may have the same criteria, and the same risk estimation in their mind, but they may decide to behave differently based on their personal intention. For example, there are two best alternative paths which are considered as low risk: one for helping, and another one for escaping. The agent with *helping intention,* will perform helping behavior rather than escaping.

6.2.1. Making goal

In this research, the simulated phenomenon of an indoor fire emergency is a simulation of a building fire. There are many simulated agents randomly located in the building. All of them trying to escape the building as fast as possible. However, there are some handicapped agents that cannot move by themselves requesting help for escaping. As a result, those simulated agents have two behavioral goals. First is escaping goal, since every agent prefers to escape the building fire safely. Second is helping goal. This research has an assumption that all agents are willing to help others if the *condition is right* for them. However, the right condition is vary based on each individual agent. Conditions could be considered as risks evaluated from different aspects which are described in the section 6.2.5.

In this research, every simulated agent has two goals: escaping goal and helping goal. They will perform either escaping or helping behavior according the situation automatically. For example, they will select the alternative that has the lowest risks. The considering of risk-level is described in section 6.2.5, predicting outcomes of each alternative. 59However, sometimes there are multiple alternatives which have the same lowest risk-level. According to this situation, the personal intention of each simulated agent is used to make a decision. More detail is described in section 6.2.6, selecting the best alternative. This section will focus on how to define a default intention for each agent type.

Table 6-1 Each simulated agent has its own personality tentative behavior based on its intention. There are two types of intention: escaping or helping intention. The intention will be used as a decision factor if there are multiple alternatives for the agent to make a decision. This table shows a default ratio to assign the intention for each agent type.

	corresponding module	Agent type	Chance of having escaping-helping intention
1	goal	Rational	50-50
2	goal	Emotionally brave	30-70
3	goal	Emotionally selfish	70-30

This section presents how an agent making its preferable goal or the case that there are multiple alternatives to make a decision. The decision will be made based on the agent's intention. Conceptually, every agent types: rational, brave, and selfish type, consists of both agents who have either *escaping* or *helping* intention.

Table 6-1 presents our assigned default ratio between escaping and helping intention for each agent type. This research is considered the agents of rational type to have an equal chance for having either escaping intention or helping intention. Thus, the chance for the rational type is 50% for having escaping intention, and 50% for having helping intention. For the brave agent type, agents in this type is considered to have helping intention more than the rational type. Thus, the brave agent type has chance 30% for having escaping intention, and 70% for having helping intention. On the other hand, the selfish agent type, agents in this type is considered to have helping intention less than the rational agent type. Thus, the selfish agent type has chance 70% for having escaping intention, and 30% for helping intention. However, these ratios are default values. It can be modified if needed.

6.2.2. Collecting information

Conceptually, this module in the RED model represents that one has to gathers information surrounding itself. The information will be used to make a decision later. Emotions can engage this module and cause a person to collect the collected information improperly. Different person may perceive information differently even the source of information is the same. The improperly collected information could be considered as distorted information. The distorted information, in this research, defined as the perceived information that is different from the actual one. The perceived information could be lost, incorrect, outdated and missing information (Fahy R. F., 2012; Heide, 2004). When emotion takes place in emergency situation, an individual has higher chance to interpret information incorrectly. For example, some person might overlook a sign of exit due to the frightening at that time (Hasofer, 2006).

Table 6-2 Example of raw information that is used in the simulation. The information no.1 is considered as person information, while the rests are considered as perceived information that each agent can perceive from its surrounding. The information no.1 presents the agent type of the considering agent. No.2 present what alternative paths are available for considering. No. 3, 4 and 5 present the shortest distance to the nearest fire, exit and handicapped agent, respectively.

	corresponding module	raw information	information type
1	information	is_rational(?agent, ?location)	personal information
2	information	Available_path(?location, ?path)	perceived information
3	information	nearest_fire(?path, ?fire)	perceived information
4	information	nearest_exit(?path, ?exit)	perceived information
5	information	nearest_handicapped(?path, ?handi)	perceived information

In this research, there are four types of surrounding information to be collected. They are 1) available alternative paths to consider from the agent's current position, 2) the shortest distance to the nearest fire, 3) the shortest distance to the nearest exit, and 4) the shortest distance to the nearest handicapped agent. These surrounding information are presented in

Table 6-14 as the information no.2-5, respectively. In this research, the handicapped agent represents one who cannot move by itself. The handicapped agent requests support from others to escape from its location in the building fire to nearby exit for its safeness. To help the handicapped agent in our simulation, the active simulated agent, rational, brave or selfish agent, is required to move to the handicapped agent's location and brings that handicapped along for escaping to an exit. The delay or difficulties by escaping with that handicapped agent are not considered in this research. Moreover, this research represents scenarios that the simulated agents can perceive incomplete information. They know only partial facts. Collected information is only information of distance between current position of the agent to a specific component: fire, exit, handicapped corresponding a specific path. This research does not consider information of the building's layout and direction. For example, the agent does not know there is an intersection ahead.

Table 6-3 Chance that an agent interprets perceived information incorrectly is caused by emotion. Rational agent is assigned the chance to incorrectly interpret information as 5-10%, while emotional agent is assigned as 10-15%, respectively.

	Agent type	Chance to perceive incorrect information
1	rational agent	5-10%
2	emotional agent	10-15%

In this research, to present how emotions impact to this module, we set a chance parameter that causes a simulated agent to perceive information incorrectly (see Table 6-3.) For the rational simulated agent, the chance is a random value between five to ten percent. For emotional simulated agent, both brave and selfish agent types, the chance is a random value between ten to fifteen percent. The chance in the emotional agent is set higher than the rational agent since we have an assumption that the more emotion engagement, the more chance to perceive information incorrectly. However, this parameter is turned off as the default setting to present a simplified phenomenon at the beginning. Learner can turn it on in the parameter modification if they want to observe a more complex phenomenon.

6.2.3. Making criteria

Criteria in this research are concerning conditions that an individual agent uses for making a decision. In this research, there are seven criteria which to be used for a simulated agent to make its decision (see Table 6-4.) Firstly, *accepted conditional distance*, this criterion, in this research, represents how emotions affect to perception of each agent type to assess what the *similar distance* is. At the same situation, a selfish agent may consider distance of its current position to a specific exit as *far*, but a brave agent may consider the same distance as *near*. With these different perceptions, both of them may behave differently toward its perception. For example, decision for escaping to that exit. Secondly and thirdly, *possibility for escaping and helping*, defined as criteria no. 2 and 3 in Table 6-4, an alternative path can be considered as possible for escaping if and only if the distance to the nearest exit is closer than the distance to the nearest fire. However, the possible-to-escape path does not guarantee this path is safe for escaping. If the path is possible to escape with high risk, the agent should avoid using this path, and use another alternative instead. Similarly, possible-for-helping criterion, a considering path can be considered as possible for helping if an only if the distance to the nearest handicapped agent is closer than the distance to the nearest fire.

Table 6-4 Conceptual criteria that use for the RED model. There are seven criteria for this research. Some criteria are used in other modules. For example, criteria no. 4,5 and 6, which are risk estimations, these criteria are used in module no.5 for predicting outcomes for each alternative.

	corresponding module	criteria name	description
1	criteria	accepted conditional distance	Different agent types have definition of *similar distance* differently
2	criteria	possibility for escaping	Escaping is possible if the distance to an *exit* is closer than distance to a *fire*
3	criteria	possibility for helping	Helping is possible if the distance to a *handicapped* is closer than distance to a *fire*
4	prediction	risk estimation for escaping	An agent evaluates escaping risk for a considering path as *low, medium or high*
5	prediction	risk estimation for helping	An agent evaluates helping risk for a considering path as *low, medium or high*
6	prediction	effort estimation for helping	An agent evaluates helping effort for a considering path as *no effort, low effort* or *high effort*
7	selecting the best	criteria for multiple alternatives	An agent ranks alternatives into categories. If there are multiple alternatives in the best category, some specific criteria will be used

Fourthly, fifthly and sixthly, criteria no.4, 5 and 6 in Table 6-4, they present risk estimation criteria. All of these criteria are used for prediction outcomes for each alternative, module no.5 in the RED model. Criteria no.4 and 5 evaluate risk for escaping and helping in a considering path, respectively. There are three level of risk estimation: *low, medium and high*. For brief description, these risk estimations evaluate situation by concerning distance of fire. The closer distance of the fire to a specific exit, or a handicapped, the higher risk for escaping and helping, respectively. The criteria no.1, *accepted conditional distance,* is used since different agent types consider *close distance* and *far distance* differently. Similarly, criteria no.6 evaluates effort for helping. It evaluates the helping effort by concerning distance between a specific handicapped agent, and an exit. There are three effort-level as *no effort, low effort* and *high effort.*

Seventhly, criteria no.7 in Table 6-4, it presents criteria for selecting the best alternative for an agent to perform its action. Briefly description, after an agent assesses risk estimations for each alternative, the agent ranks and categorizes each alternative into four categories. Alternatives in the top rank category are considered as candidates to be selected. If there are multiple candidates, the agent's intention, mentioned in section 6.2.1, making goal, is considered as an extra criterion. The more detail is described in section 6.2.6.

Table 6-5 Some decision-making rules defining of "similar distance". They represent criterion no.1, accepted conditional distance, in Table 6-4. Different agent types have different *similar distance* values. Rational, brave, and selfish agents have their *similar distance* as 2, 3 and 1 for considering distance between a targeted handicapped and fire, respectively.

	corresponding module	rule's name	conditions
1	criteria	handi_fire_similar_distance(?path)	in_rational_state(?agent) there_is_handicapped(?path, ?hand) there_is_fire(?path, ?fire) dist_handi_fire_in_range(?path, ?hand, ?fire, 2)
2	criteria	handi_fire_similar_distance(?path)	in_brave_state(?agent) there_is_handicapped(?path, ?hand) there_is_fire(?path, ?fire) dist_handi_fire_in_range(?path, ?hand, ?fire, 3)
3	criteria	handi_fire_similar_distance(?path)	in_selfish_state(?agent) there_is_handicapped(?path, ?hand) there_is_fire(?path, ?fire) dist_handi_fire_in_range(?path, ?hand, ?fire, 1)

Table 6-5 shows some example of decision-making rules representing *accepted conditional distance* concepted mention in criterion no.1 in Table 6-4. This concept is represented as *similar distance* defined in the decision-making rules. Different agent types have different concept of *similar distance.* The examples in Table 6-5 present how each agent type considering distance similarity between a handicapped and a fire. In these examples, the default values for rational, brave and selfish agents are two, three and one unit-distance, respectively. Knowing whether the handicapped is close to the fire or not could be used for helping risk estimation. If the distance between the handicapped and the fire is similar, it can be considered as a bit dangerous for help. With this situation, some agent types may consider to avoid helping this handicapped agent.

Table 6-6 Some decision-making rules representing criteria no.2 and 3, possibility for escaping and helping in Table 6-4. These possibilities aims to distance of the fire. If the fire is further than the nearest exit, or the considering handicapped agent, then it is possible for escaping and helping, respectively

	corresponding module	rule's name	conditions
1	criteria	possible_to_escape(?path)	there_is_exit(?path, ?exit) there_is_fire(?path, ?fire) exit_closer_than_fire(?path, ?exit, ?fire)
2	criteria	possible_to_help(?path)	there_is_handicapped(?path, ?hand) there_is_fire(?path, ?fire) handicapped_closer_than_fire(?path, ?hand, ?fire)

Table 6-6 shows some example of decision-making rules representing *possibility for escaping and helping* concepted mentioned in criteria no.2 and 3 in Table 6-4. The main idea of *possibility for escaping and helping* is the distance of fire should be further than distance of considering components, an exit or a handicapped agent. If the distance of the fire is closer than distance of the considering components, this alternative is considered as not possible to escaping or helping. However, there are cases that the distance to the fire is closer than the distance to the other components, but the situation is safe for escaping or helping. Since it is possible to have an intersection ahead, the collected distance information of the fire and other considering components, an exit and a handicapped agent, may be located in different direction. As a result, even the alternative is not considered as *possible for escaping or helping,* the alternative is not discard yet. If there is no other better candidates, this alternative is possible to be selected.

6.2.4. Making alternative

Conceptually, this module in the RED model is to list available alternatives. The alternatives can be considered as 1) list of available paths, and 2) list of possible actions, escaping or helping, toward the considering path. For the first one, list of available paths, it is presented as raw information no.2, available path, in Table 6-2. For the list of possible actions, it is depended on existence of raw information no.3 and no.4, exit and handicapped, in Table 6-2. If the raw information presents that there is the nearest exit or the nearest handicapped agent in the considering path, there is a possible escaping action or a helping action, respectively.

Table 6-7 Chance that an agent may discard the alternative by emotions. The rational agent is considered as ones who have better control their emotion. They have a lower chance to discard their alternatives. While the emotional agent, brave and selfish agents, are considered as ones who are not be aware to control their emotions. They have a higher chance to discard their alternative. The rational and emotional agents have 5-10% and 10-15% chance to discard their alternatives, respectively.

	Agent type	Chance to discard an alternative
1	rational agent	5-10%
2	emotional agent	10-15%

The emotion may affect to this *making alternative* module. To present how emotions impact to this module, we set a chance parameter that causes a simulated agent to discard its alternatives (see Table 6-7.) For the rational simulated agent, the chance is a random value between five to ten percent. For emotional simulated agent, both brave and selfish agent types, the chance is a random value between ten to fifteen percent. The chance in the emotional agent is set higher than the rational agent since we have an assumption that the more emotion engagement, the more chance to emotionally discard its alternative. However, this parameter is turned off as the default setting to present a simplified phenomenon at the beginning. Learner can turn it on in the parameter modification if they want to observe a more complex phenomenon.

6.2.5. Predicting outcomes for each alternative

Conceptually, this module uses contents from previous sections, making goal, collecting information, making criteria, and making alternative modules for predicting risk in different aspects. In this research, we consider risk estimation in three aspects. 1) risk for escaping, 2) risk for helping, and 3) effort for helping. This module uses criteria described in section 6.2.3, *making criteria,* to assess the risk level. In this research, risk is divided into three level, *low, medium and high.* However, these risk-level may be named in different ways in each aspect. For example, the helping effort can be considered as *no effort, little effort,* and *big effort* corresponding to *low, medium* and *high*, respectively.

Different type of agent has different criteria for making its decision. For example, in the same situation that there is a handicapped further away in three-unit distance ahead. Fire also reaching to an area that the handicapped is located. Different agents may estimate the situation differently based on their criteria. Emotionally brave agent may accept the risk conditions for helping with this three-unit distance, while the emotionally selfish agent may think this distance is too far and too dangerous for helping.

Table 6-8 shows example rules and concepts of *helping risk estimation*. Risk estimation for helping is designed to consist of three risk-levels; 1) *low* - the risk for helping a handicapped is low, 2) *medium* - the helping risk is a little dangerous, and 3) *high* - the helping risk seems dangerous. For the first rule in

Table 6-8, for example, named *risk_helping_low* (low risk-level) means an agent considers the risk for helping a handicapped would be low if two conditions are reached. First, the considering path is possible for helping the handicapped. It is possible when distance to the handicapped is closer than the distance to the fire, as mentioned at Table 6-6, describing about *possibility for escaping and helping* in section 6.2.3, making criteria. Second, distance between the handicapped and fire are not similar which is described in Table 6-5, *similar distance*. Combining with the first condition, it means the distance to the handicapped is closer than the distance to the fire. This distance between the handicapped and the fire is far enough for the helper to think the risk for helping the handicapped is low. For the second rule named *risk_helpling_a_bit_dangerous* (medium risk-level) in

Table 6-8, an agent may consider the risk as a bit dangerous when the considering path is possible for helping the handicapped, and the distances from the agent to the handicapped and to the fire are similar. Since the distance between the handicapped and fire is close, the agent may doubt a danger of the fire that might spread to the handicapped's location. As a result, the agent considers this situation as a bit dangerous. For the last rule named *risk_helping_seems_dangerous* (high risk-level.) an agent considers the situation as *seems dangerous* when it recognizes that the distance from itself to the fire is closer than distance to the handicapped. Even though the result of estimation is "*seems dangerous*", an agent cannot totally discard this alternative. There are situations that risk estimation is "seems dangerous"; however, it is possible to be safe situation. For example, considering a path that has a junction in one-distance ahead. Fire could be two-distance away from left side of the junction, and a handicapped is three-distance straight from the junction. Based on this example, even though helping the handicapped may still possible, but the risk of helping estimation is considered as "*seems dangerous*" since the nearest handicapped is four-distance away and fire is three-distance away. However, the *"similar distance"* is subjective depending on each agent. Different type of agent considers *"similar distance"* differently, as mentioned earlier in Table 6-5.

Table 6-8 Example rules for estimating helping risk. The helping risk is considered as *low* if the distance to a handicapped and distance to a fire are far away. The helping risk is considered as *a little dangerous* if the distance between the handicapped and the fire are similar. The helping risk is considered as *seem dangerous* if the distance to the fire is closer than the distance to the handicapped. However, different agent types have concept of *similar distance* differently. Thus, they may estimate the risk in the same situation differently.

	corresponding module	rule's name	conditions
1	prediction	risk_helping_low(?path)	possible_to_help(?path) NO handi_fire_similar_distance(?path, ?handi, ?fire)
2	prediction	risk_helping_a_bit_dangerous(?path)	possible_to_help(?path) handi_fire_similar_distance(?path, ?handi, ?fire)
3	prediction	risk_helping_seems_dangerous(?path)	there_is_handicapped(?path, ?handi) there_is_fire(?path, ?fire) fire_closer_than_handicapped(?path, ?fire, ?handi)

Similar to the helping risk estimation, the *risk estimation for escaping* has three risk-level: 1) *low* - risk for escaping is low, 2) *medium* – risk for escaping is a bit dangerous, and 3) *high* – risk for escaping seems dangerous. The conceptual explanation of *risk estimation for helping* can be applied to *risk estimation for escaping.* Table 6-9 shows some example rules of risk estimation for escaping. The escaping risk is considered as *low* if it reaches two conditions. First, the considering path is *possible to escape*, as defined in Table 6-6, *possibility of escaping and helping.* Second, the distance between a considering exit and fire are far away. For the second rule, the escaping risk is considered as *a bit dangerous* if the considering path is *possible to escape,* and the distance between the exit and the fire is similar. For the third rule, the escaping risk *seems dangerous* if the considering path consists of an exit and a fire; moreover, the distance to the fire is closer than the distance to the exit. However, in the same condition, different agent types may estimate the risk differently since the concept of *similar distance* is different according to agent types.

Table 6-9 Example rules for estimating escaping risk. The escaping risk is considered as *low* if the distance to an exit and distance to a fire are far away. The escaping risk is considered as *a bit dangerous* if the distance between the exit and the fire are similar. The escaping risk is considered as *seems dangerous* if the distance to the fire is closer than the distance to the exit. However, different agent types have concept of *similar distance* differently. Thus, thy may estimate the risk in the same situation differently.

	Corresponding module	rule's name	Conditions
1	prediction	risk_escaping_low(?path)	possible_to_escape(?path) NO exit_fire_similar_distance(?path, ?exit, ?fire)
2	prediction	risk_escaping_a_bit_dangerous(?path)	possible_to_escape(?path) exit_fire_similar_distance(?path, ?exit, ?fire)
3	prediction	risk_escaping_seems_dangerous(?path)	there_is_exit(?path, ?exit) there_is_fire(?path, ?fire) fire_closer_than_exit(?path, ?fire, ?exit)

Another risk estimation is *effort for helping*. Unlike escaping and helping risk estimation which is considering to distance between a fire and a concerned component, an exit or a handicapped agent, the *effort for helping* is considering to distance between an exit and a concerned handicapped agent. This estimation has three effort-level: 1) *low* - no effort, 2) *medium* – low effort, and 3) *high* - big effort. The definition of *no effort* in this research is the handicapped is located on the way before the nearest exit. The helper agent can bring the handicapped along without extra effort to the nearest exit. Effort estimation for *a little effort* represents a situation that the handicapped is further than the nearest exit, but the distance between them are considered as close or similar distance. As a result, a helper agent has to take some extra effort for going to the handicapped's location by passing the exit once and turn back to it again. For effort estimation for *big effort*, it is considered as a situation that the handicapped is further away than the nearest exit, similar to the estimation of *a little effort,* but the distance between the exit and the handicapped is beyond the helper agent consider as *similar distance.* Example rules for estimating effort is shown in Table 6-10.

Table 6-10 Example rules for estimating helping effort. The helping effort is considered as *no effort* if the handicapped agent is located closer than the exit. As a result, the helper agent is just go to the handicapped agent's location and bring along to the exit without extra effort. The helping effort is considered as *a little effort* if the handicapped is located further than the exit. However, their distance is within the range that is considered as *similar distance.* As a result, the helper agent takes a little extra effort for helping. The helping effort is considered as *big effort* if the handicapped agent is further away to the exit. The distance is further than the range that is considered as *similar distance.* As a result, the helper agent is required a big effort for helping this handicapped agent.

	Corresponding module	rule's name	conditions
1	prediction	take_no_effort(?path)	there_is_exit(?path, ?exit) there_is_handicapped(?path, ?handi) handi_closer_than_exit(?path, ?handi, ?exit)
2	prediction	take_some_effort(?path, ?exit, ?handi)	there_is_exit(?path, ?exit) there_is_handicapped(?path, ?handi) exit_closer_than_handi(?path, ?exit, ?handi)
3	prediction	take_a_little_effort(?path)	take_some_effort(?path, ?exit, ?handi) exit_handi_similar_distance(?path, ?exit, ?handi)
4	prediction	take_big_effort(?path)	take_some_effort(?path, ?exit, ?handi) NO exit_handi_similar_distance(?path, ?exit, ?handi)

6.2.6. Selecting the best alternative

Selecting the best alternative is about how an individual agent does ranking its best alternative based on evaluating of risk estimation from different aspects mentioned in section 6.2.5, predicting outcomes for each alternative. As mentioned earlier, this research assumes that every agent prefers to help others if possible. If there is a chance that the agent accepts all risk for escaping, risk for helping and effort for helping, the agent will not hesitate to help the handicapped. All types of agent prefer the lowest risk option. In this RED model, selecting the best alternative module is divided into three major sub-processes. 1) to assess risk acceptation, 2) to categorize and to rank each alternative, and 3) to select the best candidate from the best category.

Figure 6-3 shows overview of how the *selecting the best alternative* module work. The first sub-process, to assess risk acceptation, is presented as the rectangle no.1. this process examines risk acceptations corresponding to each risk estimation, escaping risk, helping risk, and risk of helping effort according to the agent type. Table 6.11 – 6.13 are used in explanation for better understanding. The second sub-process, to categorize and rank each alternative, is presented as the rectangle no.2 in the figure. This process aims to categorize each alternative to be one of the four designed categories: 1) top candidate path, 2) candidate path, 3) ignored path, and 4) the rest path.

Table 6-14 is used to described how to categorize the alternative. The third sub-process, to select the best candidate from the best category, is presented in the rectangle no.3.1-3.4 within a big dash-rectangle in the figure. This process aims to manage to select the best alternative among candidate alternatives within the same of the best available category.

Table 6-15 is used to described how to manage to select the best alternative among multiple candidate alternatives within the same category.

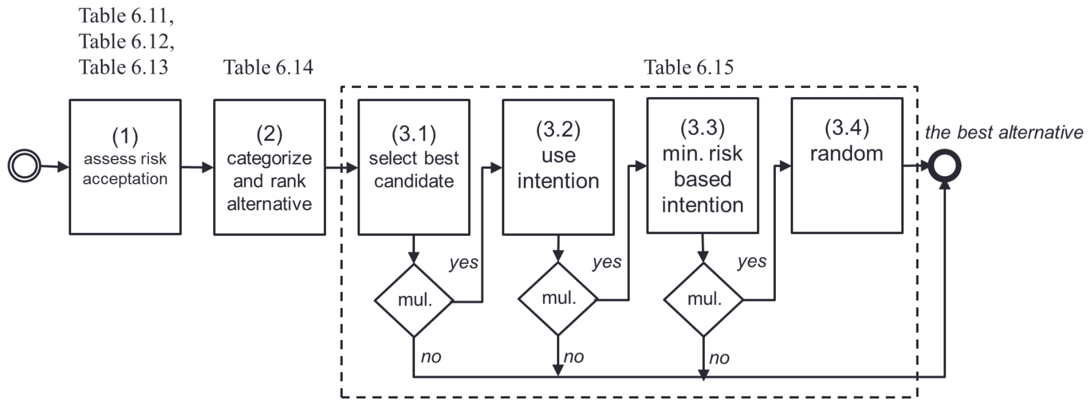


Figure 6-3 Overview of selecting the best alternative module. This module is divided into three processes. First, assess risk acceptation (no.1 in the figure.) This process performs risk acceptation for each alternative from a considering agent's point of view. It assesses risk estimations from the previous module. Second, categorizing and ranking each alternative (no.2 in the figure.) This process categorizes each alternative into one of four categories: *top candidate, candidate*, *ignored candidate*, and *the rest.* Third, selecting the best alternative (all processes in the dash-rectangle in the figure.) there are four sub-processes to handle cases that have multiple candidate alternatives remained. Briefly description is to use the agent's intention to select the best alternative. If there still are multiple alternatives remained, select the least distance to an exit or a handicapped responding to escaping or helping intention, respectively. If there still are multiple alternative remained, random one of them as the best alternative.

For the first sub-process, to assess risk acceptation, which is the rectangle no.1 in the Figure 6-3, this research considers the risk acceptation from two factors: 1) acceptation for escaping risk, and 2) acceptation for helping risk. The first factor, acceptation for the escaping risk, is about concerning distance between the nearest fire, and the nearest exit. If the distance between the fire and the exit are similar, it can be considered as a bit dangerous. On the other hand, the second factor, acceptation for helping risk, is concerning based on two risk estimation: a) the helping risk that concerns distance between the nearest fire and the handicapped. If the fire is close to the handicapped, it can be considered as a bit dangerous for helping; b) the effort for helping which concerns distance between the nearest exit and the handicapped. If the exit is much further away to the handicapped, it can be considered as requiring a big effort for helping.

Different types of agent have a different preference. For rational agent, they accept the escaping risk when the estimated risk is at *low* level. They prefer to not bring themselves to risky places. If the risk estimation is higher than that, *a little dangerous* or *seems dangerous,* they would prefer other better alternatives. For helping risk acceptation, if the rational agent considers that the *helping risk* is *low* or the handicapped is considered as far away from the nearest fire, they do not mind putting their effort for helping the handicapped. However, even the handicapped is far from the nearest fire (helping risk is low), they consider to not help if the handicapped is far from the exit (*take big effort* for helping.)

Table 6-11 show examples of the decision-making rules. The example rules present criteria that a rational simulated agent would consider for accepting the risk. The rational agent considers to accept escaping risk for an alternative path when the path has low-level of escaping risk, see rule no.1 in

Table 6-11. On the other hand, the rational agent considers to accept the risk conditions for helping when two conditions are reached. The first condition is the considering path has *low-level* of helping risk, and the second condition is the considering path requires *no effort* or *a little effort* for helping others. Otherwise, the rational agent does not well-confident for helping using this alternative path.

Table 6-11 Example rules for rational agent for accepting the escaping risk and helping risk. For the escaping risk (rule no.1), the rational agent could accept the escaping risk if and only if the escaping risk estimation is *low*. On the other hand, the rational agent could accept the helping risk (rule no.2) if two conditions are reached. First, the helping risk, that concerns relation between distance to the fire and the handicapped, is *low*. Second, the effort for helping have to be *no effort* or *take a little effort*.

	corresponding module	rule's name	conditions
1	selecting best	accept_escaping_risk (?path)	in_rational_state(?agent) risk_escaping_low(?path)
2	selecting best	accept_helping_risk(?path)	in_rational_state(?agent) risk_helping_low(?path) take_no_effort(?path) OR take_a_little_effort(?path)

The example rules presented in

Table 6-11 is only for the rational agent. For other agent types, brave and selfish agents, they can apply these risk acceptation concepts as well. However, different agent types have different preference. Table 6-12 and

Table 6-13 represent a typical preference of each agent types. Firstly, considering on the risk acceptation for escaping (see Table 6-12), The rational and selfish agents have intention to not risk themselves to the risky places. As a result, they would accept the escaping risk if the risk-level is *low.* On the other hand, the brave agent, in this research, thinks differently. The brave type of agent has confidence to handle some risky situation. As a result, the brave agent can accept the escaping risk if the estimated risk-level is in the range between *low* and *a bit dangerous*. However, none of any agent type accepts the the risk with *seems dangerous* level.

Table 6-12 Summarized conditions for every agent types to accept the escaping risk. The rational and selfish agents would accept the escaping risk when the escaping risk estimation is low. On the other hand, the brave agent is willing to handle a bit dangerous situation. The brave agent would accept the escaping risk when the escaping risk estimation within the range between *low* and *a little dangerous*.

	risk estimation for escaping		
	low	a little dangerous	seems dangerous
rational agent	✓		
selfish agent	✓		
brave agent	✓	✓	

Secondly, considering on the risk acceptation for helping (see

Table 6-13), there are two conditions to be concerned. First condition is the risk estimation for helping. This condition is a risk that concerns relation between the fire and the targeted handicapped. If the distance between them are far away, it could be considered as low risk. On the other hand, if the distance between them are close to each other, it could be considered as dangerous. Second condition is the risk of effort for helping. This condition is a risk that concerns relation between the exit and the targeted handicapped. If the handicapped is located closer than the exit, it could be considered as the helping requires *no effort,* since the helper agent just go to the handicapped agent's location and bring him along to the exit. If the handicapped agent is further than the exit, it means to help this handicapped requiring some effort. If the handicapped is not too far from the exit, it can be considered that this helping requires *a little effort.* On the other hand, if the handicapped is far away from the exit, it can be considered as the helping requires a *big effort.*

Table 6-13 is summarized conditions for every agent types to accept the helping risk. As mention earlier, there are two conditions to be concerned. First is the helping risk estimation which is rely on distance between the fire and the target-to-help handicapped. Second is the risk of effort for helping which is rely on distance between the exit and the handicapped. From the

Table 6-13, the rational agent would accept the helping risk if the first condition is *low* or the fire is far away to the handicapped; and the second condition is in the range between *no effort* and *little effort.* These conditions mean the rational would accept the risk and willing to help a handicapped if the fire is far away to the handicapped, and the helping does not require much effort to do. The selfish agent would accept the helping risk if both conditions are *low.* This means the selfish agent will accept the helping conditions if the fire is far away to the handicapped, and the helping requires *no effort* or the handicapped is located closer than the exit. With this condition, the selfish has confident that they are not put themselves to a risky situation. On the other hand, the brave agent would accept the helping risk with two situations. First situation is if the first condition is *low* risk, the brave agent does not care for the second condition. This means if the fire is far away to the handicapped, the brave agent does not care about effort to help this handicapped. The brave agent may feel safe enough to focus on helping if the fire is far away. Second situation is if the first condition is *a little dangerous,* the brave agent can accept the helping risk if the second condition is in range between *no effort* to *a little effort.* This means if the fire is not too far to the handicapped, the brave agent is willing to help the handicapped if it not take a big effort. However, none of all agent types would accept the risk if the situation *seems dangerous*

Table 6-13 Summarized conditions for every agent types to accept helping risk. There are two conditions to be concerned. First condition is the helping risk estimation. Second is the helping effort estimation. The rational agent would accept the risk if the first condition is low and the second condition, effort for helping, is between *low* and *little dangerous.* The selfish agent would accept the helping risk if the both conditions are at its *low* level. On the other hand, the brave agent would accept the helping risk with two cases. The first case, if the first condition is *low*, the fire is far away to the handicapped, the brave agent will not mind to help the handicapped. As a result, they can accept all level of effort. The second case is if the helping risk is at *little dangerous,* the fire is further than the handicapped, but not too far. In this situation, if the effort is between *no effort* to *little effort*, the brave agent can accept the risk.

	risk estimation for helping			effort for helping		
	low	a little dangerous	seems dangerous	no effort	a little effort	big effort
rational agent	✓			✓	✓	
selfish agent	✓			✓		
brave agent	✓			✓	✓	✓
		✓		✓	✓	

For the second sub-process, to categorize and to rank each alternative (rectangle no.2 in the Figure 6-3, after assessment of risk acceptation each alternative is categorized into one of the four groups; 1) top candidate alternative, 2) candidate alternative, 3) ignored candidate alternative and 4) the rest alternative.

Table 6-14 presents rules used for categorized the alternative paths into one of these four categories. For the first category, the top candidate alternative category, rule no.1 in the

Table 6-14, is a group that the path is considered as possible for both escaping to an exit and helping the handicapped. Moreover, its risk for escaping and helping, as mentioned above, are accepted by the agent. Top candidate category is the best option for the agent to consider. For the second category, the candidate alternative category, rule no.2 in the table, is a group that the path's risk is acceptable either escaping risk or helping risk. This category is the second-best option for the agent to consider. However, this process does not evaluate which of the escaping risk acceptation or helping risk acceptation is better than another. The third category, the ignored candidate alternative is the worst option for the agent. It considers on the path that is too dangerous or useless to select. The alternative that is too dangerous, rule no.5 in the table, can be consider as a path that has fire in just one-unit distance to the considering agent. In the other word, there is a fire in the next step. The alternative that is useless for selecting, rule no.4 in the table, is the path that has neither exit to escape nor handicapped to help. The last category, *the rest alternative*, represents the leftover alternatives, rule no.6 in the table, that their risk estimations are not accepted by the considering agent.

Table 6-14 represents rules used for categorizing the alternatives. All types of agent would prioritize on *top candidate*, *candidate*, *the rest* and *ignored alternative* categories, respectively.

Table 6-14 Rules for categorizing alternative in to categories. There are four categories: top candidate path, candidate path, ignored candidate, and the rest candidate categories. For the *top candidate path* category, this category represents alternative paths that are accepted for both escaping and helping risk estimations. For the second category, the *candidate path,* this category represents alternative paths that are accepted only either the escaping or helping risk estimations. For the third category, the *ignored candidate path*, this category represents too dangerous or useless candidate paths. Too dangerous path means a path that there is a fire right next to current location. Useless path means a path that there is neither any exit for escaping, nor handicapped for helping. For the forth category, the *rest candidate path*, this category represents the leftover of the *top candidate path, candidate path,* and *ignored candidate path* categories. These categories are ranked from the most to the least preferable as *the top candidate path, the candidate path, the rest candidate path,* and *the ignored candidate path* categories, respectively.

	Corresponding module	rule's name	conditions
1	selecting best	top_candidate_path(?path)	considering_path(?agent) accept_escaping_risk(?path) accept_helping_risk(?path)
2	selecting best	candidate_path(?path)	considering_path(?agent) accept_escaping_risk(?path) NO accept_helping_risk(?path)
3	selecting best	candidate_path(?path)	considering_path(?path) accept_helping_risk(?path) NO accept_escaping_risk(?path)
4	selecting best	ignored_path(?path)	considering_path(?path) there_is_no_exit(?path) there_is_no_handi(?path)
5	selecting best	ignored_path(?path)	considering_path(?path) there_is_fire_next_step(?path)
6	selecting best	the_rest_path(?path)	considering_path(?patth) NO top_candidate_path(?path) NO candidate_path(?path) NO ignored_path(?path)

For the third sub-process, it is to select the best candidate from the best category (rectangles no.3.1-3.4 inside the dash-rectangle in the Figure 6-3. The aim of this sub-process is to handle how to select the best alternative for an agent to perform its action. From the last sub-process, each agent categorizes its considering alternative paths into four categories, and ranks them as *top candidate path, candidate path, the rest path,* and *ignored path* categories. Support the agent select its best category (rectangle 3.1 in the Figure 6-3), for example *the candidate path,* there are cases that there are multiple alternative paths within this category. For this example, all these alternatives could be considered as the best candidates from the best available category, the *candidate path* category. These alternatives are accepted for either escaping risk or helping risk. However, which performance this agent should be selected: an alternative path for escaping or for helping? At this situation, the agent's intention (see section 6.2.1, making goal) becomes a key factor to select the right alternative (rectangle 3.2 in Figure 6-3.) In this research, if there are multiple alternatives to be selected, an agent prefers to behave as its personal intention. As a result, if the agent has escaping intention, it will select its best alternative based on escaping. On the other hand, if the agent has helping intention, it will consider its best alternative to help others. Support this example, the considering agent has helping intention. If there is only one alternative left, that alternative is considered as the best alternative of the agent. However, it is possible that there are multiple alternative paths that are accepted for their helping risk. Which alternative the agent should be select? At this situation, the agent could select the best alternative by selecting the most minimal risk corresponding its intention (rectangle 3.3 in Figure 6-3.)

Table 6-15 shows criteria for an agent to select its best alternative when there are multiple alternatives. If the agent has helping intention, the agent can select the alternative which has the least distance to the handicapped as its best selection (rule no.2 in

Table 6-15.) On the other hand, if the agent has escaping intention, the agent can select the alternative which has the least distance to an exit as its best selection (rule no.1 in the table.) If there is only one alternative left from this process, that alternative can be considered as the best alternative for the agent. However, it is possible that there are multiple alternatives left which they have the same the least distance to the handicapped. In this situation, the agent can randomly select one of these alternative as its best selection (rectangle 3.4 in Figure 6-3) since all of remaining alternatives have the same purpose, helping purpose in this example, with the same smalled distance to the handicapped.

Table 6-15 Criteria for an agent to select its best alternative when there are multiple alternatives. If the agent has escaping intention, the criterion is to select the alternative that has the least distance to exit. On the other hand, if the agent has helping intention, the criterion is to select the alternative that has the least distance to the handicapped.

	corresponding module	agent's intention	method to minimize risk
1	selecting best	escaping intention	the least distance to exit
2	selecting best	helping intention	the least distance to handicapped

6.3. Summary

This chapter mainly describes on correspondence of 1) the RED model and the soft-half-baked microworld, and 2) the RED model and its decision-making rules.

Theoretically, the microworld requires a learning model to achieve a designed learning goal. The soft-half-baked microworld inherited this concept from the traditional microworld as well. The RED model is representing an agent's thinking model. All agents have the same thinking process: making goals, collecting information, making criteria, making alternatives, prediction outcomes for each alternative, selecting the best alternative and take an action. However, when emotions involve the agent's thinking process, it impacts to the agent's thought. As a result, each simulated agent behaves differently as rational person, brave person and selfish person. In the same situation, some of them may consider helping others; on the other hand, someone else may consider on escaping rather than help others. This reflects a simple version of real world phenomena. This research provides a set of learning scenarios representing this phenomenon. Learners can observe a set of these scenarios. They may reflect on their own thinking process, and be motivated to be aware their thought. In conclusion, the correspondence of the RED model toward the soft-half-baked microworld is as a complement for creating such learning scenarios and utilizing learners to achieve the learning goals.

This research uses the RED model and its decision-making rules to represent how rational- and emotional-agent's thought. All agents have the same processes for making a decision. However, when emotion involves their thinking process, they may behave differently. The decision-making rules are a factor that make those differences happed. The rules are used to create a mechanism of an emotion-based decision-making following the RED model concept. The mechanism is a key to make the designed phenomena of escaping and helping behavior in an indoor fire emergency to happen. The rules cause different agent types to behave differently. For example, defining that a brave simulated agent tends to accept more risk to for helping others than a selfish person. Section 6.2 describes how does each RED model's process relates to the decision-making rules. However, this section mentioned only some of the decision-making rules. More rules are presented in APPENDIX A.

Even though the RED model and decision-making rules can represent a simplified version of how ones make a decision, there are still big gaps between the decision-making model and the actual human being's thought. This RED model is designed for the learning purpose. The rules presented in this research focuses on typical concepts that can be accepted from most people. Complex and subjective factors are not concerned here since it is based on accumulated knowledge and experience from person to person. For example, the definition of *effort for helping* rules are concerned only the distance between a handicapped who needs help and the nearest exit in that path. Complex factors such as level of disability of the handicapped, or fatigue level are not concerned here since it is a personal dependence.

CHAPTER 7 LEARNING MATERIAL

The objectives of this research are: 1) to propose a learning platform using surprise to motivate learners' self-awareness, and 2) to motivate learners' self-awareness of their thought in the indoor emergency. To achieve both objectives, we propose a learning environment representing a simulation of escaping and helping behaviors in an indoor fire emergency. The learning environment is designed following the proposed learning platform using surprise to motivate learners to realize their thought. The definition of *surprise* in this research is a representation of difference between expectations and reality (Casti, 1994; Lorini, 2007). A concept of the learning platform using surprise to motivate learners to be aware of their thought is depicted in Figure 7-1. There are three phases (underlining with blue-colored text in the figure.) The first phase is *anticipating phase* (presented with blue-colored as no.1.) The learner observes a given phenomenon (process a. in the figure), then uses his current knowledge and experience to predict the phenomenon's outcomes (process b.) and explicitly expresses the predicted results as his opinions (process c.) In the learning platform, there is a peer who plays a role as a scaffolder to support the learner in the learning. This peer can be a person or even a computer. In this research, this peer is a computer-based simulation. This simulation is created following the concepts of soft-half-baked microworld and the RED model mentioned in chapter 5 and 6, respectively. Its role is as a peer to observe the same phenomenon given to the learner, and to generate its opinions based on its own logic. The second phase is an *evaluating phase* (presented in blue-colored as no.2,) It is occurred when the learner compares his opinions with the scaffolder's opinions. Comparison results, especially the different ones, may make the learner feel surprise (process d. in the figure) since the comparison results are different from the expectations. The different comparison results can imply that the learner's thinking process is probably different from the simulation's mechanism. However, this research does not aim to judge whose opinions are the correct ones. The actual emergency is more complex than this simplified and controlled simulated emergency. It aims to motivate the learner to use this surprise to reflect on their thinking process (process e. in the figure.) The third phase is *self-monitoring phase* (presented in blue-colored as no.3.) Based on the different comparison results, the learner is expected to be motivated to question his own thinking process (process f. in the figure.) The learner may try to figure out what make the different comparison happen, or question himself whether there is any overlooking information during he make a prediction. As a result, the learner is expected to be aware of the thinking process and may adapt it when he has to encounter the actual situation in the future.

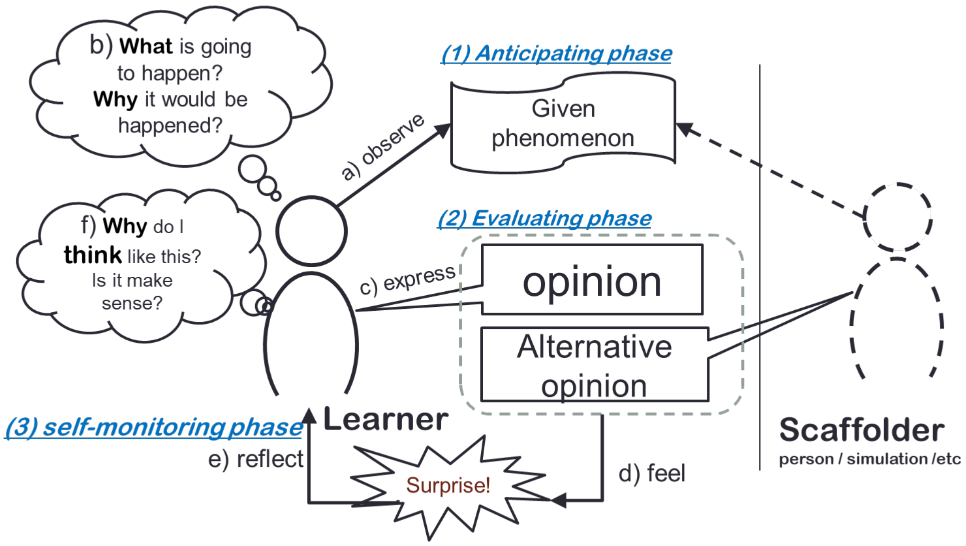


Figure 7-1 A concept of the learning platform using surprise to motivate learners to be aware of their thought. There are three phases: anticipating, evaluating and self-monitoring phases (presented with blue-colored as no.1-3), respectively. A learner observes a given phenomenon (a) and use its current knowledge to predict its expected outcomes (b.) The learner explicitly expresses its predicted opinion (c.) The learning platform has a scaffolder which plays a role for giving alternative opinion to the learner. This scaffolder can be a person or a system. In this research, the scaffolder is a simulation system created by following concepts of the soft-half-baked microworld mentioned in chapter 5. The simulation system provides alternative opinions to the learner. The learner compares its own opinions with the alternative opinions. Comparison results, especially the different ones, are expected to cause the learner feel surprise (d.) The difference can imply that the learner's thought is different to the simulation's mechanism. The learner reflects the comparison results to itself (e.) The learner may try to figure out what causes the different comparison to happen. As a result, the learner is expected to be better aware of its thinking process.

To implement a learning course, the learning materials should be carefully prepared to support the learner to be motivated to realize their own thought.

Table 7-1 presents an overview of the designed learning course. There are three phases: 1) pre-learning, 2) main-learning and 3) post-learning. For the *pre-learning phase,* its objectives aim to provide learners about the problem of emotional behaviors during indoor fire emergencies, and to seed curiosity to learner mind. The learners may imagine what would they do if they were in the given situation. However, different person may have different background of knowledge about a term of an "indoor fire emergency" in their mind. Different persons would have different pictures in their mind. For example, one may imagine about a wall of fire, another one may imagine a situation filled with cloud of smokes, and a different one may think about the darkness. This phase aims to lead the learners to have the same imagine about this simulated indoor fire emergency (see section 7.3.1.) For the *main-learning phase*, it is a main part that aims to let a learner operate with the simulation system (see section 7.3.2.) The learner can observe the simulated phenomenon, explicitly express his or her opinion predicting the phenomenon's outcomes. Compare those predicted outcomes with the results generated from the system and reflect the content to their mind, as presented in Figure 7-1. The concepts in Figure 7-1 are presented in this phase. The learning materials in this phase aims to achieve two purposes: 1) to explain the learners how to use the simulation system, and 2) to guide the learners to explicitly express their thought toward the observed phenomenon. For the *post-learning phase*, it aims to evaluate the results of learning (see section 7.3.3.) Learners are expected to be motivated to realize their own thinking process by reflecting the comparison results between their predictions and simulation results. This research provides a set of questionnaires carefully selected to guide learners to question their thought. As a result, the learners are expected to be aware of their thought.

Table 7-1 Overview of the learning course. It is divided into three phases: pre-learning, main-learning and post-learning phases. The pre-learning phase aims to shape the mutual understanding of the scenarios of emergency we used in this research, and seed the curiosity about their behaviors if they were in the emergency themselves. The main-learning phase aims to let the learners explicitly express their prediction toward the given phenomenon. Questionnaires are used to guide the learners to think deeper. The post-learning aims to motivate learners to realize of their thinking process. A set of questionnaires are carefully selected to guide learners to question their thought.

Phases	Order	Goal	Learning material	Learning activity
Pre-learning	1	h) Introduce objective of the learning i) Introduce concept of rational and emotional decision making j) Seed curiosity on self-awareness	f) Video and text of emergency scenarios: to seed curiosity in the learner's mind	Motivate learner to realize loss in emergency (15 mins)
Main-learning	2	k) Explicitly describe learner's prediction l) Let surprise happens to trigger learners to be aware of their thought	g) Explanation of using the simulation (microworld) with example	Understand how to interact with the microworld (10 mins)
	3		h) Run the soft-half-banked microworld with the RED Model	Set parameters and express the expected results (15 mins)
	4	m) Reflect learners thinking process		Run the simulation (the microworld) (10 mins)
	5		i) Questionnaires I: to guide learners to give reasons for their predictions	Compare expected results and actual results (15 mins)
	6			Aware difference and similarity and expected surprise happened (20 mins)
Post-learning	7	n) Evaluate results of learning	j) Questionnaires II: to guide learners to be aware of their thought	Reflect on self-awareness (25 mins)

This chapter focuses on the learning materials using in the learning course (see

Table 7-1 column *learning material*.) The chapter aims to describe what are the intention behind each learning material, what are the final learning materials providing to learners, and how the learning materials correspond to the designed learning platform. The structure of this chapter is divided as the objective of the designed learning materials, scope and concern of the design, and the content of the learning materials. In each section, we describe both the specific intention and corresponding implementation.

7.1. Objective of the designed learning materials

In general purpose, the main objective of these learning materials is to make the learning go smoothly. It means with the designed learning material, the learners get the idea what the learning activities in the learning course is, can imagine scenarios of the designed indoor fire emergency the same way as others, are able to follow the learning activities provided by the learning course to achieve the learning goals without or the least problem. Since the learning course is divided into three phases: pre-learning, main-learning and post-learning phases as mentioned in

Table 7-1) The objective of the learning materials in each phase may be different. For the *pre-learning phase*, the learning materials are designed for two purposes. The first objective is to let the learners tune the image of emergency in their mind to be as our design. Without this learning material, different learner may have a definition and pictures of the indoor fire emergency differently. With this learning material, the calibration would make the learners have the same image of an indoor fire emergency as the designed emergency phenomenon in their mind. The second objective is to seed a curiosity of their own behavior in the learners' mind.

For the *main-learning phase*, the learning materials are divided into two parts: explanation of how to use the simulation system, and questionnaires for guiding learners to think deeper about what are reasons to them for the predictions they made (see

Table 7-1 in main-learning section.) For the first part, the explanation of how to use the simulation system is necessary since the learners should understand how to modify the simulation parameters, how to run a simulation, how to observe the live demo, and how to interpret the educational information such as graphs, and statistic information of concerned values generated by the simulation system. For the second part, questionnaires are used to guide the learners to think about what are their expected results such as number of survivor of a specific agent type should be higher than another type. Moreover, the questionnaires require the learners to give reasons that cause them to make those answers. These questions guide them to realize of what is their thinking process is during making their predictions.

For the *post-learning phase,* the learning materials are also questionnaires. However, the questionnaires in this phase are not the same as the questionnaires in the main-learning phase. Its objective is also different. The objective of using questionnaires in this phase is to guide the learners to gradually think about their thought. However, the learning course require the learners to reflect on their thinking process in many steps, too many questions may cause the worse results since the learners may be exhausted. Only few questions are carefully selected to evaluate the learning results.

Based on these objective of the learning materials, we expect these learning materials could guide the learners to carefully think when they make predictions: what are the expected results, and why those results should be happened, and to question themselves whether their thinking processes are good enough or not. As a result, we expect that the learners are motivated to be aware of their thinking processes. The definition of "being motivated", in this research, does not mean they can explicitly make their own thinking model by themselves. We expected them are stimulated to monitor and remind how their thinking processes are. They may realize to adapt new knowledge they perceive from this learning course which they have never realized it before participating this learning course. Even thought, this learning course is a trial use case, we expect to use the learning results and feedbacks to direct how to improve and develop an experiment in the future. The trial use case is designed to target on the research objective, "whether the learners could be motivated to realize of their thought or not."

7.2. Scopes and concerns of the designed learning course

7.2.1. The learning course is considered as a trial use case

This learning course is considered as a trial use case to evaluate the research methodology. The reason that this learning course is not considered as an experiment, from the author's point of view, is the population issue. The target population refers to the entire group of individuals which the research are interested in specific conditions. However, we cannot request the whole population to take the experiment. Only some numbers of them should be randomly sampled from the entire interested population. They can be considered as representatives of the target population, and participate the experiment. However, in this research, the participants are limited to a certain group of the first-year undergraduate students of a Sirindhorn International Institute of Technology (SIIT) in Thailand. As a result, the author considers this learning course as a *trial use case* rather than an experiment.

However, our participants are considered as ones of our ideal target population, except the proper random sampling. Our ideal target learners, in this research, are middle to late adolescence to early of adulthood who are in range of sixteen to twenty-two years old. In other word, the target participants are range between high school students to undergraduate students. The term of adolescence is defined as ones who are in age range between ten to nineteen years old (WHO, 2017). People in these age range are forming their identity by their physical growth, intellectual, emotional and social development. Taking the learning course for motivating to be aware of their thinking process benefits them to prepare for adulthood. We have three criteria for selecting our target participants.

1) **Decent reasoning ability**: this research requires learners to predict results of the simulated phenomenon. The learners should be able to give reasons for their predictions. Moreover, the research aims to motivate learners to be aware of their thought. The learners are expected to be able to reflect the learning content to their mind and realize how their thinking processes are. Reasoning ability is a necessary factor to achieve the objective of the research.
2) **Low experience of emergency**: there are two reasons for aiming to target on the low experience of emergency participant. The first reason is the low experience persons tend to have less bias from their experience. When they are requested to compare their predictions and simulated results, these low experience participants tend to have higher chance to get the different comparison results which are the key to cause the surprise to happen. Moreover, this research aims to use surprise to motivate learner to think deeper about their thinking process, but not to judge the correctness. The low experience participants tend to have less bias from their experience. If different comparison results are occurred, we assume the low experience participants tend to find possibility that cause the difference happen rather than to judge that the simulated results are incorrect since they had a difference experience. The second reason is the high experience persons may have difficulties or may not be convinced to the simplified simulated scenarios since they have experience with the complex emergency already. The emergency in their imagination is probably different to the low experience persons.
3) **Concentration**: the learning course requires participants to answer questionnaires. There are many questions and most of them are required the learners to give reasons

behind the answer they made. As a result, the learning course takes time and consumes thinking effort. If participants cannot be patient and concentrate to the learning course for two hours, approximately, it may affect to the research results.

Based on these three criteria, the late adolescence or teenager are our target population. At this range of age, they have their own reasons to handle problems by themselves. They are mature enough to have responsibility on the task they are assigned. Moreover, typical person at this range of age are students which their main job is studying. It has higher chance that they have low experience about an emergency. In this research, most of the participants in our trial use case are eighteen years old, and are undergraduate students of Sirindhorn International Institute of Technology (SIIT) in Thailand. They are considered as ones of our desired population.

Even though the learning course is considered as a trial use case based on a difficulty of proper sampling the population, we aim to use the results from this trial use case to improve the method to promote awareness of the learner to realize their thinking process. Moreover, there is another expectation from the participants we selected from SIIT which is considered as one of high quality academic institutes in Thailand. The expectation is the quality of the feedback from the participants toward the trial use case. As a result, they are sincerely describe their opinions in the questionnaires that which part they are agree or disagree in the trial use case. This issue will be presented in **エラー! 参照元が見つかりません。**.

7.2.2. Why does the indoor fire emergency is selected as the learning scenarios

The indoor fire emergency is selected to be our learning scenarios over other types of emergency such as natural emergency: earthquake, tsunami, avalanche or flood; or man-made emergencies: car crashes or war, as examples. The main reason to select the indoor fire emergency is more common and more familiar to most people than other emergencies. It is more common because people live and pursue their daily activities in buildings more than ever since massive development of cities. They live at houses, apartments or hotels, work at office buildings, go shopping at department stores, for examples. They can imagine if there is an emergency to happen, what kind of situations would be. Unlike other emergencies, some countries have never experience an earthquake or tsunami in their life, an avalanche happens in the mountains where there are not many people living there; moreover, massive amount of snow are required. On the other hand, many locations have no wars for generations. For those emergencies people may know them from medias; however, it is difficult for them to imagine about the actual emergency. For the indoor fire emergency, even though they may not have any directed experience to the emergency, but with familiarity to the environment it is easier for them to imagine to the situation. Moreover, there are higher chance that they have some one related to them experienced the indoor fire emergency, than knowing some one that experience avalanche. As a result, the indoor fire emergency is selected since it more common and more familiar to most people than other emergencies.

7.2.3. The trial use case is conducted in Thai language

Since the essential hypothesis of the research is “whether the learners could be motivated to be aware of their thought using surprise”, we conduct this trial use case to confirm it. Even though it is not considered as an experiment because of the limitation of using too specific population, it would show the possibility of the research. In this trial use case we provide the learning materials, which is described in more details in section 7.3, in Thai language. The main reason that the materials are made in Thai is we concern to reduce the load of reasoning to the learners. Since the learning course requires learners to imagine about multiple situations, each situation requires the to explicitly describe their thought with reasons. Moreover, they also are requested to compare their predictions with the observed simulated results, and reflect those content to their mind. This can be considered as a task that consume a lot of thinking processes. To prevent them from exhausted, we carefully select the most important questions to conduct the questionnaires and use Thai language to reduce their thought load. As a result, the whole learning materials are provided in Thai for the learners. However, we describe them in English in this dissertation.

7.2.4. How to implement and measure the surprise to happen

This research defines surprise as the difference between expectations and reality (Casti, 1994; Lorini, 2007). To make those difference happen, we design our learning platform which have comparison process as a key to motivate learners to be aware of their thought. The learning platform provide chances that the learners predict their expected results of given scenarios, and chance to compare their predictions with observed simulated results. We expect the different comparison results cause them feel *surprise*. The learners’ predictions can be considered as the *expectations* and the observed simulated results can be considered as the *reality* as defined in the definition, respectively. The comparison between learners’ predictions and observed simulated results can be considered as a comparison between the learners’ thinking processes and the mechanism of the RED model. When the comparison results are not as their expectations, they may feel curious that why does the difference happen. We use this chance to give them questions, in the trial use case, to guide them to question themselves. They may try to find out the acceptable reasons by themselves by comparing new hypothesis with their original thought. They can modify the simulated parameters and run the simulation again to test their hypothesis. As a result, they are motivated to gain a better awareness of their thinking processes.

To evaluate whether the learner is motivated to be aware of their thought or not, we use consequence of questions to measure them. The questions are carefully selected. They gradually guide the learners to thinking deeper step-by-step. For example, the questions aim to point out which results are different from the expectations, are those difference acceptable, what are reasons that make you accept or not accept them. Finally, in the very end, the questionnaires ask the learners whether these processes remind them to think about their thought or not. We consider if the learner admit that they remind to their thought, we assume that they are motivated to be aware of their thought. However, the term of "being motivated" may lead to confusion. In this research, we define the term "being motivated" as the learners have change their stage of knowing. Before participating the trial use case, they may have knowledge at a particular stage, and after participating the trial use case, they change to another stage. The stage in this research is before participating the trial use case they may have a set of certain personal understanding toward the behavior in an indoor fire emergency. Afterward, those personal understanding may be changed, or not changed but have a better explanation based on the learning processes the took. For example, a learner may find a different comparison results between his predictions and the simulated results. The leaner tries to figure out what may cause the difference to happen, he may question himself that "was there any overlook information when making predictions?" Finally, he can find possible reasons that can cause the difference to happen. Another learner may have a similar situation. She tries to figure out the reasons that cause the difference to happen. However, she still cannot find it, but with the deep thinking about the issue, she has more confidence on her thought. She may even refuse the observed simulated results with better reasons. These examples can be considered as "being motivated." However, we are not expected the learners to explicitly understand can present their thinking processes as a concrete thinking model.

7.3. Content of the learning materials

The content of the learning materials will be described based on the information in Table 7-1, the overview of the learning course. The learning course is divided into three phases: 1) the pre-learning phase, 2) the main-learning phase, and 3) the post-learning phase. In the pre-learning phase, the learning materials are video and text contents to present overview of emergency to learners' mind (see learning material a. in Table 7-1.) These learning materials are described in section 7.3.1. In the main-learning phase, the learning materials are divided in to two parts. The first part is about an engaging of the simulation (learning material b. and c. in the Table 7-1.) The second part is about questionnaires which aims to let the learners give reasons for their predictions. These learning materials are described in section 7.3.2. In the post-learning, the learning materials are also questionnaires; however, these questions aim for guiding the learners to be aware of their thought. These learning materials are described in section 7.3.3. The following sections present the learning materials in each phase. They describe both intention behind the content and the actual content providing to the learners.

7.3.1. The learning materials in pre-learning phase

The learning materials in this phase are divided into two parts. The first part is learning materials which give the learners the overview of some behaviors in emergencies. Each behavior relates to emotions. The learners are expected to understand how emotions impact to our behaviors. The second part is to describe an overview of the learning course that they are participating. They can understand what learning activities they are going to participate with for this learning course.

1) The learning material presenting the overview of behaviors in emergencies

   The learning materials in this phase are video and text contents. The contents present case studies of behaviors in emergencies. Those case studies are selected with an intention to seed some curiosities in learners' mind. We ask them a question "if it was you, what do you do?" This question does not need the answer from the learners. It is intentionally asked to the learners to stimulate them to question themselves if they were a person in the case studies, what are their decisions.

   In this section, we select two news that relates to behaviors in emergencies. The first news, see Figure 7-2, is about an emergency of electrical shock (Morning-news, 2017). There was a woman was shocked by the electricity. Her son found the mother was shocking. He decided to help her; however, the helping was failed. Both of them was dead by the electrical shock. This example aims to show the learners that even we have knowledge that we should turn off the source of electricity before everything else for this such emergency. However, the extreme emotions may cause people not to be aware the knowledge they have. As a result, people may perform improper behaviors and are leaded to dangerous situations. These emotions could be worrying of the safety-safeness of a family member, frightening for the unexpected incident or other emotions depending to a particular person.

Figure 7-2 A news is about an emergency of electric shock. There was a woman who was collapsed by electrical shoeck. Her son found her and attempted to bring her out. However, both of them were dead by the electrical shock.

The second news, see Figure 7-3, is about the destructive earthquake and tsunami in 2011, Tōhoku, Japan (NHK, 2015). The story is about a young cameraman who experienced the incident. He said that while he was managed to escape to a high and safe place, he saw an old man trying to escape the tsunami nearby his location. He decided to shoot a video for this incident. At the end, the old man could not manage to escape. The cameraman said he was regret about this incident. He thought the old man may be survived if he went to help him. This incident causes him to feel guilty. However, a son of the old man saw the video taken by the cameraman. The son had a chance to meet the cameraman to thank him for shooting the video. The son said it was good for the cameraman to no go for helping his father, otherwise the cameraman may be not survived too. Moreover, the existence of the video makes the son feel easy because he knows what happen to his father. This example aims to show the learners that the emergency is complex. It can be considered in many aspects. People may think a decision is bad form a particular aspect; however, it may be not bad if it is viewed from another aspect.

Figure 7-3 This news is about incident of tsunami in Tōhoku area, Japan (2011.) The story is about a cameraman felt guilty because he did not help an old man escape to a safe place. He took a video instead. However, a son of the old man came to meet him with gratitude for the video he took. The son said it was good for him to not help his father, otherwise he may not survive too.

2) The learning material presenting the overview of the learning activities

Before moving to the main-learning phase, the definitions of the rational and emotional persons are described to the learners to let them have the same image of the simulated emergency in their mind. In this research, the rational person is ones who are aware of the degree of their emotions. They can manage to not let the emotions control their thoughts and behaviors. On the other hand, the emotional person is ones who let the emotions take place and influence their thoughts and behaviors. In this research, the rational and emotional persons have the same thinking process. The factors for evaluating the situations may be the same. However, the emotions cause them to evaluate or to judge the situation differently. For example, in a certain situation a rational person may consider the situation as low risk, while an emotionally brave person considers it as no risk. On the other hand, an emotionally selfish person may consider the situation as high risk. 1

We also present the overview of the learning course to learners as depicted in Figure 7-4. The learning course is divided into six steps. Step no.1 and 2 present the pre-learning phase, step no.3 and 4 present the main-learning phase, and step no.5 and 6 present the post-learning phase, respectively. The step no.1 is an introduction of case studies that show example behaviors in emergencies as mentioned in section 7.3.1. It aims to let the learners question their thought for themselves. Moreover, this step also aims to tune the image of an emergency in the learners' mind for participating the learning course. This tuning is necessary since different person may have different background knowledge and experience toward an emergency. Without this tuning they may imagine the term "emergency" differently, and it may affect to the learning outcomes. Based on the introduction in the step no.1, the expected results, such as the learners have an idea of how emotions affect decision-making processes and behaviors, are considered as a primitive knowledge for participating the learning course (no.2 in the Figure 7-4.) After that the learners are informed that the learning course is conducted by a simulation of an indoor fire emergency. the simulation represents a phenomenon of helping and escaping behaviors by simulated agents in an indoor fire emergency. The learners are introduced how to use the simulation system which is described in section 7.3.2. They are also asked to predict the outcomes of the simulated phenomenon through questionnaires (step no.3 in the figure) and run the simulation (step no.4.) There are two approaches to run the simulation. The first approach is a single-process run, the second approach is multiple-process run. There are described in more details in section 7.3.2. After that, the learners are requested to compare their predictions with the observed simulated results (step no.5.) At the step no.6, another set of questionnaires are used for asking the learners' opinion toward the comparison results. The questions are carefully designed to guide the learners to gradually think of what reasons that cause them to make predictions as they did. The learners may have new ideas for their predictions which is considered as their primitive knowledge is changed (feedback to the step no.2.) They can modify the simulation parameters, make new predictions and run the simulation again to test their hypotheses.

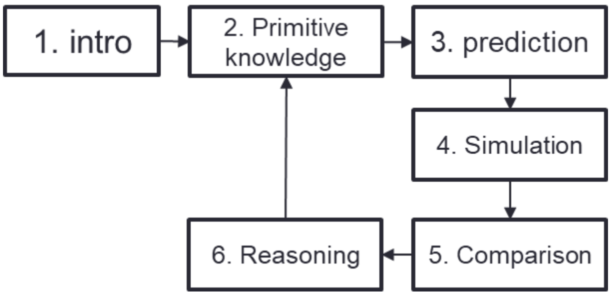


Figure 7-4 The overview of the learning course. It is divided into six steps. The first two steps, 1 and 2, represent as the pre-learning phase. Step no.3 and 4 represent the main-learning phase. Finally, the step no.5 and 6 represent the post-learning phase.

7.3.2. Explanation of using the simulation

This learning materials are considered as one of the material used in the main-learning phase (the material b. in the

Table 7-1.) There are two intentions for these learning materials: 1) to describe how is the simulated phenomenon that the learners are going to participate with, and 2) to describe how to use the simulation system. For the first intention, it aims to describe what does the simulated scenario look like, what kind of simulated agents in the simulation, what behaviors they can perform. For the second intention, it aims to explain how to interact with the simulation system, how to modify simulation parameters, how to run the simulation, and how to interpret the information generated from the simulation.

1. The intention for describing how the simulated phenomenon is

   In this research, the simulated phenomenon is scenarios that simulated agents perform helping and escaping behavior in an indoor fire emergency. All simulated agents have the same mechanism of thinking processes. For example, they have two intentions: to help others and to escape to the nearest available exit. They collect information and evaluate risks of the current situation, and select the best option to perform their actions. However, different agents may have different ability to control their emotions. The simulation presents three types of agent: 1) the rational agent, 2) the emotionally brave agent, and 3) the emotionally selfish agent. The rational agent represents ones who have balance to control their emotions. On the other hand, the emotional agents, both the brave and the selfish agents, represents ones who let their emotions influence their decisions. For example, feeling of so much confidence may turn one to become an emotionally brave person. These emotions affect their decision-making process. As a result, even they have the same mechanism of decision-making, the emotions cause them to evaluate the situation differently. For example, a rational agent considers a particular situation as a bit dangerous to use for escaping, while an emotionally brave agent considers it as safe, and an emotionally selfish agent consider it as too dangerous. These different evaluations cause them to behave differently in the simulation.

As mentioned earlier, the simulation presents an indoor fire emergency. each simulated agent has two intentions, escaping and helping others. The agents are randomly located in the building. The building, see Figure 7-5, can be considered as a one-storey-high building. There are rooms, passages and exits. Fires are randomly ignited in the building. All simulated agents tend to escape the building as fast as possible. This is considered as *escaping intention.* The building presented as Figure 7-5 can be represented as nodes and edges following concepts of the Graph theory. The building is divided into areas representing in different colors. The red colored rectangles are exits. The agents will be considered as survive if they are able to reach one of the exits. Each area can be considered as a node. White rectangles represent doors or passages between two areas. They can be considered as edges in the Graph theory. There are twenty-two nodes (including exits), and twenty-seven edges.

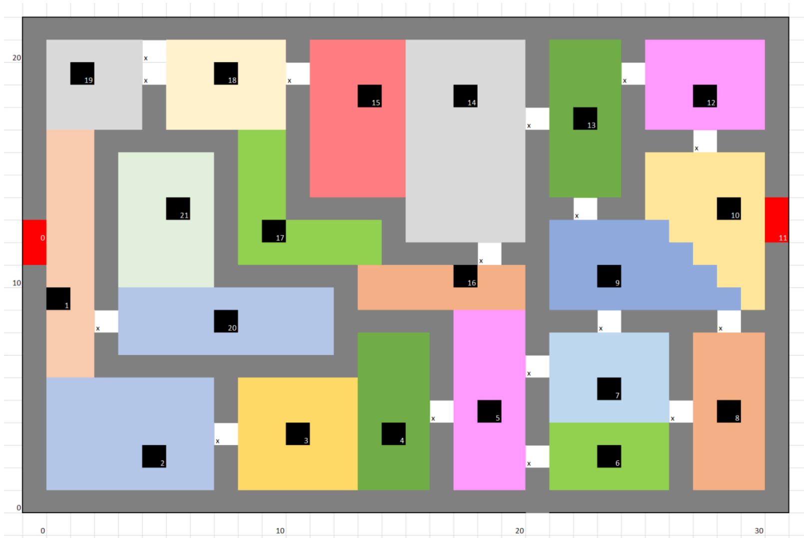


Figure 7-5 A floor plan's layout of a building which is used in the learning course. There are 21 rooms, 2 exits. Applying with the graph-based theory, it can be represented as 22 nodes and 27 edges in a graph. Each node in the graph is represented as a black square dot. Each node dominates its own area

representing in colors. The red-rectangle are exits. The white colored rectangles represent doors or passages connecting between two areas.

The simulated agents do not have only the *escaping intention*. Another intention is *helping intention*. We set up a type of handicapped agent to represent ones who require help for escaping in the simulated indoor fire emergency environment. The handicapped type of agent cannot move by themselves. Other types of agent, rational, brave and selfish agents, are required to help the handicapped. They can help the handicapped by moving to the location of the handicapped, and bring the handicapped along for escaping. To simplify the phenomenon, the handicapped, in this research, have no effect to the movement of the helper agents. However, the handicapped agent is different to the other types of agent. The handicapped agent can be considered as inactive agent since it cannot move or make a decision my itself, while other types are active agent. The handicapped agent's role is a component in a simulated environment to make the phenomenon happen. Like the fire component which have a concept to stimulate fear to the agents. All agents try to avoid and not use a path that consist of fire. Similarly, the handicapped agent has a concept to stimulate pity to the agents. As a result, the active agents may decide to help the handicapped before escaping.

Another learning materials informing to the learners are definition of factors that they have to predict. Table 7-2 shows the seven factors that the learners are requested to make their prediction to. The first two factors, *survivors* and *deaths*, are number of the agents who can successful and failed to escape to an exit, respectively. For the factors no.3 – no.7 are better described with example scenario. Figure 7-6 presents a scenario for describing these factors. The figure shows an example scenario that an agent decides to help a handicapped. Whenever there is an agent have intention to help, the counter of the factor *helping intention* is increased one (factor no.3 in the Table 7-2, and factor no.3 in Figure 7-6.) if the agent can reach to location of the handicapped, the counter of *accessible help* is increased (no.4 in the figure.) If the agent manages to bring the handicapped along to the exit, the counter *success escaping* (no.5) is increased, otherwise, the *failed escaping* counter is increased instead (no.7.) However, if the agent are failed to access to the handicapped since the beginning, the counter of *failed access* is increased (no.6.)

Table 7-2 There are seven factors that are required the learners to make their predictions. The factor no1 and 2 is number survivors and deaths representing number of agents that successful and failed to escape to an exit, respectively. The rest factors, no.3-7, are better to be described with Figure 7-6

	factor	definition
1	survivors	number of the survivors of each type who can reach the exit
2	deaths	number of the deaths of each type who cannot manage to the exit
3	helping_intention	number of attempt for helping
4	accessible_help	number of reachable to the handicapped
5	success_escaping	number of safely help
6	failed_access	number of failure to access to the handicapped
7	failed_escaping	number of failure to safely escape but success to access the handicapped

Figure 7-6 Example situation that an agent tends to help a handicapped. The counter of *helping intention* factor*,* factor no.3 in Table 7-3, is increasing whenever there is an agent have an intention to help a handicapped. If the agent can reach to the handicapped, the counter of *accessible help* is increased (factor no.4.) Moreover, if the agent and the handicapped manage to escape to an exit successfully, the counter of *success escaping* is increased (no.5.) On the other hand, if the agent cannot reach to the handicapped, the counter of *failed access* is increased (no.6). If the agent can reach to the handicapped (no.4), but they are failed for escaping (no.7), the counter of *failed escaping* is increased.

2. The intention for describing how the simulation is used

The learning materials in this part aims to describe the learners of how to interact with the user interface (UI) of the simulation system. The learning materials describe definitions of the components appeared in the UI, what parameter the learners can interact with, how to modify those parameters and how to run the simulation, and how to interpret information generated from the simulation. In the learning course, we start with the simple UI to describe definition of each component in the display, see Figure 7-7. The UI can be divided into four parts. The learners can interact with part a. and b. (red rectangles in the figure.) Part a is used for control start/stop the simulation, run step-by-step, and reset the simulation. Part b. is a parameter setting. In this simple UI, there are only three parameters: number of rational, emotional and handicapped agents, respectively. Part c. presents the movement of the simulated components (green colored rectangle in the figure). There are two shapes of the components, rectangle and circle. The rectangles represent structure and incident, in this case are exits and fires. The circles represent simulated agents. The red, green and brown colored rectangles represent fire, exit, and burnt exit, respectively. The burnt exit is considered as a broken exit. It is no longer use for escape. The blue, orange and yellow colored circles represent the rational, emotional and handicapped agents, respectively. At this step, we are not separated the emotionally brave and selfish agents apart. Part d, is live reports corresponding the current simulation (light blue colored rectangle in the figure.) In the actual UI, part d. is located beneath the part c. However, for better visualization we relocate part d as depicted in the Figure 7-7. The live reports present seven factors as mentioned in Table 7-2.

After presenting the simple UI to learners, they can practice using the simulation. They can modify simulated parameters by sliding the slide bars to change number of each type of agent (part b. in the FIG7-8.) They can run and rerun the simulation by the controller (part a. in the figure), observe how the simulation goes (part c) and see the live reports from part d. After the learners get used to operate the simulation, the next step is to present a bit more complex one to the learners. It is an actual simulation the learners use in the learning course (see Figure 7-8.) The most parts are the same as the simple UI described in Figure 7-7 except the part b and part c. The part b. represent parameter setting. Unlike the simple UI, it has more parameters. There are parameters to set the number of the rational, brave, selfish and handicapped agents. Moreover, there are an extra parameter called "*emo boost*" which can turn on or off as a switch. By default, it is turn off (set as zero.) If it is set as turn on, all active agents, rational, brave and selfish agents, are affected from their emotions more than usual. This information is what the learners received. The actual mechanism, which is hidden from the learners, is that it activates how the emotions can affect the RED model in module *collecting information* and *making alternative* as described in Table 6-3 and Table 6-7, respectively.

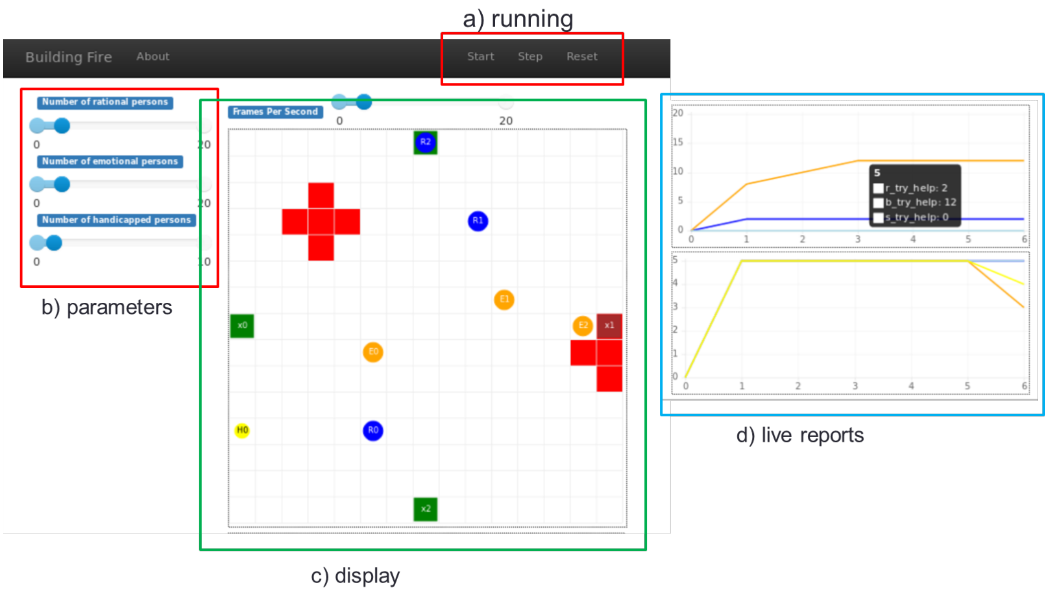


Figure 7-7 Simple UI presents the display of the live simulation that a learner can observe. Parts a and b, red colored rectangles, are allowed a learner to interact with. Part a. is a controller for running the simulation. It can control start/stop running, run step-by-step, and reset the simulation. Part b. is parameter settings. In this simple UI shows only number of each type of agent. Part c., green-colored rectangle, presents the movement of components in the simulation. The rectangles represent structures and incidents such as exits and fires. While the circles represent simulated agents. The red, green and brown colored rectangles present the fire, exit, and burnt exit, respectively. The burnt exit is the exit that covered with fire. It is broken and cannot be used for escape anymore. The blue, orange and yellow colored circles represent the rational, emotional, and handicapped agents, respectively. Part d., light blue colored rectangle, presents the live report about number of survivors, deaths, and other factors presented in Table 7-4. In the actual UI, the live reports is presented beneath part c.

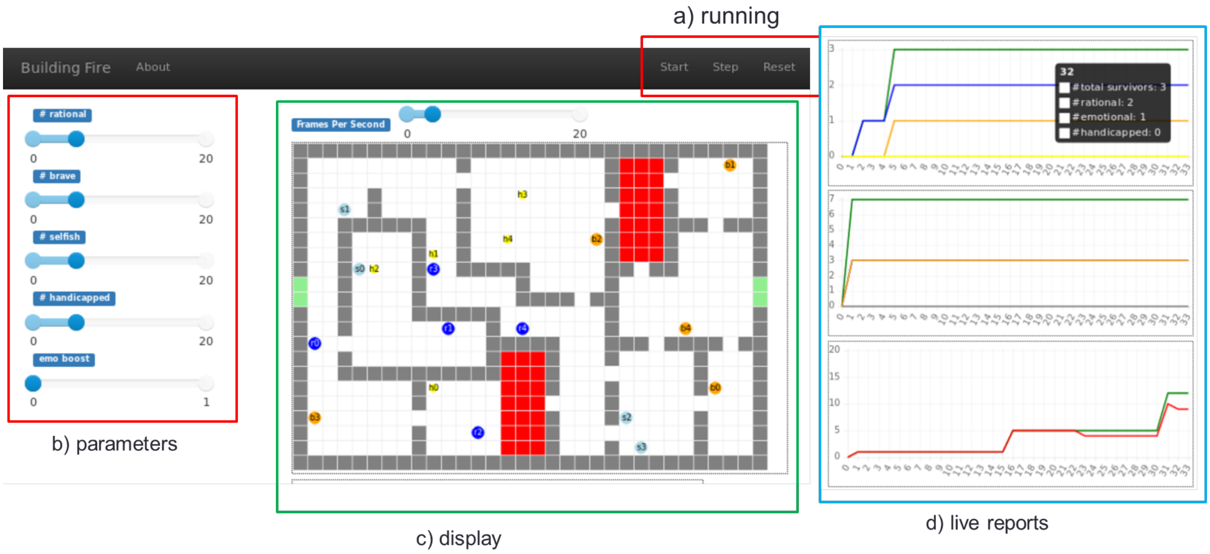
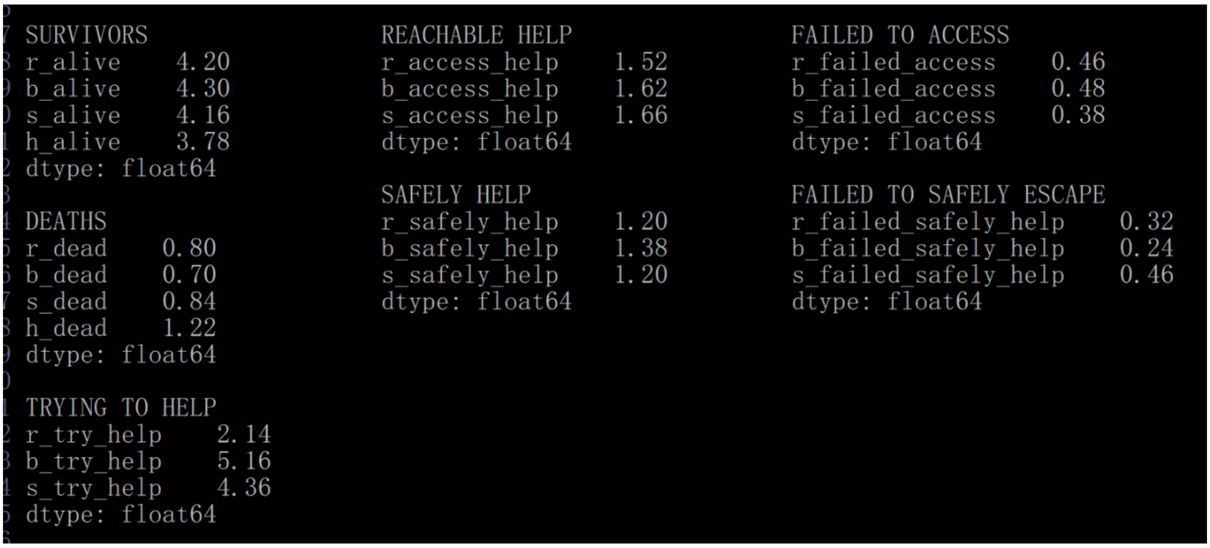


Figure 7-8 UI of the actual simulation that the learners use in the learning course. There are four parts the same as the simple UI in Figure 7-7. However, part b. and part c are different. The parameters in part b are number of rational, brave, selfish and handicapped agents. Moreover, another parameter named "emotional boost" is added. This parameter is as a switch to turn on or turn off (default is turn off.) If it is turn on, all agents are affected by emotions more than usual. For the part d, the map is larger and there are walls too. The map represents the layout in Figure 7-5. The wall is represented by gray colored rectangle. Agents are represented as circles the same as Figure 7-7; however, the colors are a bit different. The rational, brave, selfish, and handicapped agents are blue, orange, light-blue, and yellow colors, respectively.

However, only results from a single simulation may not represent much information. The learning course also provide multiple running of the simulations which have the same setting. We call it as *batch run.* The batch run will repeat running fifty times, as default value, of simulations with the same setting. It returns a report showing results for an individual run and the average results for the batch run. The results are value of the concerning factors (mentioned in Table 7-2) Figure 7-9 shows example of the average results generated from the simulation. The information in the report can be plot graphs for better visualization to the learners (see Figure 7-10.) Figure a, on the left side, presents comparative average values among different types of agents. The x-axis presents the seven concerning factors which are *survivors, deaths, helping_intention, accessible_help, success_escaping, failed_access,* and *fail_escaping,* respectively. Y-axis is the number of agents that achieve the particular factor. Figure b, on the right side, is an example information of the rational agent. It presents relation between number of *heping_intention* and *failed_escaping* factors. It is presented in the hex-bin format which the darker color means the more frequency that happened in the simulations. X-axis presents number of *helping_intention,* while y-axis presents number of *failed_escaping*. In this figure, the darkest color is located at (5,0). This means there are eight times (the darkest color) out of fifty runs that the rational agents have five *helping_intention*, and there are zero time that they are failed to help the handicapped.


```
SURVIVORS                REACHABLE HELP               FAILED TO ACCESS
r_alive     4.20         r_access_help     1.52       r_failed_access     0.46
b_alive     4.30         b_access_help     1.62       b_failed_access     0.48
s_alive     4.16         s_access_help     1.66       s_failed_access     0.38
h_alive     3.78         dtype: float64               dtype: float64
dtype: float64
                         SAFELY HELP                  FAILED TO SAFELY ESCAPE
DEATHS                   r_safely_help     1.20       r_failed_safely_help     0.32
r_dead     0.80          b_safely_help     1.38       b_failed_safely_help     0.24
b_dead     0.70          s_safely_help     1.20       s_failed_safely_help     0.46
s_dead     0.84          dtype: float64               dtype: float64
h_dead     1.22
dtype: float64

TRYING TO HELP
r_try_help     2.14
b_try_help     5.16
s_try_help     4.36
dtype: float64
```

Figure 7-9 Example average results of the fifty runs. The information generated from the simulation. They are seven concerning factors that are asked the learners to make their predictions. This information can be plot as graphs to present the learners as depicted in Figure 7-10.

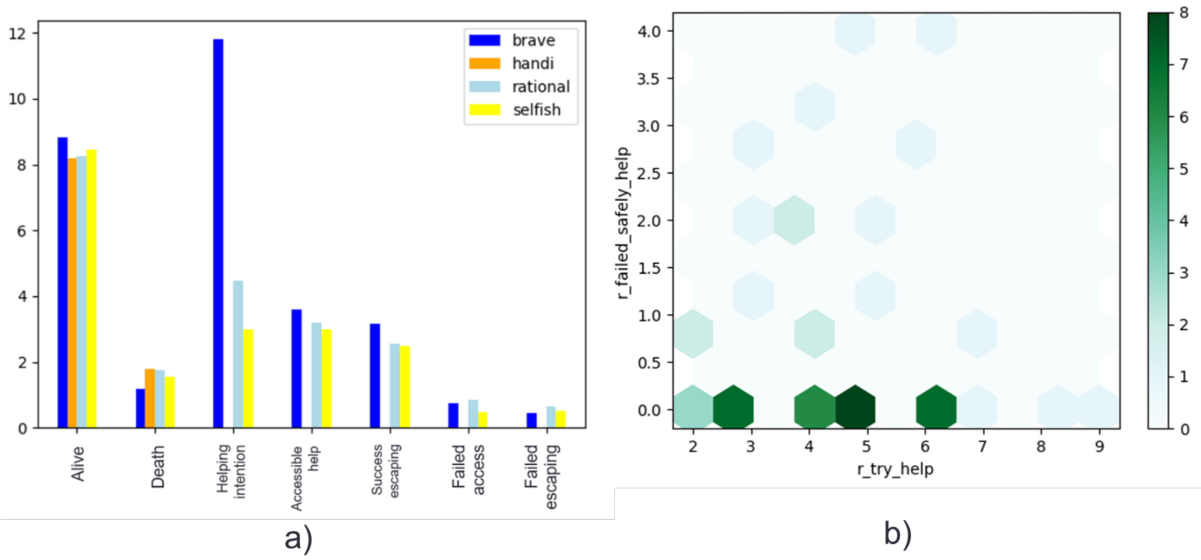


Figure 7-10 Example graphs which are results of the batch run. Figure a., on the left side, presents comparative average values of seven concerning factors among different types of agents: rational, brave, selfish, and handicapped agents. Figure b, on the right side, is an example information of the rational agent. The graph presents relation between *helpling_intention* (x-axis) and *failed_escaping* (y-axis.) The graph is presented in hex-bin format. The darker color means the more frequency that happened in the simulations. For example, the darkest color in this figure is a value around coordinate (5,0). It means there are 8 times (the darkest color) out of 50 runs that the rational agent have 5 time of *helping_intention*, and there are 0 time of *failed_escaping* that they are failed to help the handicapped.

7.3.3. Questionnaire and its intention

For this learning materials, the questionnaires are used twice as presented as the learning material d and e, in the main-learning and post-learning phases, respectively (see Table 7-1.) In total, there are twenty-five questions, the main-learning phase has eighteen questions, and the post-phase has seven questions, respectively. Figure 7-11 shows the overview of the questionnaires materials. They are divided into four parts as A, B, C and D parts. Part A, B and C are belonged to the main-learning phase. Part D is belonged to the post-learning phase. For the learning material in the main-learning phase, part A and part B are considered as collecting the general information. They are gender and age in the part A. For part B the questions are about asking what are the rational, brave and selfish person in the learner's thought. For example, one of the questions in the part B is "How does the selfish person concern to help others during the indoor fire emergency? Please answer as *High, Medium or Low.*"

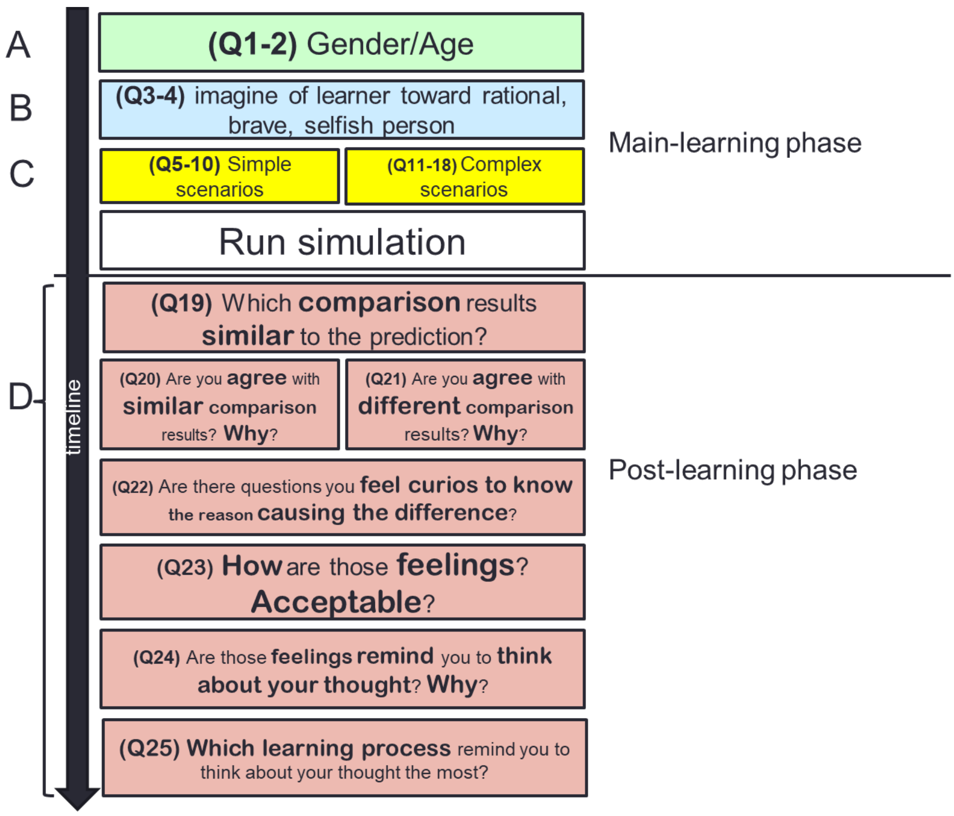


Figure 7-11 Overview of the questionnaires that are used for both the main-learning and the post-learning phases. The questionnaires are divided into four parts. Part A, B and C are belonged to the main-learning phase. They aim to collect general information (part A and B) and guide the learners to make predictions and give the reasons that make them answer as they did. Part D is belonged to the post-

learning phase. It aims to guiding the learners to question their thought and be aware of their thinking processes.

For part C, in the main-learning phase, there are two scenarios to be considered. The first scenario is defined as a simple scenario which are corresponded with question no.5-10, while the second scenario is defined as complex scenario which are corresponded with question no.11-18 (see part D in Figure 7-11.) The simple scenario represents situations that there are only two types of agent in the scene. Those agents are handicapped agents and another active type of agent (either the rational, brave, or selfish agent.) It is considered as *simple scenario* since there are only one type of active agent at a time. The complex scenario represents situations that there are all types of agent in the scene. It is considered as *complex scenario* since there are multiple types of active agents at a time. Questions in part C asked the learners to make their predictions toward the given simple and complex scenarios. The predictions are about to descending rank the agent types related to the seven concerning factors mentioned in Table 7-2. For example, please descending rank the types of agent who have the most *helping intention*, and please give your reasons. These questions do not only ask for what are their predicted results, but also ask for the reasons why they answer as they did. These pairs of *why-why* questions aim to guide the learners to think deeper and realize what are the reasons that cause thy have those opinions.

After finish making predictions, the learners modify parameter setting as assigned in in the simple and complex situations, and run the simulations as batch run. Afterward, they are moved to the post-learning phase. In this phase, the learning materials are questionnaires that are presented as part D in the Figure 7-11. These questions are carefully designed for guiding the learners to gradually realize how their thinking processes are. Question no.19 asks the learners to compare their predictions and the simulated results which are generated from the simulation system. The comparison results can be considered as a comparison between the learners' thinking processes and the decision-making processes of the simulated agents (the RED model.) The intention of this question is to explicitly show them the similar and different comparison results. Moreover, we expect that the different comparison results will lead them to questions their thought by themselves such as why the differences are happened, is there any important information I overlooked when I made a decision, as examples. The following questions are designed to gradually guide them to questions themselves. Based on the definition of surprise which is the difference between expectations and reality (Casti, 1994; Lorini, 2007), we expect the *surprise* is happened since there are difference between the learner's predictions (expectation) and the observed simulated results (reality.) In other words, this comparison process is necessary to cultivate surprise in the learner's mind. Question no.20 and 21 ask their opinion whether they agree or disagree toward those comparison results, and what are reasons that make them to agree or disagree. These questions aim to guide the learners realize not only the comparison results are similar or different, but also monitor their opinion whether they agree or not with the reasons to support their opinions. Question no.22 ask the learners that is there any of comparison results that make them feel curious to know the reasons that make them different, and which are those questions. Question no.23 ask the learners that if they are curious to know the reasons, what kind of the feeling they have, and do those comparison results acceptable for them. Based on this question, no.23, there are default options of feelings and acceptability (see Table 7-5.) There is also an option that the learners can write their own feeling apart from these default options. For the feeling, it is divided into *exceed expectation* and *against expectation.* The *exceed expectation* refers to the situation that the comparison results are as their expected, but its values are beyond their expectation. For example, a learner may expect the rational type of agent has the number of *helping intention* less than the brave type of agent. The comparison also shows the results as expected (see Figure 7-10.) However, the learner did not expect that difference is three-time greater as presented in the graph. As a result, it is *exceeding expectation.* On the other hand, *against expectation* means the predictions and simulated results are opposite. Both questions no.22 and 23 aim to guide the learner to questions their thought. They may try to find out reasons that cause the different comparison results by themselves. Some ideas may occur, and they can modify the simulation parameters and run it again to test their hypotheses. If they can find acceptable reasons it may imply that they find the new idea that previously they did not have. This does not mean just find a new idea, since this idea is a result of trying to figure out how their own thought work. For example, is there any missing concept that was overlooked while making prediction. Question no.24 ask the learners whether those feeling remind them to think about their thought or not, and what are the reasons to support their answer. This question aims to guide them to monitor their feeling and thoughts that the whole processes they have done causes them a better understanding of their thinking process or not. These consequence of questions, especially question no.22-24, are aims to measure whether the learner is motivated or not. Question no.25 refers to in Figure 7-4 which are an overview of the entire learning course, and asks the learner that if they are reminded to think about their own thought, which step stimulate them the most. For this question, we expect the learners answer the step no.6, which is *reasoning,* is the step that stimulate them to realize of their thought the most.

Table 7-5 Default options for questions no.23. The question asks learner that what kind the feeling they have when they are curious to know the reasons that cause the different comparison results between their predictions and simulated results, and is it acceptable or not.

	feeling		acceptability	
	exceed expectation	against expectation	acceptable	unacceptable
1		✓	✓	
2		✓		✓
3	✓		✓	
4	✓			✓

7.4. Summary

This chapter describe on the learning materials that provide to learners. It describes for both the intention to design the learning materials corresponding to the research objectives, and the content of the learning material itself. The learning materials are described into three parts. Each part represents the learning materials in each learning phase: pre-learning, main-learning and post-learning phased (see Table 7-1.) The learning material in the *pre-learning phase* aims to describe overview of how emotions affect to our behavior in an emergency. Another objective is to tune the image of emergency in each learner's mind as the research designed. This tuning is necessary since different people may have different perspectives of indoor fire emergency based on each personal knowledge and experience. The learning material in the *main-learning phase* are focused on describing how to interact with the simulation. It includes to describe the character designed indoor fire emergency, what kind of possible behaviors can be performed in the simulated environment, to describe the symbols that appear in the simulation, how to modify parameters and how to interpret information and read the graphs generated from the simulation. The last part is the learning materials describing about the questionnaires which are used in both main-learning and post-learning phases. The questionnaires used in the main-learning phase aims to guide the learner to think deeper while they make predictions. The learner requires to explicitly express their expected results and reasons that cause they believe the expected results to happen. On the other hand, the questionnaires in the post-learning phase aims to guide the learner to question their thought by themselves. It gradually guides the learner to think step-by-step. The learner is requested to compare their predictions with the observed simulated results, identify which results are similar and different, give opinions whether the comparison results are acceptable or not, and what are reasons to make them think like that. Finally, the questions ask the learner to monitor their thought if they are remind about their thinking processes or not.

CHAPTER 8 TRIAL USE CASE OF THE DESIGNED LEARNING COURSE

There are twenty-five questions are used in this trial use case. Those questions are deliberately selected to for three purposes. The first purpose is to guide the learners to carefully think and predict their expected results toward the given simulated emergency scenarios. The learners are requested to answer about *what* are their expected results, and *why* they believe those results would be happened. The second purpose is to guide the learners to question their thought by themselves. Finally, the third purpose, after gradually guiding the learners as mentioned in the first two purposes, it is to collect the learner's responses to evaluate whether they are motivated to be aware of their thought or not. This chapter aims to describe the responding results collected from the learners.

8.1. Target of respondents

There are some concerned characters of respondents for this research. First, it is logical thinking. This research has to well-select the respondents since this research is related to using *surprise* to motivate self-awareness. Surprise is expected to happen when comparing their prediction results and simulated outcomes are different. High logical thinking person may produce less difference in comparison. This may cause less chance for surprise to happen. However, too little logical thinking respondents are not desirable as well since they have to realize to reflect their thought. Second, it is experience. This research is a conceptual simulation of a building fire emergency. Experienced person or expertise in the emergency domain may not be convincing due to they may feel unrealistic. Third is patience since this research could take time. It requires respondents to explicitly express what they are thinking and give reasons why they are believe to that idea. Without patience they might cannot last until finish the experimentation.

Based on these three concerned criteria, too mature and too young may be not suitable. The respondents of this research are a group of first year undergraduate students of Sirindhorn International Institute of Technology (SIIT). Most of them are less than twenty-year-old. There are seven males and one female.

8.2. Experiment setting

As mentioned in chapter 3, methodology, the experimentation proceed as follows:

1) At pre-learning phase, learners got learning material, description about behavior under emergency, example cases about helping others for motivating them to realize how important of decision and behavior in emergency.
2) At main-learning phase, learners were introduced how to use the simulation system on a demonstration program, how to modify parameters, and how to interpret the activity of the simulated agents in the screen.
3) At main-learning phase, learners opened the experimentation program and were assigned to modify parameters according to the given tasks. They made an understanding on the scenarios and explicitly express their thought on questionnaire. Learners had to make a prediction and reasons on given scenarios.
4) At main-learning phase, learners run the simulation, observe simulated outcomes
5) At main-learning phase, learners compare their predictions with the simulated outcomes
6) At main-learning phase, learners were aware on similarities and differences in comparison. They were requested to answer the questionnaire by explicitly describe their thought about comparison, agree or disagree, and gave reasons for those answers.
7) At post-learning phase, learners were requested to answer the questions about self-reflection.

8.3. Expected learning results

This trial use case is conducted following the learning course described in Table 8-1. The learning course consists of three learning phases. The first phase is *pre-learning phase.* Its purposes are to introduce overview of learning tasks that the learners are going to participate, and to describe how the simulated emergency is about. The learning materials in this *pre-learning phase* are video and text content (see learning material b. in Table 8-1.) The contents present examples of behaviors in emergencies. They are intentionally designed for seeding curiosity to the learners' mind of what they would do if they were a person in that those emergencies. In *main-learning phase*, its purposes are to let the learners predict the results of the given scenarios of simulated emergency, and run those simulations. The learning materials in this phase aim to introduce the learners how to use the simulation system (learning material b in the table.) It includes the explanation of the simulated components, how to modify simulation parameters, how to run the simulation, and how to interpret the outputs generated from the system. Another learning materials are questionnaires (learning material d in the table.) These questions aim to guide the learner to carefully think during making their predictions, and to collect those predicted results. In the *post-learning phase*, it purposes are to evaluate whether the learners are motivated to be aware of their thought or not. The learners compare their predictions with the observed simulated results. They are gradually guided to question their own thought through questionnaires which are the learning materials in this phase (see learning materials e in the table.) We expect that making question to own thought is an initial step to lead ones to be aware of their own thinking process.

Table 8-1 Overview of the whole processes in this learning course. There are three phases: 1) pre-learning phase, 2) main-learning phase, and 3) post-learning phase. The purpose of the pre-learning phase is to describe overview of learning tasks and describe the simulated emergency scenarios to the learners. The purpose of the main-learning phase is to let the learners make their predictions of the simulation. The purpose of the post-learning phase is to evaluate whether the learners are motivated to be aware of their thought.

Phases	Order	Goal	Learning material	Learning activity
Pre-learning	1	a) Introduce objective of the learning b) Introduce concept of rational and emotional decision making c) Seed curiosity on self-awareness	a) Video and text of emergency scenarios: to seed curiosity in the learner's mind	Motivate learner to realize loss in emergency (15 mins)
Main-learning	2	d) Explicitly describe learner's prediction e) Let surprise happens to trigger learners to be aware of their thought f) Reflect learners thinking process	b) Explanation of using the simulation (microworld) with example	Understand how to interact with the microworld (10 mins)
	3		c) Run the soft-half-banked microworld with the RED Model	Set parameters and express the expected results (15 mins)
	4			Run the simulation (the microworld) (10 mins)
	5		d) Questionnaires I: to guide learners to give reasons for their predictions	Compare expected results and actual results (15 mins)
	6			Aware difference and similarity and expected surprise happened (20 mins)
Post-learning	7	g) Evaluate results of learning	e) Questionnaires II: to guide learners to be aware of their thought	Reflect on self-awareness (25 mins)

Before describing about the expected learning results, some understanding about the questions that are used to evaluate of being motivated should be mentioned first. Figure 8-1 presents the overview of the questionnaires used in the learning course. This chapter focuses to described only part C and D in the figure. More details of the questionnaire are described in section 7.3.3 (*questionnaires and its intention.)* Questionnaires in Figure 8-1 is corresponding to the learning course mentioned in Table 8-1. The part A, B and C in Figure 8-1 are the learning material d in the *main-learning phase* of Table 8-1, and the part D is the learning material e in the figure, respectively. Questions of the part C, in the *main-learning* *phase,* request the learners to consider different situations of the simulated indoor fire emergency. Learners are asked to predict **what** are their expected results according to given situations, and **why** they expect those results. This pair of what-why answering applies every given situation. It indirectly guides the learner to use their thinking processes deeper than just ask for **what** are their expectation. After finishing the predictions, they run the simulated following the instruction in the learning materials then the learning process moves to the *post-learning phase.* There are seven questions in the part D. All of them are carefully selected for guiding the learners to question their own thinking processes. Question no.19 (see the Figure 8-1) asks the learners to compare their predictions with the observed simulated results and identify which answers are similar and different. This research defines the *surprise* as the difference between expectations and reality (Casti, 1994; Lorini, 2007). In this case, the learners' predictions are considered as *expectations* and the observed simulated results are considered as *reality,* respectively. Thus, if there is any of different comparison results, it is considered as the *surprise* is happened. Question no.20 and no.21 aim to guide them give reasons about they are agree or not agree for those comparison results, and what are the reasons to support their opinions. For the question no.20 asks the learners as "do you agree on the similar comparison results or not and what are reasons to think so?" We expect the most learners would agree to the comparison results, since they are the same as expected. However, the question no.21 ask the agreement on different comparison results. These questions, especially question no.21, require thinking processes that figure out whether the alternative options (observed simulated results) make sense or not. We expect the learners start to monitor their thinking processes. They may question themselves that whether their thought reasonable enough or not, what make those different comparison results happen, is there any overlooked information during the prediction, for examples. Questions no.22 asks them which comparison results that they are curious to know the reasons causing the difference to happen. They may or may not have some idea to explain the reasons in their mind. The learners are allowed to modify the simulation parameters for test their hypothesis. Question no.23 asks them what are the feelings to make them curious to know the reasons of the differences, and is it acceptable. The question provides default feeling to be selected as *exceed expectation* and *against expectation.* The *exceed expectation* means the comparison results are as expected, but its values are beyond the learner expectation. It could be considered as positive surprise since their predictions are have the same result as the simulated results. On the other hand, the *against expectation* means their predictions and the simulated results are different. It is considered as *negative surprise* since their comparison results are not as expected. For the question about acceptation the comparison results, it requires thinking processes to compare which of their predictions or the simulated results are more reasonable. If the learner can find reasons to support the different comparison result, then the learner could accept it. On the other hand, the learner cannot find out a good reason to support the difference and believe their predictions are better, they can reject it. However, at least they have chances to realize of how they think. These questions aim to indirectly guide the learners to reconsider of their thought about how they make those predictions through the comparison. Question no.24 asks the learners if those feeling cause them to remind of their thinking processes or not, and why they think as they do. With those previous questions we expect the learner remind to realize of their own thought. We expect to use this answer to evaluate our learning course. Fifty percent of the participants are expected to be motivated to realize their own thought. However, more detail of each question is described in section 7.3.3. Question no.25 asks the learners which learning process, in their opinion, stimulate them to remind on their thought the most. The learning processes are divided into seven steps as mention in Figure 7-4, the overview of the learning course, in the section 7.3.1. In this question, we expect the *reasoning* process is the most votes from the learners. Moreover, the persons that are motivated to realize their thought in question no.24 are expected to vote the *reasoning process* at least fifty percent.

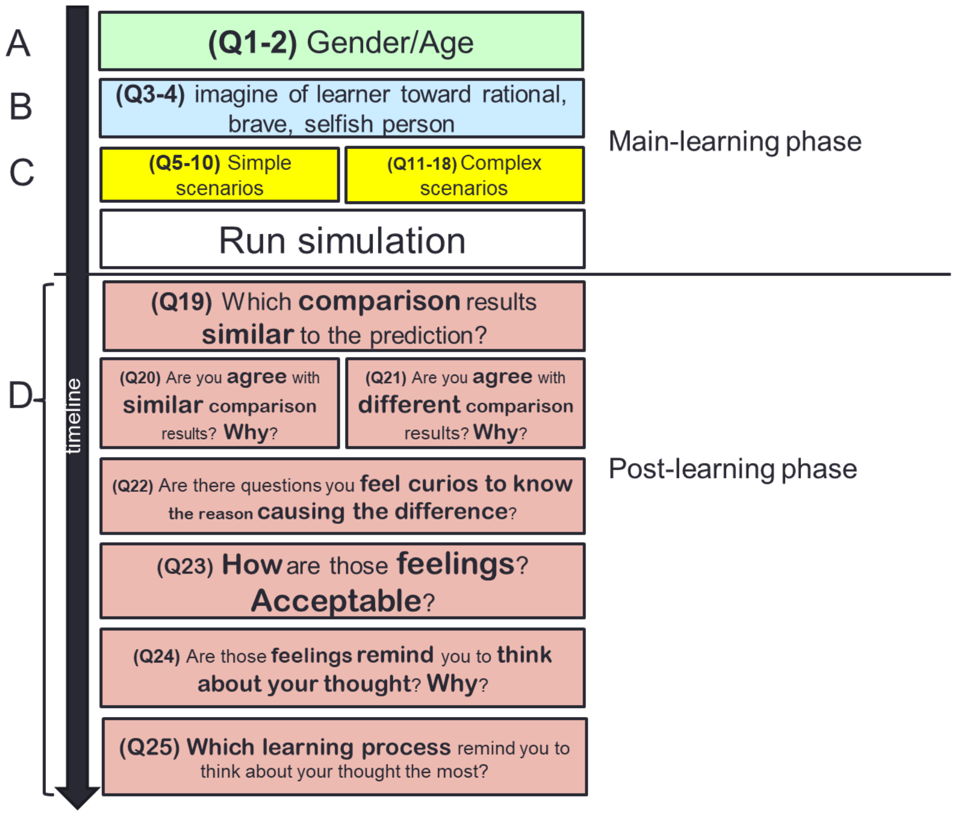


Figure 8-1 The overview of the questionnaires. The questionnaires are divided into four parts. The first three parts, A, B, and C, are belonged to the *main-learning phase,* while part D is belonged to the *post-learning phase.* Part A, B and C aim to guide the learners carefully think to express their predictions and reasons supporting the predictions. Part D aims to guide the learners to gradually question themselves about their thinking process and motivate them to be aware of their thought.

8.4. Result of trial use case

8.4.1. Example reports the learners could observe

As mentioned in section 7.3.3, questionnaire and its intention, there are two set of scenarios, *simple scenarios* and *complex scenarios*, requesting learners to make their predictions. The first set of scenarios, *simple scenarios*, are situations that there are fire handicapped agents staying with fire of another type of agent. Figure 8-2 is an average simulated result of a scenario after running the simulation as 50-time recursion. It is a scenario that there are five rational agents with five handicapped agents. Y-axis is number of agent, X-axis, from left-to-right, are Alive, Death, Try to help, Accessible help, Safely help, Failed access, and Failed escape, respectively. Alive and Death are number of survivors and death of each agent after finishing the simulation. Try to help means number of time that this agent type *try to help* a handicapped with *helping intention.* However, this number does not imply the helping is successful or not. Accessible help means number of time that this agent type can reach to the handicapped while it hold *heling intention* with it. This does not imply the helping is successful as well. Safely help means number of that agent type successfully bring the handicapped along to exit safely. Failed access means number of that agent type hold *helping intention* to help a handicapped, however, this agent failed to reach to the handicapped. Failed escape means number of that agent type can reach to the handicapped, but they cannot escape successfully. It is time-up or they was caught by fire and died.

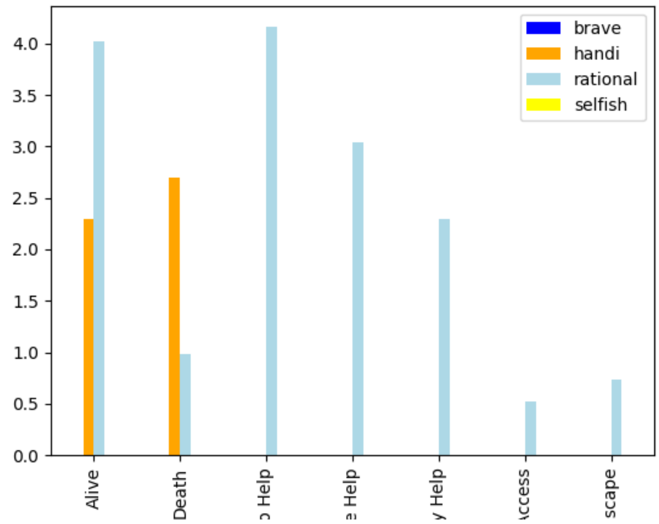


Figure 8-2 Example of a report that each learner can observe. This resport is results corresponding to simple scenario Predition 01 described in Table 3-2. This case is a scenario that there are 5 rational, and 5 handicapped in the scenario.

Figure 8-3 is an average simulated result of a scenario after running the simulation as 50-time recursion. It is a scenario that each agent type there are five individual in the scenario. X- and Y-axis are the same as described earlier.

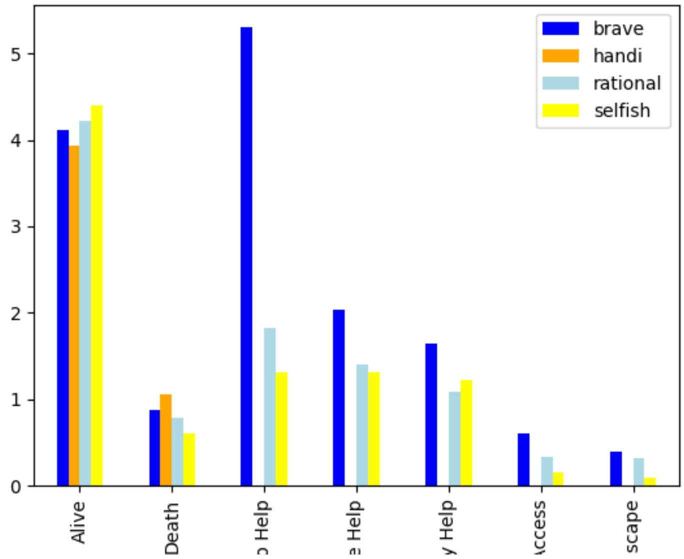


Figure 8-3 Example of a report that each learner can observe. This report is results corresponding to mixture-of-agent scenario Prediction 02 described in Table 3-3. This case is a scenario that there are 5 agents for each agnet type.

8.4.2. Result from questionnaire

Since the questionnaire is divided into four parts as mentioned in Figure 8-1 (overview of the questionnaire), this section will describe the results from learners into four parts as well. The first three parts, A, B and C in Figure 8-1 represent the questions belonged to the *main-learning phase,* while the questions in part D are belonged to the *post-learning phase.*

1. **The first section (part A)**: These questions aim to collect general information such as age and gender on question no.1 and no.2, respectively. Blue color is male gender and red color is female gender. Most of them are 18-year-old as presented in Figure 8-4 and Figure 8-5, respectively. In this trial use case most of the participants are male gender (87.5%) which are seven person in total.

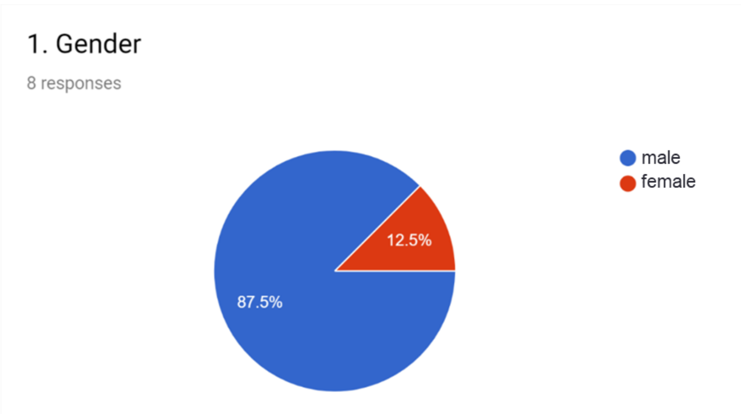


Figure 8-4 Gender of respondents: blue color is male, red color is female

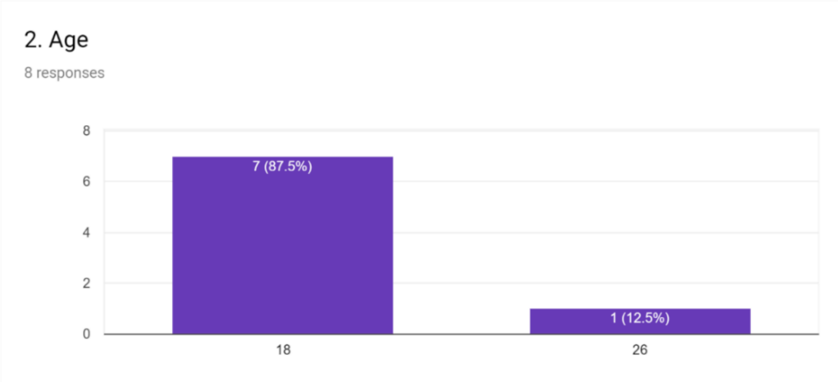


Figure 8-5 Age of respondents

2. **The second section (part B)**: These questions aim to monitor how a learner view each type of person, the rational, brave and selfish persons, in their mind. Different person may have different definitions of these concepts. There are two aspects to be monitored. The first aspect is *helping intention.* The second aspect is *escaping intention.* The questions in this part ask a learner to level those aspects into three levels: low, medium and high, respectively. The people with higher level of *helping intention,* tend to consider to help others than ones who have lower intention. Similarly, the people with higher level of *escaping intention* tend to prioritize on self-safeness.
Question no.3 asks the learners to assign level of *helping intention* as low, medium and high to the rational, brave and selfish persons, respectively. The results are showed as Figure 8-6. The blue, red and orange colors are high, medium and low level of *helping intention* respectively. Rational person is considered as ones who have medium-to-high level of *helping intention.* That means based on this population, the rational person, in their mind, has a balance of this intention with a bit tend to help others. For the brave person, all learners consider this type of person to have a high level of *helping intention.* For the selfish person, the results are varied. There are range from high to low. However, most learners are considered the selfish person as low *heling intention. We can summarize the key points as follows:*
    - The rational person: the most of learners think the rational person are quite balance, not low and not high, *helping intention*.
    - The brave person: all learners have the same opinion that the brave person has high level of *helping intention*

- The selfish person: learners' opinion are varied. However, the most of learners consider the selfish person has low level of *helping intention* rather than other levels

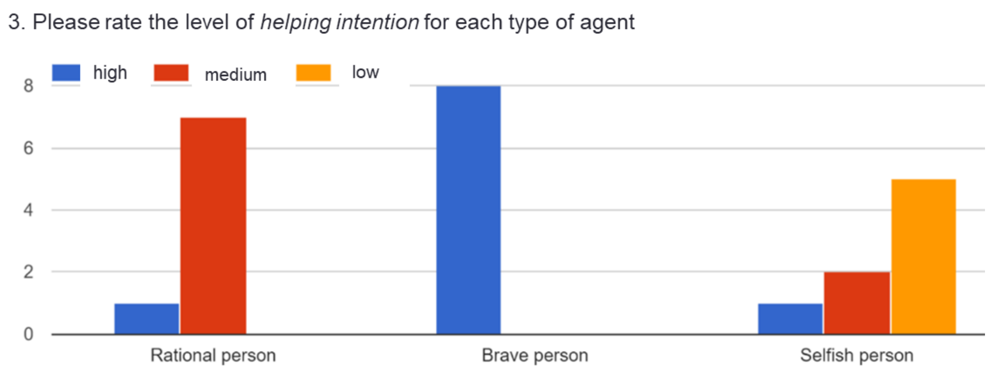


Figure 8-6 Monitor learner's mind that which agent type tend to have "*helping intention*". Blue, Red and Orange color are High, Medium and Low, respectively.

Question no.4 asks the learners to assign level of *escaping intention* as low, medium and high to the rational, brave, and selfish person, respectively. The results are showed as Figure 8-7. The blue, red and orange colors represent high, medium and low level of *escaping intention.* The rational person is considered as one medium-to-high level of *escaping intention*. It is similar for the *helping intention*; however, it is obvious that the rational person, based on this population, tend to escape rather than helping other. For the brave person, the results are varied. There is no outstanding level for the brave person. For the selfish person, the results have range from high-to-low. However, most of the learners consider it has high level of *escaping intention.* We can summarize the key points as follows:

- The rational person: learners think the rational person tend to have *escaping intention* at level medium to high. However, the ratio of high *escaping intention* is greater than the *helping intention*.
- The brave person: learners think the brave person differently. It seems, from learners' point of view, the brave person has all possibility regarding on *escaping intention.*

- The selfish person: learners think the selfish person has high level of *escaping intention*. However, it is not absolute agreement as the case of the brave person on *helping* intention. It may imply that selfish person is not concern only themselves.

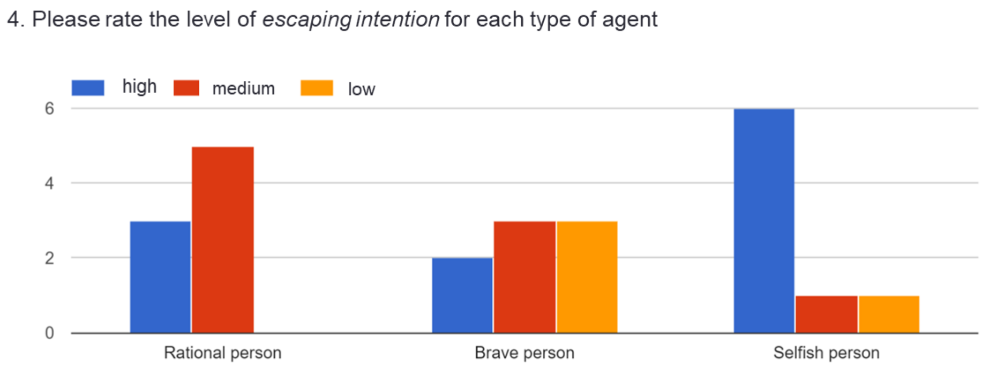


Figure 8-7 Monitoring learner's mind that which agent type tend to have "escaping intention" . Blue, Red, Orange colors are High, Medium and Low, respectively

3. **The third section**: the questions in this part aim to guide the learners to have a deep thinking before give answers. The questions request the learners to answer both what are their expectations, and what are reasons that support their answers. Learners have to write their reasons to explicitly express their opinion. In this part, there are two scenarios that the learners have to engage with. They are *simple scenarios* and *complex scenarios* (see part C in Figure 8-1.) The *simple scenarios* represent a set of simulated emergency situations that there are only the handicapped agent and only another type of the active agent: either rational, brave or selfish type at a time (see Table 8-2.) By default setting, five agents are assigned for each type of agent. For example, there are five rational agents and five handicapped agents in the scenario. This setting aims to let the learner consider relation only between a specific active agent and the handicapped. On the other hand, the *complex scenarios* represent a set of simulated emergency situations that all types of agent are presented in the scene. Since each type of agent may behave differently, thus, the complex situation is occurred.

Question no.5 and no.6: they are considered as *simple scenario.* The learners are asked to set the number of each agent as showed in Table 8-2. After that the question no.5 asks them to rank the type of active agents that have the highest *number of survivors* in descending order. Question no.6 ask them to express the reasons that they believe to support their answer in question no.5. As a result, the learners have to answer both **what** and **why** to these pair of questions. To describe the results, we would refer the rational, brave, selfish and handicapped agent types as R, B, S and H, respectively.

Table 8-2 Setting for the *simple scenarios*. Learners are requested to set number of each type of agent as showed in the table and make their predictions from question no.5 to no.10. Each situation there are only two types of agent at a time.

	Rational	Brave	Selfish	Handicapped
1	5	0	0	5
2	0	5	0	5
3	0	0	5	5

The results of question no.5 is depicted as Figure 8-8. Fifty percent of the learners think selfish type of agent should have the highest number of survivors, and the brave type have the least number survivors (purple colored segment.) Twenty-five percent, the second most vote, think the rational type should have the most survivors and the selfish type has the least numbers of survivors. It is interesting that for the majority vote, the selfish type is expected to have the most survivors, but the second most vote shows that the selfish type is expected to be the least survivors. However, based on these two results, both of them think the rational type has more survivors than the brave type. The reason that make the selfish type can be considered as the most and the least survivors are presented in question no.6's results. Reasons to support the most majority vote (S > R > B) is the selfish type focuses on escaping rather than others, then it has the highest number of survivors, for example. While reason to support the second majority vote (R > B > S)) is that the rational type is a careful one, then the rational type has the highest survivors. Both reasons are corresponded to how the learners view each type of agent as well. The rational person is considered to have medium-to-high level of *escaping intention*, thus it has high chance to survive, while the selfish person is considered as quite-high level of *escaping intention.* We can summarize the key points as follows:

- The majority vote at 50% think $S > R > B$; selfish type has the highest survival range, and brave type is the least.

- The second majority vote at 25% thought $R > B > S$; the order of the rational type is greater than the brave type, the same as majority vote. However, it is interesting that the selfish type in second majority vote, which was the first rank in majority vote, becomes the least here.
- The reasons to explain their thinking process shows that in major vote ($S > R > B$) learners believe that the selfish type focuses on escaping then they have more change for survive. While the second major vote ($R > B > S$) believe that the rational person is a careful type. Thus, they have high survived rate.
- Reasons that learner gave are make sense for the imagine the have toward the rational and the selfish person. The rational person has level of *escaping intention* in medium-to-high range, while the selfish are quite high rate.

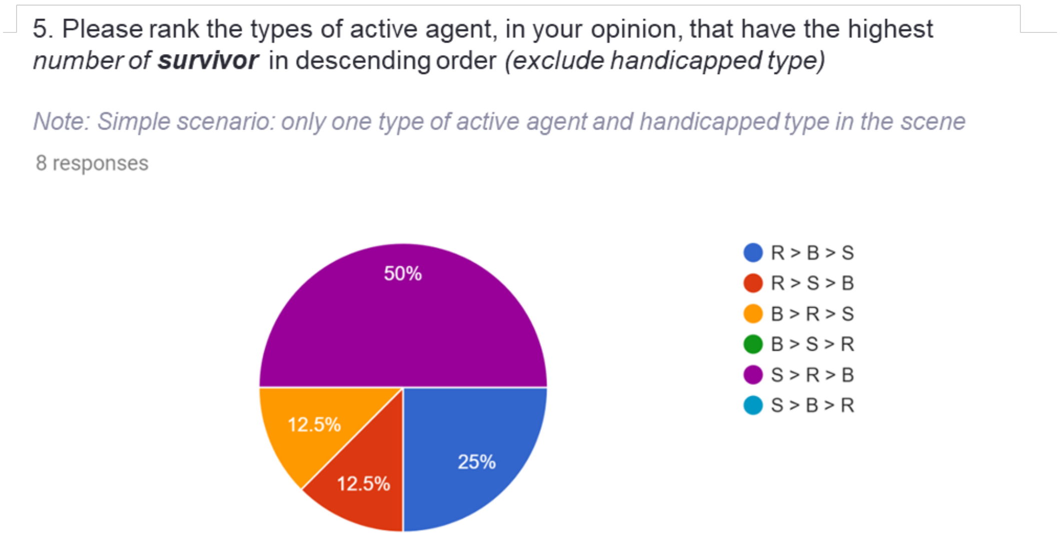


Figure 8-8 Prediction results of which agent type would have the highest *numbers of survivors*. R, B and S are Rational, Brave and Selfish, respectively

Question no.7 and no.8, they are considered as *simple scenarios*. Based on the same setting as described in Table 8-2. Question no.7 asks the learners to rank the types of active agent that could help the handicapped to have the high number of survivors in descending order. In the other words, which type of agent have the most successful helping rate. This question is different to the question no.5. This question, no.7, focuses on who is the best helper type, while the question no.5 is who is the best survivors. The results of this question are presented in Figure 8-9. The results can be categorized to only two options. The majority vote result (62.5%) is the brave type is the best helper and the selfish type is the worst helper. For the second most vote (37.5%) is that the rational type is the best helper and the selfish type is the worst helper. Both results show that the learners believe that the selfish type is the least type to help others. Only the rational and brave types are considered as the best helper. Results from question no.8 shows that the reasons that support the most vote (R > B > S) is since the rational type seems to be reasonable to select the right path for helping and escaping. Moreover, the brave type may be too brave and perform a reckless behavior which lead them to dangerous situations. As a result, they vote the rational type is the best helper. On the other hand, the reasons that support the second most vote (B > R > S) is the brave type tend to have more chance to go for helping than others. The more chances to go, the more chances to success for helping. As a result, they think the brave type is the best helper. We can summarize the key points as follows:

- The majority vote, 62.5%, think $R > B > S$, while the second majority vote think $B > R > S$.
- These imply that the selfish person is not a preferable candidate for the handicapped to stay with.
- Reasons to explain of selecting $R > B > S$ show that the rational type tends to help a the handicapped in some sense already, then they go for helping. Moreover, the rational type seems to be reasonable to select the right path to exit, in learners' opinion. On the other hand, the brave type may have too much brave and act reckless behavior.
- Reasons to explain of selecting $B > R > S$ show that the more chances the brave type to go for helping, the more survivors for the handicapped, since the brave type has the highest *help intention.*

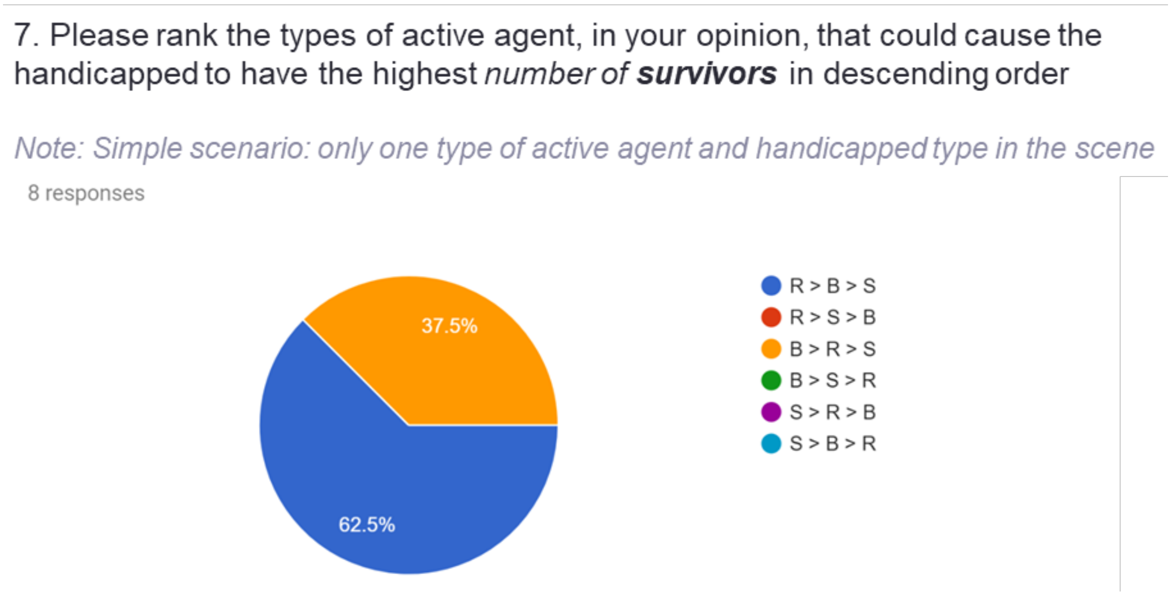


Figure 8-9 Prediction of which agent type would support the handicapped to have the highest rate. R, B and S are Rational, Brave and Selfish, respectively

Question no.9 and no.10, they are considered as *simple scenarios*. Based on the same setting as described in Table 8-2. Question no.9 asks the learners to rank the type of active agent that has highest *helping intention* in descending order. The *helping intention* is defined as an attempt for helping others. Ones who have this *helping intention* do not mean they are successful of helping. They may have the intention and can reach to the handicapped but failed for escaping. They even have the intention but failed to access to the handicapped as well. These questions, no.9 and no.10, intentionally ask the learners to consider only the *helping intention.* More details of the definition can see Figure 7-6 in section 7.3.2. Figure 8-10 presents the results of question no.9. The most majority vote (62.5%) think the brave type has the highest *helping intention* and the selfish type has the least *helping intention.* The second most vote (25%) think the rational type has the highest *helping intention*, and the selfish type is the least. Similar to question no.7 that everyone thinks the selfish type are the least to have this *heling intention*. The interesting answer is there are 12.5% that thinks the selfish type has the highest *helping intention*, and the brave type has the least intention. This segment is completely opposite to the majority vote. Result from the question no.10 show that the reasons to support the majority vote (B > R > S) is the brave type can accept more risk than other types. Thus, it tends to help others and the *helping intention* is higher than others. The reasons to support the second most vote (R >

B > S) is that the rational type should be able to handle problems better than others, then the rational may have higher *helping intention.* For the reasons to support the selfish type to have the highest intention (S > R > B) is that the selfish type should be the one who have the best situation analysis, then the selfish type may have the highest intention. Based on this reason, the author's opinion doubt that whether the learner may confuse the selfish type with the other type. We can summarize the results as follows:

- The majority vote, 62.5%, is *B > R > S*; while the second majority vote is *R > B > S*
- These results can imply that the selfish person is not considered as high *helping intention* (consistence with question no.3)
- The interesting answer is that there are 12% think the selfish type has the highest rate of *helping intention*.
- The reasons that support *B > R > S*: the brave type accepts risk to challenge himself, the brave tends to have character to help others, then *helping intention* should be high
- The reasons that support *R > B > S*: the rational type seems to handle problem better than others

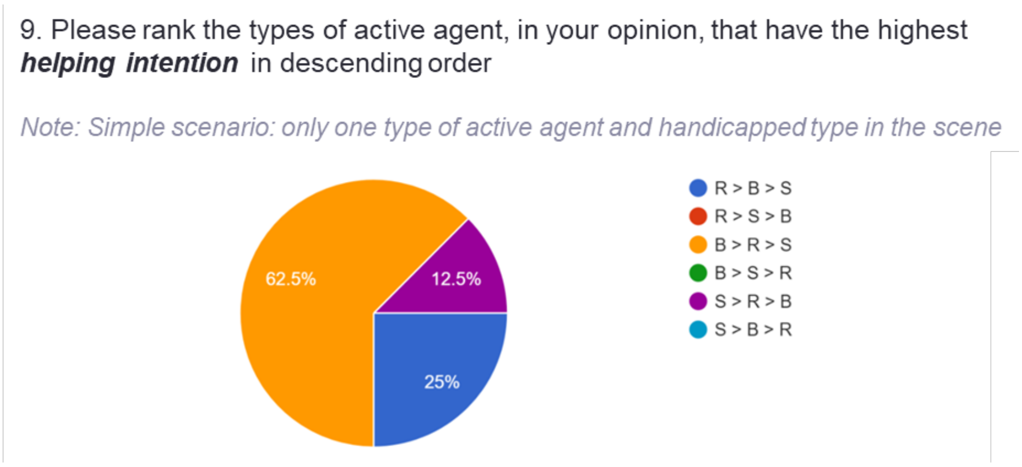


Figure 8-10 Prediction of which agent type would have helping intention the most. R, B, S are Rational, Brave and Selfish, respectively.

Questions no.11 and no.12, they are considered as *complex scenarios*. The *complex scenarios* are the situation that consist of all types of agent in the scene. By default setting, there are five agents for each type of agent (see Table 8-3.) The *complex scenarios* are used in question no.10 to no.18. There are two scenarios to be concerned. The first scenario is that each type of agent is assigned to be five agents at a time. The second scenarios are that each type of agent is increased from five to ten. These scenarios are considered as complex since different types of agent are in the same scene. Each of them behave differently depends on its criteria to make its decision. Question no.11 asks the learners to rank the types of active agent that have the highest *accessible help* in descending order. The definition of *accessible help* is that when one has *helping intention,* it performs helping behavior. The *accessible help* means that one can reach to the handicapped for helping purpose. However, this activity does not mean the helping is successful since the helper and the handicapped may be failed to escape. More details of the definition can see Figure 7-6 in section 7.3.2. These questions, no.11 and no.12, focus on only whether the agent can reach to the handicapped or not.

Table 8-3 Setting for the *complex scenarios*. Learners are requested to set number of each type of agent as showed in the table and make their predictions from question no.11 to no.18. These scenarios consist of all types of agnet.

	Rational	Brave	Selfish	Handicapped
1	5	5	5	5
2	10	10	10	10

The results from question no.11is depicted in Figure 8-11. The most majority vote (62.5%) think the brave type has the highest *accessible help,* and the selfish type has the least. The second most vote (25%) believe the rational type has the highest of the *accessible help* and the selfish type has the least. Based on the results, none of them think that the selfish type has the highest *accessible help*. The results in this question similar to the results in question no.9 and no.10. The learners also give the similar reasons to support their predictions. The reasons from question no.12 that support the majority vote (B > R > S) is the brave type seems to have more *helping intention*. The more *helping intention*, the more chances to access the handicapped. On the other hand, the reasons to support the second most vote (R > B > S) are that the rational type seems to be good at handling problem better than others. As a result, they have a higher rate of *accessible help.* We can summarize the key points as follows:

- The majority vote, 62.5%, is *B > R > S*; while the second majority vote, 25%, is *R > B > S*

- These predictions have the same character with the previous question, questioning about *helping intention.*
- The reasons that support $B > R > S$: the brave type seems to accept risk better than other types, then the brave type has higher *accessible help*
- The reasons that support $R > B$: the rational type seems to be better reasonable ones than other types, then the rational type can handle problem better. As a result they have the highest *accessible help*
- Ones who support Brave person gave reasons that brave person will do his best to help others

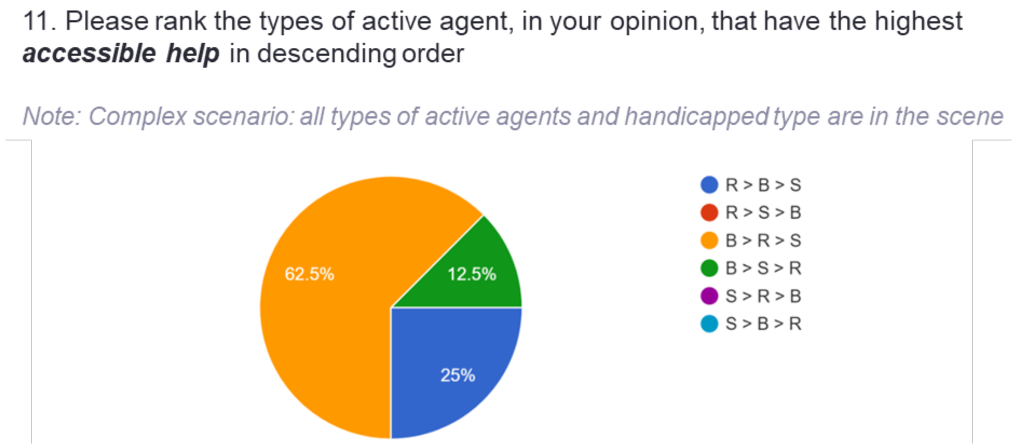


Figure 8-11 Prediction of which agent type would be able to reach to handicapped person the most. R, B, S are Rational, Brave and Selfish, respectively

Question no.13 and no.14, they are considered as *complex scenarios,* which there are all types of agent in the scene at a time. The question no.13 asks learners to rank the type of active agent that have the highest *successful escaping* in descending order. The *successful escaping* means the situation that the helper agent can rerach to the handicapped and bring the handicapped along to the exit safely. More details of the definition can see Figure 7-6 in section 7.3.2. The result from question no.13 (see Figure 8-12) shows that the majority votes (37.5%) think the rational type has the highest *successful escaping* while the selfish type has it the least. There are two majority votes (25%.) For the first one, the learners think the brave type has *successful escaping* the most, and the selfish type has the least. For another one, learners think, oppositely, the selfish type has the *successful escaping* the most, while the brave type has the least. Results from question no.14 show that the reasons that support the majority votes (R > B > S) that the rational

type is reasonable, they can find the right option to exit. The rational type is a good analyzer that can find a good path to exit. The reasons to support the first of the second most votes is (B > R > S) that the brave type tends tend to help others. As a result, the more attempt to help, the more chance to be success to help other. For an another second most votes (S > R > B) is that the selfish type tends to prioritize on their safeness the most. If the selfish type intends to help someone, they probably select the safest path. Thus, its *successful escaping* is high. We can summarize the key point as follow:
The majority vote, 37.5%, is $R > B > S$

- There are two second majority votes, 25%, which are $B > R > S$ and $S > R > B$
- It seems many options are considered, different people have different opinion
- Reasons supporting $R > B > S$: the rational type is reasonable, he can find the right option to exit; The rational type is good to analyze the right path to exit.
- Reasons supporting $B > R > S$: the brave type tends to help handicapped more than other types. The more chance to help, the more successful they can.
- Reason for whom support $S > R > B$: selfish type tends to concern himself the most. If the selfish type helps others, he should have high confidence to do; After reach to handicapped, selfish type would directly go to exit and not consider other persons.

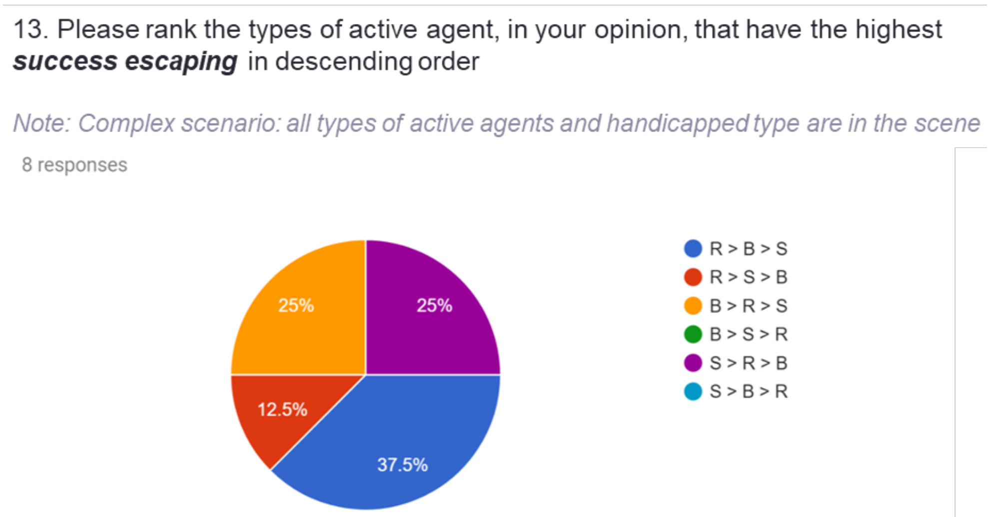


Figure 8-12 Prediction of which agent type would be able to take the handicapped to exit successfully. R, B, S are Rational, Brave and Selfish, respectively

Question no.15 and no.16, they are considered as *complex scenarios.* The question no.15 asks learners to rank the type of active agent which has the highest number of *failed access* in descending order. The *failed access* means a situation that an helper agent has *helping intention* and perform action as going for help the handicapped. Unfortunately, that helper cannot reach the handicapped. More details of the definition can see Figure 7-6 in section 7.3.2. The results from question no.15 (see Figure 8-13) show that the majority votes (37.5%) think the brave type has *failed access* the most, while the selfish type has the least. There are two of the second majority votes (25%.) For the first one, learners think the selfish type has *failed access* the most, and rational type has the least. For the another of the second majority votes, learners think rational type has *failed access* the most, while selfish type has the least. The interesting matter is the two opinions are the opposite of each other. It implies that in the same scenario, people may think not only different, but also completely opposite to each other. Additionally, the result show that all type of active agents are selected as the type that has the highest of *failed access.* Moreover, they have reasons to support each of them as well. The results from question no.16 show the reasons to support the majority votes (B > R > S) as the brave type tend to help many ones, it may over its capability and lead them to dangerous situation. The results that to support the first second most votes (S > B > R) is the selfish type may leave the handicapped before they meet each other, as a result, the number of *failed access* are high. For an another second most votes (R > B > S) is the rational type may change their mind from helping to escaping since they can realize the danger of the situation. We can summarize the key points as follow:

- The majority vote, 37.5%, $B > R > S$
- There are two second majority votes, 25%, $S > B > R$ and $R > B > S$
- All agent type are considered as the highest rate
- It is interesting that the second majority votes are opposite to each other
- Reasons supporting $B > R > S$: brave type might tend to help many persons, it may be over his capability. As a result, they could fail to escape; the brave type wants to help, but may have no idea how to do that; the selfish type does not tend to help anyone, then his *failed escaping* is low
- Reasons supporting $S > B > R$: selfish type may leave the handicapped for his safeness. Then the *failed escaping* rate is high.

- Reasons supporting $R > B > S$: rational type may try to help, but it is not guaranteed to be success; with situation might change, rational person may change their mind and escape without helping.

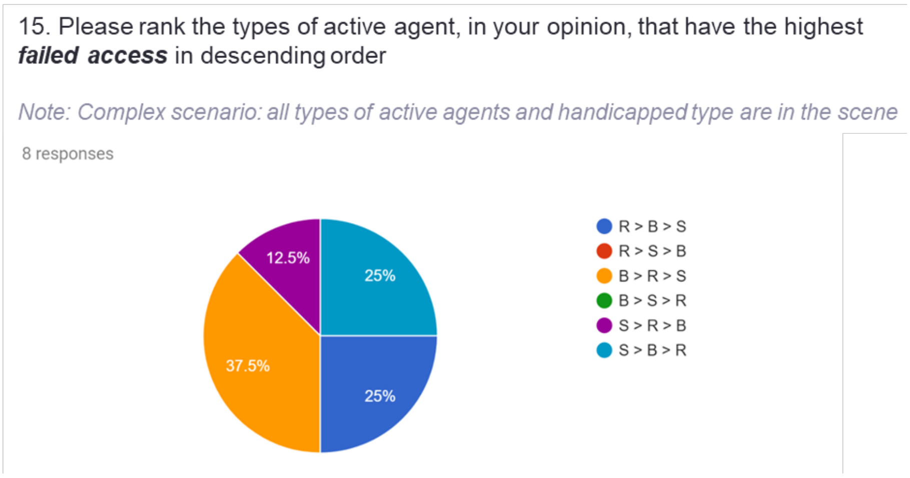


Figure 8-13 Prediction of which agent type would be failed to reach to Handicapped the most. R, B, S are Rational, Brave and Selfish, respectively.

Question no.17 and no.18, they are considered as *complex scenarios.* This question asks learners to increase number of agent in the scenario. In this question, the number is changed from five agents to ten agents for every type of agent. Question no.17 asks learners that will the *survivor* number change or not. There are two default options as *increase and decrease*. It is possible for learner to add their own option if they feel the default ones are not right to their opinion. Figure 8-14 shows the results of question no.17. Blue, red, orange, green and purple colors are *increase, decrease, not change, depend on agent type* and *not change,* respectively. Blue and red colors are the default options which are *increase* and *decrease,* respectively. There are some learners add their own option in the questionnaires. However, orange and purple colors, which are added by learners, have the same definition. Thus, we group the orange and purple colors together. The results show that majority votes (37.5%) think the number of survivor are decreasing. There are two second most votes (25%) which are the blue color (increasing) and the combination of orange and purple colors (not change.) Result from question no.18 show that reasons to support *decreasing* are that increasing number of agents may cause the panic situation. As a result, there are less chance for helping others. Moreover, increasing the brave type can imply that increasing chance of reckless behaviors. In other words, there are more chance for failure to escape. The reasons that support *increasing* are that the more agents is the more problem. However, it also increases chances of working together. Moreover, increasing agents could be considered as increasing *helping intention* as well. As a result, the number of the survivors are increased. The reasons that support *not change* are that every type of agent is increased in the same rate. Thus, there is no different. We can summarize the key points as the follows:

- Based on answers from learners, the purple and orange colors, which the learners added by themselves, could be considered as the same category. It is *not change.*
- The majority vote, 37.5%, is red color: *decreasing*
- There are two second majority votes, 25%, are *increasing* (blue color) and *not change* (combination of purple and orange colors)
- Reasons supporting *decreasing*: the more agents could cause panic to happen. As a result, there are less chances for helping others; Increasing the brave type imply to have more reckless activities. As a result, more chance to fail to survive.
- Reasons supporting *increasing*: the more agents is the more problem, but it has chance to work together too; More agents is increasing rate of *helping intention,* then the survival rate increased.
- Reasons supporting *not change*: every agent type is increased at the same rate, then there is no impact.

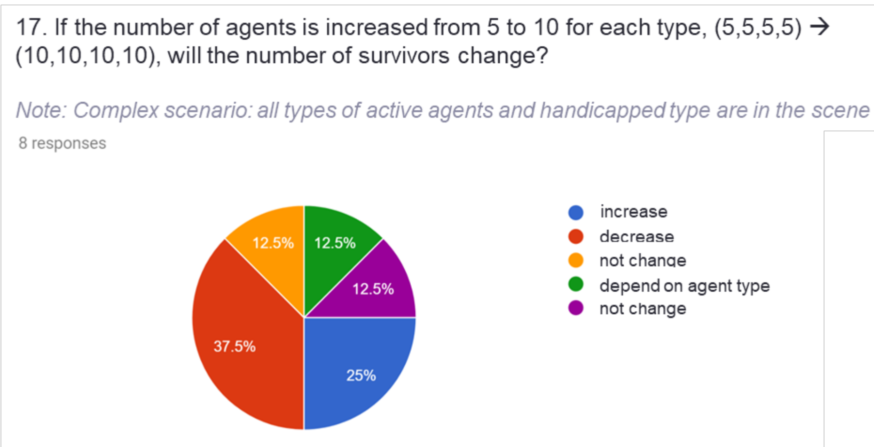


Figure 8-14 Prediction of how does increasing number of agents would change the survival rate and Red color are decreaing and increasing, respectively. Purple, Green and Orange color are no impact, depend on situation, and the same rate (from *other* option)

4. **The fourth section**: the questions in this part are designed to indirectly guide the learners to question their thinking processes by themselves. Learners are requested to compare their predictions and the observed simulated results. They are requested to identify which comparison results are similar and different. They are asked whether they can agree with those comparison results or not. What are their feeling toward those comparison results. Are the comparison results exceed or against their expectation? Finally, based on the whole learning activities they have, are they stimulated to remind on their thinking processes or not. Which learning process stimulate them the most. Based on these consequence of questions, learners are gradually assigned to think about their prior thought during making predictions. They are expected to be aware of their thinking processes. More details of questionnaire design and the intention inside are described in section 7.3.3.

   Question no.19: After the learners finish their simulation and compare their predictions with the observed simulated results, this question has asked them to identify which comparison results are similar or different from their predictions. Figure 8-15 show the summary results from the learners. In the figure, the number at the x-axis represents counting number of the learners that corresponding the information in y-axis. The information in y-axis, from top to bottom represent the question no. 5, 7, 9, 11, 13, 15 and 17, respectively. In the figure, the there are *(s)* and *(c)* at the beginning of the information. The *(s)* means this question is belonged to the *simple scenarios,* while the *(c)* means that question is belong to the *complex scenarios*, respectively. The result from question no.19 shows that most of the *simple scenarios* are similar comparison results. It can imply that most of the learners' predictions are similar to the observed simulated results. It may be since the *simple situation* are not difficult to make predictions. However, the predictions are become more difficult when they are belonged to *complex situation.* The results from question no.19 show that question no.5 is the question that most learners can predict the results which are similar to the observed ones the most. Question no.5 is asking that which type of agent that have the high number of survivors. It is interesting that in the *simple scenarios* the answers from the learners are not much different, and many of them have the similar results as the observed ones. While the answers from the *complex scenarios* are vary than the *simple scenarios*. Moreover, there are more different comparison results in the *complex scenarios* rather than in the *simple scenarios*. It may relate to the mixture types of agent in the same scenario causes some difficulties to make a precise prediction. We summarize the key points as follow:

- The most similar comparison result is on question no.5 from *simple scenarios*, which agent type is the highest survival rate: the selfish type has the most survival rate.
- The second most similar comparison result is on question no.13 from *complex scenarios*, which agent type can bring handicapped person the exit the most: R > B > S
- The most difference comparison result is on question no.17 from *complex scenarios*, does increasing agents affect survival rate? Decrease 37.5%, increase 25%, no effect 25%
- The second difference comparison result is on question no.11 from *complex scenarios*, which agent type has the most *accessible help*: B > R > S for 62.5% and R > B > S for 25%
- Interesting issue is that most scenarios in *complex scenarios* have differences comparison results. It may relate to the more complex situation since there are mixture of agent types together

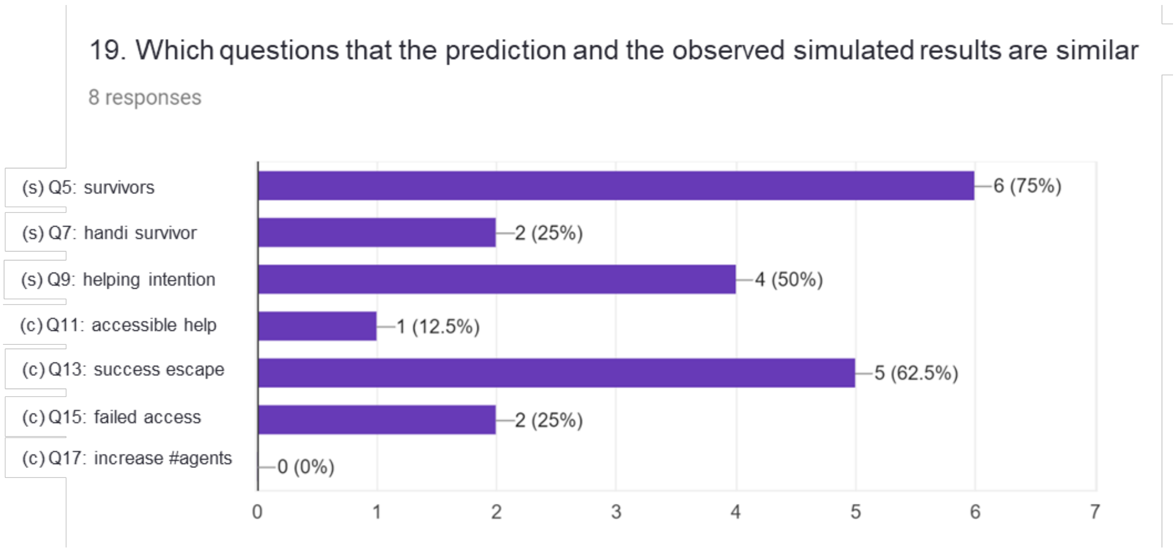


Figure 8-15 Results of comparison between predicted outcomes and simulated outcomes. Y-axis, from top to bottom, represents question no.5, 7, 9, 11, 13, 15 and 17, respectively. X-asis is number of learners.

Question no.20: this question asks the learners whether they agree on the *similar* comparison results or not, and what are the reasons to support the answer. The results show that all learner all agree on the comparison results. Their given reasons are ”as expected.”

Question no. 21: Similar to the question no.20, except this question ask for the agreement on the *different* comparison results. The results from this question have both agree and disagree. Reasons for the agree opinions are like “I may have a wrong analysis.” For the disagree opinions, most of them are similar to they found unexpected alternative opinions. Based on the results, there are disagreement more than agreement. Moreover, there are some signs of the curiosity as well. One of them said “surprise” and said “I don’t like it” to a particular result. We summarize the key points as follow:

- Example of agree opinions:
  - Anything could be happened
  - I may have a wrong analysis

- Example of disagree opinions
  - Disagree because Brave person might be fool
  - Disagree because Brave person would be failed escaping, Rational person should be survived more *(NOTE: this learner may found out that survival rate of Rational person is lower than Brave person – author)*
  - Disagree because Selfish person and Rational person should have higher survival rate than Brave person. Rational person would carefully think for both helping and escaping while Selfish person mostly focuses on escaping. As the result, both agent types should have better survival rate, especially the Selfish type.
  - Disagree on Brave person has high *failed accessible* rate
- Example of curiosity opinion
  - Surprise that Selfish person has high survival rate (like in the movie)
  - I do not think that Brave person have high *failed accessible* rate than Rational person

Question no. 22: this question asks the learners to identify which comparison results that make them feel curiosity to know the reasons that make the difference happened. Learner can select more than one option The results of this question depicted as Figure 8-17. From the figure, the number on the x-axis is a counting number. It represents the total number of learner who select that option. The information on the y-axis is a list of questions. The questions are question no.5, 7, 9, 11, 13,15, 17 from top to bottom, respectively. the symbols *(s)* and *(c)* at beginning of the question represent this question is belonged to *simple scenarios* or *complex scenarios,* respectively. The results show that the comparison results from the *complex scenarios* are the most questionable. We summarize the key points as follow:

- The highest questionable question is no.17, will the increasing of agents in the scenario would change the survival rate or not. It is consistent with question no.19 that it is the most difference comparison result.
- The second highest questionable question is no.15,
- Interesting issue is that the question no.11, which agent type has the most *accessible help*, which is the second most different comparison result, has zero mark. This may imply that learners are able to find possible reasons to explain how the difference happens
- Most questionable questions are related to *complex scenarios* which is all agent types engage the scenarios.

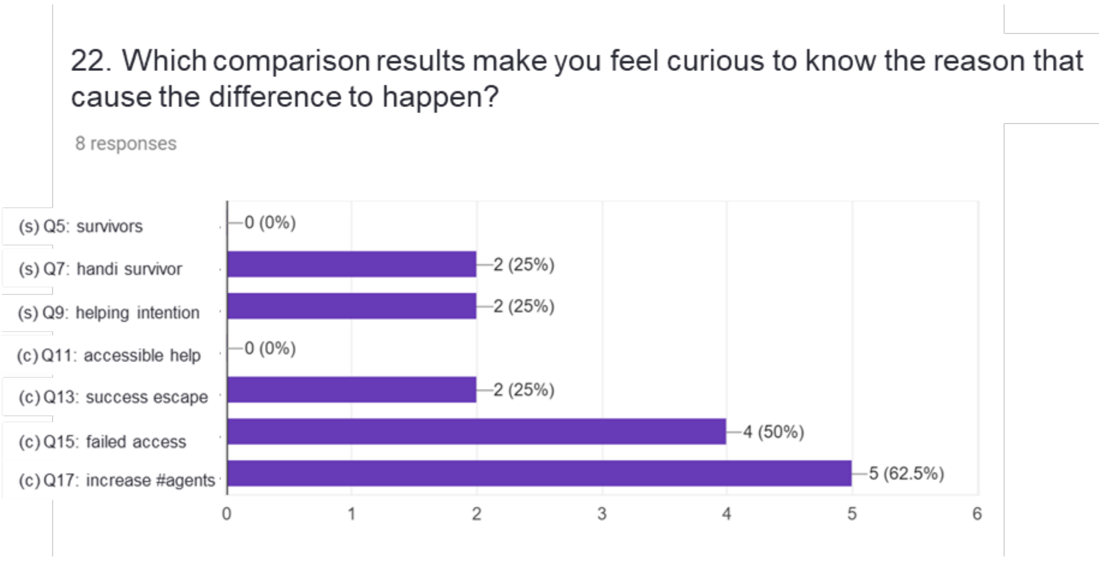


Figure 8-16 Which comparison that the learner feels questionable the most. Y-axis, from top-to bottom, represents question no. 5, 7, 9, 11, 13 and 17, respectively.

Question no. 23: this question ask the learners about what are their feeling toward those questionable comparison results in question no.22, and will the learner accept the results? There are five preset options, from top to bottom, as follows (see Figure 8-17):

1. The results are opposite to expectation, now they are acceptable
2. The results are opposite to expectation, now still disagree the results
3. The results are exceeded expectation, now they are acceptable
4. The results are exceeded expectation, now still disagree the results
5. Others opinion, learners can make it themselves

The result that opposite or against the expectation can be consider as *negative surprise* it may cause the learner try to find out what reasons that cause the difference happen. Which results, the learners' predictions or the observed simulated results, are more reasonable. The learners may find some possible explanation to the difference, they may modify the simulation parameters and rerun the simulation to test their hypothesis. Trying to figure out how the difference happen cause them explore their thinking processes. They may question themselves whether there is any overlooked information during they make predictions. Moreover, it may cause the learners try to set new hypothesis to solve how the difference happen. As a result, the learners may have better understanding about their own thinking processes by exploring their own thought, and/or expand their imagination to set up hypothesis based on the attempt to find out the solution. Based on the results from question no.23, we can summarize the key points as follow:

- There are many feeling, opposite and exceeded expectation, toward those questionable questions. There are both agree and disagree on the results
- The most questionable question is no.17, will the increasing of agents in the scenario would change the survival rate or not.
  - Exceeded expectation, now is acceptable: 67%
  - Opposite expectation, now is disagree: 33%
- The second most questionable question is no.15, which agent type that tend to be failed to reach *(failed access)* to the Handicapped the most
  - Opposite expectation, now is acceptable: 20%
  - Opposite expectation, now is disagree: 40%
  - Exceeded expectation, now is acceptable: 40%

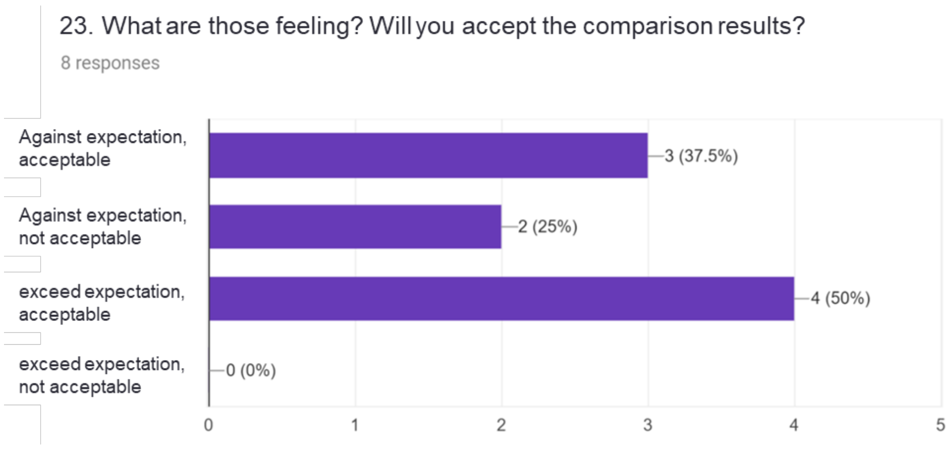


Figure 8-17 what is the feeling toward questionable questions no.22

Question no. 24: the question asks learners that does the feeling in question no.23 motivate learners to think about their thinking processes or not, and please give reasons. The question proved two default answer as yes and no which presented in blue and red colors, respectively. The question also provides additional option for someone who may have an alternative opinion. This question is expected to be used for evaluating our learning course. Series of questions presented previously are designed to gradually guide the to think and make question to their thought. More details are presented in section 7.3.3 (questionnaire and its intention.) The results from question no.24 is depicted as Figure 8-18. Blue color is *yes*. Orange and Red colors could represent the same meaning as *no* since some learners add their opinion as "no feeling" which can be considered ad "no"

- 62.5% of the learners are motivated to think about their thought
- Unfortunately, none of them gave reasons

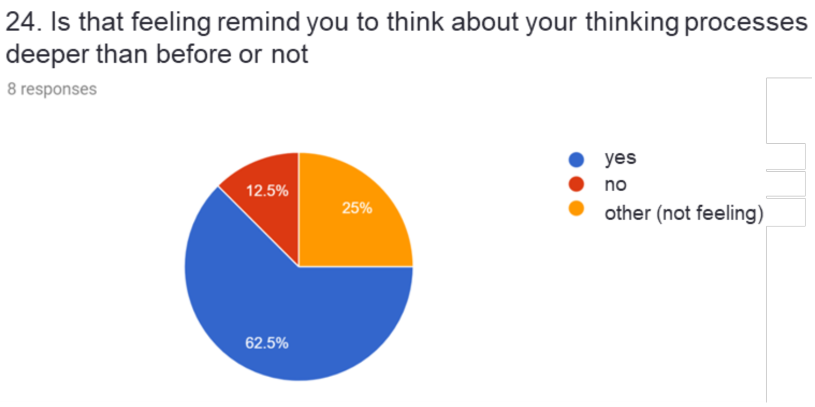


Figure 8-18 does the feeling in question no.24 motivate the learners to think about their thinkingprocess or not. Blue color is *yes*. Red and orange colors could represent the same meaning, *no*.

Question no.25: This question aims to evaluate the learning course in this trial use case. Based on the whole learning activities the learner participated, it can be divided into 6 steps (see Figure 8-19.) Those steps are 1) introduction, 2) updated primitive knowledge, 3) prediction, 4) simulation, 5) comparison and 6) reasoning. More details are described at 7.3.1 (the learning materials in the *pre-learning phase.)* this question asks the learners that which step they consider that stimulate them to remind to their thinking process the most. The results are presented as Figure 8-20. From the raw collected data, there are two steps that are considered as the majority votes (37.5%.) They are *prediction* and *reasoning* steps, which are step no.3 and no.6, respectively. However, if we are looking into the data, the learners who said they are stimulated to remind of their thinking processes, from the question no.24, vote for the *reasoning* step at 40% which is the most vote (see Figure 8-21.) For the other steps, these learners vote for step no.2 primitive knowledge, no.3 prediction, no.4 simulation as twenty percent, respectively for each step. However, we have an expectation that the *reasoning* step is the step that stimulate learners to think of their thought as mentioned in section 8.3 (expected learning results.) Even though the *reasoning* step is voted as the step that stimulated them the most. However, we expect the vote greater than fifty percent. The discussion on this issue is described in section 8.5.4. We can summarize the results of question no.25 as follows:

- Based on the raw information, there are two processes that make learners to think the most:
    - *Prediction* (37.5%) and *Reasoning* (37.5%)
- Based on learners who answered they are motivated to think about their thought (62.5% of total) in question no.24
    - *Primitive knowledge*: 20%
    - *Prediction*: 20%
    - *Simulation*: 20%
    - *Reasoning*: 40%
- For ones who are motivated to think about their thought, *Reasoning* process affects them most.

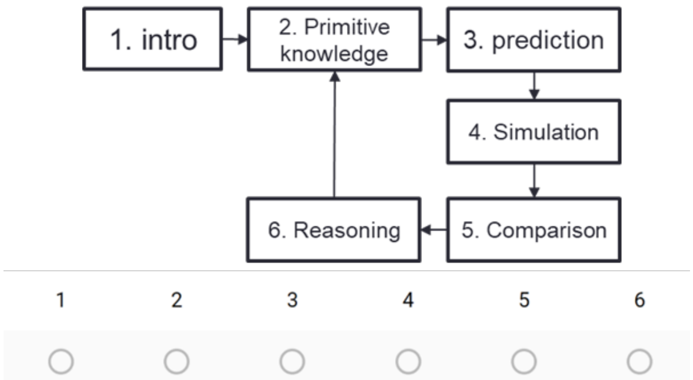


Figure 8-19 Outline of the learning activities which are divided into six steps. They are used in this trial use case for conduct the learning course.

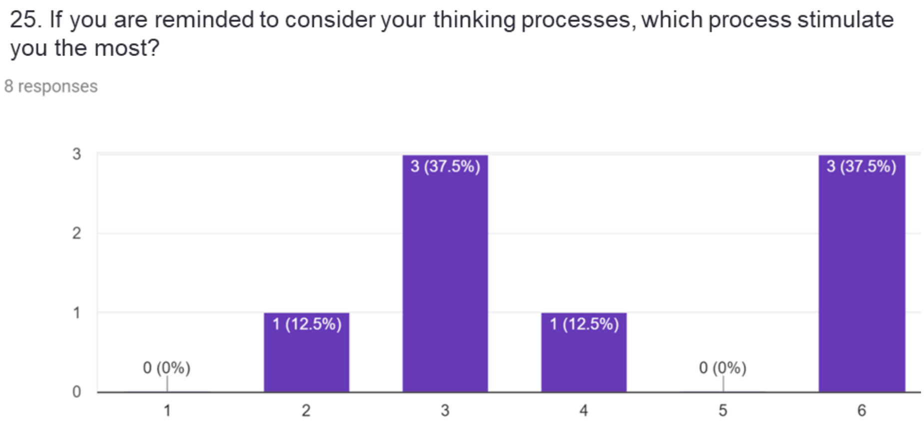


Figure 8-20 This graph presents which learning steps that the learners consider it to stimulate them to think about their own thinking process the most. The *prediction* and *reasoning* step, no.3 and no.6, are the most votes

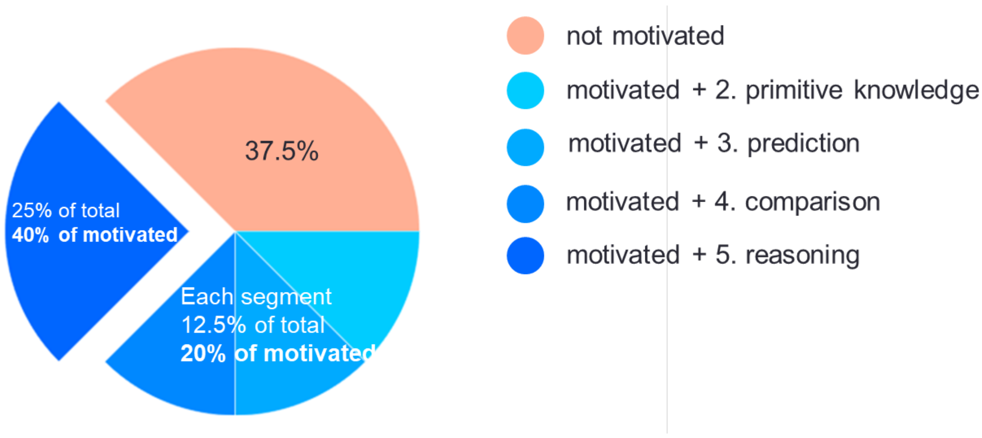


Figure 8-21 proportion between the learners who said they are motivated to realize of their thought and the learner who think the *reasoning* step stimulate them to realize their thought the most. The learner who selected the *reasoning* step as stimulating them the most are 40% of ones who said they are motivated to realize their thought.

8.5. Conclusion and discussion

This chapter is focused on reporting the results of the designed learning course conducted in this trial use case. The learning course is implemented following the proposed learning platform using surprise as a learner trigger to motivate learners to be aware of their thought. The results described in this chapter are made by the learning activities in the *main-learning phase* and *post-learning phase*. The results are the answers made by the learners responding the given questionnaires. The questionnaires are divided into two parts. The first part used in the *main-learning phase*. These questions aim to guide learners to explicitly express their opinion toward the given simulated emergency scenarios. The learners are required to answer the questions in the pair of what-why style. It means the learners described **what** are their predicted results, and give reasons that support **why** they have those predicted results. The questionnaires in the second part are used in the *post-learning phase.* they aim to guide the learners to gradually question their thinking processes by themselves. We have an assumption that questions our own thinking processes is the initial step to be aware of self-thinking processes as mentioned in section 8.3 (expected learning results.) Learners make their predictions relate to the seven factors: *survivors, deaths, helping intention, accessible help, successful escaping, failed access, and failed escaping,* described in Table 7-2 of section 7.3.2 (explanation of using the simulation.)

The results from this trial use case showed that learners had similar prediction on the *simple scenarios* (questions no.5-no.10), but started to have more different opinions in *complex scenarios* (questions no.11-no.18.) In some questions the results even showed that their thoughts were completely opposite to each other. For example, question no.15 on Figure 8-13. After learners finished their predictions, ran the simulation, observed the simulated results and made a comparison with their prediction results, they explicitly showed their opinion about agree or disagree on the comparison results. In the free-written questionnaire, some of them said they were curious why such phenomena happened. This could be a sign of *surprise.* For the similar comparison results, all of them had no issues as our prediction in section 8.3. They agreed and accepted the result. However, for the different comparison results, there were both accepted and not accepted the results. Some cases they said the results were opposite to their expectation, on the other hand, some cases were exceeded their expectation. Based on the proposed experiment, 62.5% said they think about their thought deeper. Additional, based on these group of respondents, 40% of them said the *reasoning* step causes them to be aware on their thought the most. Moreover, the vote result from the whole participants show that the *reasoning* phase and *prediction* phase are the steps that stimulate them to realize on their thought the most.

8.5.1. Discussion: evidence of the surprise is occurred in the trial use case

This research has assumption that surprise can be considered as a good learning trigger to motivate learners to be aware of their thinking processes. However, what is the surprise in the trial use case, how the surprise is created, when the surprise happens, and what are evidences that imply the surprise is happened. This section would like to clarify those questions from the view of conducting the trial use case. Conceptually, the definition of surprise, in this research is the difference between expectation and reality (Casti, 1994; Lorini, 2007). In this trial use case, learners' predictions can be considered as *expectation* since their predictions are the results from their effort to compile their current knowledge and personal experience to make reasonable solutions. On the other hand, the observed simulated results can be considered as the *reality* which generated from the simulation system. Based on the definition of the surprise, and the learning activities that let the learners to compare their predictions with the observed simulated results, if the comparison are different it implies that the surprise is happened since there are difference between the expectation (predictions) and the reality (observed simulated results.) The evidence to imply that the surprise is already happened is the learners feel curios to know the reasons why their prediction and the observed simulated results are different. This curiosity can imply that the learners, by some reasons, they may feel confident at a certain level of their predictions. When they realize that there is another opinion which is unexpected different from theirs, then they feel curious to know how this alternative opinion can be conducted. They may feel challenge to know which one are more reasonable than the other. As a result, they may try to figure out the reasons of the alternative opinion. This makes them to think in the way they never realize before. On the other hand, it is possible for them to monitor their own thought whether there is any overlooked information during the prediction or not. Finally, they have better understanding on their own thinking processes, and may have new idea to handle with the particular problem that they never realize before. In the other word, surprise cause the learners to be aware of their thought by making comparison between their prior thought and the alternative ones. In the trial use case, the results from question no.22. This question asks them which comparison results that they feel curios to know what make the different between their thought and simulation mechanism (the RED model and its rules.) However, the simulation mechanism is not revealed to learners, they have to make new hypothesis and test it by themselves. They have to make new hypothesis by themselves. They can modify parameters, re-run the simulation to test their hypothesis. If they could find new reasons that could support the simulated outcomes to be occurred, they can realize that their prior thought is imperfect, and it may not be the only possible outcomes. As a result, new perspective to think toward a specific situation could generated in the learners' mind.

8.5.2. Discussion: evidence of being motivated to realize own thought in the trial use case

First of all, we would like to clarify what situation can be consider as being motivated to be aware of self-thinking processes. The situation that the learners compare their predictions with the observed simulated results, find out that they are different. With some methods, if they realize that their prior thought is not reasonable, then they change their mind and apply the new knowledge instead. This is not being aware of their own thought. It is to adapt the new knowledge in to mind. It is to receive a new instruction to follow. Being aware of self-thought is to understand how one's own thinking processes are. It is not just memoizable. In order to understand one own thought, people should be able to question themselves about how they think. The learning course used in this trial use case provides questionnaires that aim to gradually guide the learners to question their thinking processes. The designed intention of these questions is mentioned in section 7.3.3. This section aims to clarify the relation between the concept mentioned above and the trial use case. The evidences that supports this concept are the results from the series of questions. Question no.19 asks the learners to identify which comparison results are similar or different. Question no.20 and no.21 ask them whether accept the comparison results or not. Question no.22 is more specific. It asks the learners to identify which different comparison results that make them feel curious to know their reasons that cause the difference. Question no.23 asks the learners what are those feeling, and can the learner accept the different comparison results or not. These questions are designed to gradually guide learners to question their own thinking processes whether it is reasonable or not. If they realize that their prior thought is not reasonable, they also feel surprised and reflect it to their knowledge. On the other hand, if they realize that their prior thought are more reasonable, they can reject the observed simulated results. By following tasks in the questionnaire, they are required to reconsider their prior thought, try to guess the mechanism that create the alternative opinions (the observed simulated results) and compare them which one is more reasonable. With these thinking activities, it would be consider as being motivated to figure out how one own thought is. It is not just to memorize the contents. For example, the result from the trial use case. The result in question no.21 which is to ask the learners whether they accept the different comparison or not. The example signs of curiosity are as follows:

- Surprise that Selfish person has high survival rate (like in the movie)
- I do not think that Brave person have high *failed accessible* rate than Rational person

Moreover, in the questions no.22 and 23 which ask the learners which comparison results that they feel curious to know the reasons that cause the difference, and what are those feeling, respectively. Results from question no.22 show that there are 5 out of 7 issues (71.4%) that the learners are curious to know why the differences happen. Based on those curiosity, in the end, the learners show that there are both accept and not accept the comparison results. The results from question no.24 which asks the learners whether or not that they are stimulated to remind about their thought. The results show that there are 62.5% admit that they are motivated to realize about their thought. This value exceeds our expectation which is set at

50%. Moreover, 40% of these motivated learners said the *reasoning* step motivate them to realize on their thought the most (question no.25.)

8.5.3. Discussion: differentiation a rational thinking and an emotional thinking

A rational person and an emotional person could be very similar to each other. Each of them may have the same decision-making processes: to making goals, collecting information, making criteria, making alternative, predicting results of each alternative, and selecting the best alternative. However, the ability to handle with emotions are different. The emotional person allows the emotions to take place and affect to their decision-making processes. For example, criteria for making a decision more rely on emotions rather than facts. As a result, the emotional thinker performs emotional behaviors.

In this trial use case, the simulation represents helping and escaping behaviors of the simulated agents in the indoor fire emergency. Those behaviors are different since each particular agent allows different level of emotions to affect their decision processes. In this research, the rational and emotional also have the same decision-making model (the RED model) embedded to the agent. However, the emotional agents, such as brave and selfish agents, let the emotions of high-confident and fear affect and control their decision. Then they have different criteria's values to consider what is dangerous or safe. The simulated agents that allow high level of emotion to involve their decision-making processes, they are defined as an emotional agent. On the other hand, the agent that let a decent level of emotions involving their decision-making processes, they are defined as a rational agent. However, how the learners can realize these concepts or how the learners can differentiate the different between the rational and emotional thinking through the simulation?

Behaviors are results of the decision-making processes. Thus, rational thinking would produce the rational behaviors. On the other hand, emotional think would produce the emotional behaviors as well. Learners can differentiate the rational thinking from the emotional thinking through engaging the trial use case in the *simple scenarios*. A *simple scenario* is a situation that consist only two types of agent at once (see 8.4.2, page 106.) For example, there are five agents of handicapper type, and five agents of rational type in a scenario. Another scenario can be five agents of handicapped type, and five agents of selfish type. Based on the *simple scenarios*, learners have chance to predict and observe the simulated of these scenarios, and compare the results from those two scenarios. They can modify simulation parameters to test their hypothesis and make sure that they can differentiate those agent's behaviors. However, this is how a learner to differentiate rational and emotional thinking in the simulated environment which is designed with limited and controlled factors. To differentiate the rational and emotional thinking in the actual human being would be more complex than the simulation. Nevertheless, the rational thinkers are able to present their logics. They can identify what are causes and effects, input and output, think and behave based on facts rather than emotions. While the emotional thinkers are opposite.

8.5.4. Discussion: Limitations

In this trial use case, we realize that there are some limitations which are needed to figure out how to improve it in the future. The first issue is the number of questions for evaluate the learning course. There are many questions to ask and many aspects to explore what do the learner think, and what are reasons behind those thinking. However, only a few handpicked questions are selected since it is necessary to balance about collecting information and to preventing the learners' interesting drop. In this trial use case the learners are requested to make predictions toward two set of scenarios, the *simple scenarios* and *complex scenarios.* The *simple scenarios* represent only two types of agent at a time. For example, only five agents for the rational type and five agents for the handicapped. In this trial use cases, each learner has to make predictions and run the simulation three times for the *simple scenarios*, a pair of 1) the rational and handicapped types, 2) the brave and handicapped types, and 3) the selfish and handicapped types. Similarly, each learner has to run two time more for the *complex scenarios* with the same reason. In total, the learners are required to run the simulation at least five times and make predictions for each run too. For the best condition to collect the learners' information, each factor that request the learners to predict the result should be evaluated. However, to do such as mentioned is both time consuming and take so much thinking effort for conducting predictions. For example, question no.19 and no.20 asking learners that which comparison results are similar to the prediction, and do you agree with the comparison results, respectively. If there are seven issues in questions no.19, then question no.20 should be used seven times as well to check if the first issue is acceptable or not. Even though it may be great for collecting the learners' information, but it is not good for the learners. To prevent the learners to use too much effort, only some question are carefully selected. As a result, the question no.20 cannot evaluate the issue well. For example, the question asks learners that do you agree with the comparison result? However, even the learners answer agree or disagree, we cannot know which issue they are agree, and which issues they are not agree. What we can do is to evaluate the overview concepts.

As mentioned in section 8.3 (expected learning results), that based on this designed learning course, we expected that more than fifty percent of the learners are motivated to be aware of their thought (question no.24.) Moreover, the *reasoning* process is expected to be the process that motivate the learners to be aware of their thought the most, and the persons that referred themselves as being motivated should vote for the *reasoning* process at least fifty percent as well. We consider the number fifty percent since it can represent the average number. However, results from the trial use case show that, there are 62.5% of all learners vote for the *reasoning* process. This result exceeds our expectation. The result from question no.25 show that there are two processes that achieve the top votes. They are *prediction* and *reasoning* processes. This result is as expectation as well. However, based on the learners who said they are motivated to realize of their thought, only 40% of them vote for the *reasoning* process. This result is under our expectation. The question is what does it means? How to interpret this information? And is this number, 40% is satisfied for this research? Does this number mean this learning course disqualify or not? We would like to divide the issues in two topics. The first topic is that how to judge the learning course as qualify or not. The second topic is what does the number mean. For the first topic, how to judge the learning course as qualify or not, it should be evaluated with its objective. The objective of this research is to motivate learners to be aware of their thought on human decision-making in an emergency. This learning course provides a simulated indoor fire emergency phenomenon as the learning environment, design an emotion-based decision-making model, the RED model, to represent how a simulated agent makes its decision, define decision-making rules which correspond to the RED model. This research proposes a soft-half-baked microworld which is designed to overcome limitations that the traditional microworld and its family cannot handle. To evaluate the results, questionnaires are designed to guide the learners to think deeper and to guide them to question on their own thinking processes. Finally, in the trial use case, there are signs of the learners are being motivated to be aware of their thought as mentioned in 8.5.2. As a result, we think this learning course is qualified. For the second topic, what does the number means? Since the number does not indicate whether the learning course is qualified or not. We consider the number as one of our references. We set a reference number as 50% since it can imply to an average number. For the results in question no.24, we expect that the learners are motivated at least 50%, and the actual results are 62.5%. This result is considered as satisfied since the results are greater than expectation. For the results in question no.25, there are two expectations. The first expectation is the *reasoning* process is the process that motivate leaners the most to be aware of their thought. The actual results show that there are two processes that are the highest votes. They are the *reasoning* and *prediction* processes. This result can be considered as satisfied since it is as expectation. However, the second expectation is the learners who said they are motivated to be aware of their thought are expected to vote for the *reasoning* process greater than 50%. However, the actual result show that there are only 40% of them that vote for the *reasoning* process. We can consider this result as dissatisfied. The number that is under the expectation indicate that there are some problems need to be improved, but it does not mean the learning course is disqualified. Like the other learning courses, for example, a class in a school. We cannot expect all students will pass the exam. However, we should focus on how to increase numbers of student that pass the exam, and to reduce the number of failure students instead. For example, there are 37.5% of the total learners that are not motivated (question no.24.) Actually, the question requests the learners to write their reasons for being motivated and not motivate. Unfortunately, none of them give a reason in this question. One of the possible reason is that all of them were exhausted since this question is almost the last one. The learners take a lot thinking effort already. Another possible reason is the limited number of the questionnaires. As mentioned in previous paragraph, to get the more precise information, it requires the more thinking effort of the learners.

Another limitation is about the surprise. This research use surprise as a learning trigger to motivate learner to be aware of their thinking processes. The question is what will happen if the learner does not feel surprised? Before further discussing, we would like to give definition of the surprise that is used in this research. Surprise has many definitions in academic domains (see section 2.2.) For example, surprise is a difference between expectation and reality (Casti, 1994; Lorini, 2007), or consider it as physical response of emotion like startle (Lewis, 2012). For our research, we use the first definition: the different between expectation and reality. The surprise is occurred when the comparison between learner's predictions and the observed simulated results are different. The learners are expected to feel surprised since they put their thinking effort to imagine about the situation and make predictions. However if they find out that the simulated results are not as expected, most people probably wonder why the difference is happened. If the expected surprise has a different definition to us, we would consider it as out of our scope. However, it is possible that there are persons that feel nothing about the comparison results. For example, a learner may be not in the mood to take the learning course. He may predict the expected outcomes; however, he may do not care about the results. If it is the case, we also consider it as out of our scope. Our proposed learning platform aims to motivate the learners who are in the mood to learn.

CHAPTER 9 CONCLUSION AND DISCUSSION

9.1. Conclusion

Self-awareness is an important skill that each individual needs in daily life. It is even more important in a critical situation. However, it is difficult for individuals to be aware of their own thinking process. They may have useful knowledge for certain situations, but they fail to apply it to solve the problems they face. For example, many people know what the proper behaviour is for an emergency situation, but many of them may still behave improperly and emotionally when they confront the actual situation. One of possible reasons for this is that ordinary people may not have many opportunities to understand their decision-making process and how their decisions affect their behaviour. Unlike emergency services, such as the police, fire fighters, and rescue teams who have been trained to cope with emergency situations, ordinary people tend to behave inappropriately. It is important for people to be able to apply the right knowledge to the situation and to improve self-awareness of their thinking process. However, self-awareness is very difficult to cultivate, because mental processes are implicit and vague.

With regard to how people can develop their self-awareness, authors believe that *surprise* can cause greater self-awareness, so it can be used as a good activator for learning. We are not aware of how we will be able to cope with a situation and we tend to believe that we will think and act appropriately although we have no evidence for this. If we can observe our thinking process and realize that the result of our thinking is not reasonable, we will "be surprised" to find that we are not good at thinking and so we will be motivated to cultivate greater self-awareness of our thinking processes.

The role of surprise is a trigger that makes learners have a deeper realization of their own thinking. This dissertation has the following two objectives:

1) to motivate learners to develop self-awareness of their thinking process in an emergency, and
2) to propose a learning platform using surprise as a learning trigger for motivating learner's self-awareness.

To achieve the research objectives, a research methodology is proposed in chapter 3. This chapter is divided into four sections. First, it describes the design of the experiment. It presents an analysis by extracting important components of the experiment; and a learning platform is designed using surprise as a learning trigger and then the overall design of the whole experiment is explained. Second, the design of the learning material is described which is the key to make learners realize the importance of the learning subject. Third, the design of the questionnaire is explained which is used to allow the learners to describe their thoughts explicitly. The learners will also make a comparison between their thoughts and the simulated outcomes leading to further reflection on their thinking processes.

Chapter 4 describes the Microworld and its family, the Half-Baked Microworld. Definitions of the Microworld and the Half-Baked Microworld are presented. The next section discusses their limitations, and this is why we propose the Soft-Half-Baked Microworld in order to handle its limitations.

Chapter 5 describes an emotion-based decision-making model. This model is used with the Soft-Half-Baked Microworld to allow specific events to take place. These phenomena relate to the behaviour of rational, brave, selfish and handicapped agents in an emergency. All agent types have the same decision-making model; however, emotions can impact on some decision-making criteria and cause the agents to behave differently. The learners observe such behaviour and this leads them to reflect on their thinking process.

Chapter 6 focuses on the present relations and correspondences between the decision-making model and decision-making rules. Many examples of those rules are presented to describe the mechanisms that make each type of agent behave in different ways. However, these mechanisms are hidden from learners during the experiment.

Chapter 7 discusses the results of the experiment. The experiment requests learners to predict the results they expected with regard to certain scenarios. The scenarios are divided into two types, simple and complex. After running the simulation, learners are requested to compare their predictions and the simulated results. The different results of the comparisons are expected to motivate learners to monitor their thinking process. The experiment shows that, for simple scenarios, there are a few different results from the comparison. All learners agree and accept the comparison results. However, in complex scenarios, the experiment shows that learners have diverse opinions with their own reasons. Some learners agree the comparison results, while the others do not. Learners are requested to present reasons for those agreement and disagreement. There is no judgement on these different opinions since the objective is to provide opportunities for learners to observe their own thoughts. As a result, 62.5% of the learners accepted that the experiment motivated them to reconsider their thinking processes.

Chapter 8 presents a summary of this dissertation. The original research and its impact on communities is presented. The research's limitations, possibilities for future work and a discussion are presented in this chapter.

9.2. Significance of research outputs

This section aims to present the original work in this research and the contributions to knowledge science and academic communities.

9.2.1. Original research

To achieve the aims mentioned above, this research prepared simulated emergency scenarios for learners to develop their self-awareness. The scenarios include a mixture of agents, who are rational and emotionally brave, emotionally selfish and handicapped persons, trying to escape the simulated emergency. Learners try to describe their thoughts explicitly as predicted results, and then compare actual simulated outcomes with their predictions. The comparisons will lead learners to develop a greater awareness of their thinking processes. There are three major research outputs of significance in this study which are as follows:

1) *A learning platform for motivating self-awareness using surprise as a learning-trigger*: This learning platform uses surprise as a learning trigger for cultivating self-awareness. It encourages learners to ask themselves questions about their thoughts. As a result, they will be motivated to develop a greater awareness of their thinking processes. The learning platform has a potential which is not only limited to the emergency domain.
2) *The Soft-Half-Baked Microworld:* This provides a simulated environment which is designed following a theoretical concept of the Microworld. It aims to let a specific phenomenon take place and allow the learners to observe the scenarios. Based on this research, learners achieve their learning goals by reflecting on their own thinking processes.
3) *A Rational-Emotional Decision-making model (RED model):* This is a model used with the Soft-Half-Baked Microworld. Its purposes are to let specific phenomena take place. For this research, the phenomena is the agents' behavior in an emergency situation. This model describes how emotion has an impact on the decision-making process. It is used to represent how rational and emotional agents make decisions in

given scenarios. However, its mechanism is hidden from learners since the objective is to cultivate self-awareness, not to judge its correctness.

9.2.2. *Impact on the knowledge science community*

The proposed learning platform, which uses surprise as a learning trigger, can be considered as a means to promote *knowledge creation*. The knowledge here is the ability to be aware of one's own thinking process. This learning platform is not only limited to developing self-awareness of how one thinks in an emergency behavior domain, other domains are also acceptable. Moreover, we expect that those individuals who are motivated to be aware of their own thinking processes will be able to apply this capability in different ways and situations.

9.2.3. *Impact on the academic community*

This section would like to present the impacts on the academic community from three different points of view. Firstly, with regard to the learning aspect, our proposed learning platform is expected to develop better quality of learning rather than typical learning. The reason for this is that once people are motivated to understand their thinking process on a specific subject, they are considered to have a deeper thinking on that subject. They can understand the reasons that make them think the way they do, not only to memorize content. Secondly, the proposed Soft-Half-Baked Microworld reduces the limitations that are associated to traditional Microworld and Half-Baked Microworld. The Soft-Half-Baked Microworld focuses on providing a learning phenomenon happen, and the correctness of the learning model is considered to be of less importance. As a result, the limitations of the traditional- and Half-Baked Microworld, which require that the model has to be well-defined by equations or rules, is resolved. Thirdly, with regard to decision-making and human behavior research domains, the proposed an emotion-based decision-making model (RED model) provides both concepts and implementation to represent how rational, emotionally brave, emotionally selfish individuals behave in an emergency. Decision-making criteria can be modified in the decision-making rules. This concept can be applied to other domains as well.

9.3. Limitation and future work

This research has some limitations which suggest possible directions for future research. Firstly, a greater number of respondents would be possible. There are many interesting points of views obtained from only eight respondents. Sometimes their answers came from unexpected thoughts. To explore and find the relationships between them would be a good way of improving the learning platform using surprise to motivate their self-awareness. Secondly, the subjective domain depends largely on the particular experience and interests of the participants. If the learners are not enthusiastic or interested in the subject, they may become tired and not take the trouble to present their thoughts accurately. Since this research requires individuals to make predictions and their reasons for doing so, only a limited number of questions can be used. Otherwise, the learners will lose interest in the topic.

With regard to future work, the author noticed a knowledge-to-action gap among the respondents. Since they are first-year undergraduate students, they are not familiar with the content used in class. For example, many of them are new to programming language. Even if they have attended their lectures and they understand the content, they will still have difficulties in solving problems in the laboratory. This phenomenon, namely, having certain knowledge but being unable to apply it properly, could be suitable for use with the proposed learning platform. Future work could investigate how to design an experiment that allows such students to feel surprised and motivated enough to be able to use the knowledge from their lectures properly by applying it to their work in the laboratory.

9.4. Discussion

To cultivate self-awareness of an individual's making in an emergency situation is a method for improving an individual's meta-thinking. It aims to make one think about one's own thinking. To understand what we are thinking is not easy because the thinking process is implicit. It is hard to be observed. This research introduces a learning platform to help learners to observe their own thinking processes explicitly. It uses surprise as a trigger to lead to greater self-awareness on the part of learners so that they can have more understanding their own thoughts as explained in previous sections. Even though the learning design can achieve the learning goal, motivating self-awareness on decision making in an emergency by providing opportunities for learners to observe their own thoughts results in some issues with this learning platform which should concern us.

Firstly, the simulated results are not claimed that they will exactly happen in real emergency situation. The simulated results here are generated from limited and controlled factors in a simplified simulated environment, while the actual emergency situations are beyond more complex than this learning environment. Learners are motivated to aware of their thought and they have to adapt it to actual situation by themselves.

Secondly, 'surprise' used as a trigger for learning is an unexpected feeling when learners' prediction of simulated results are different from the observed results. This surprise can cause both positive and negative feelings. These feelings make them aware that the results of their thinking i.e., their predictions, may not reasonable. This surprise will motivate learners to find out what aspects they might have missed or perhaps processed information mistakenly.

Thirdly, the decision-making model representing rational and emotional decision-making might cause concerns that it cannot represent a decision-making process of actual human beings. As mentioned previously, there is no single agreement on how to describe the how human decision-making process. Learners or those who are interested in this research might believe in different decision-making models. This research introduces a simplified model to present on our learning platform. The role of the model is to allow the phenomena to take place. Models of different designs could be used equally well on this learning platform.

Fourthly, factors involved in the decision-making process may vary from person to person. It is similar to the decision-making model issue, as mentioned above, where there is no single agreement to describe how many factors would be involved in the decision-making process. People have different preferences, so to apply this learning platform, it is better to configure the decision-making model independently based on the learning goals.

Fifthly, the learning outcomes achieved through interaction with the microworld depend largely on the surrounding instructional activities (Miller, 1999). Learning activities and interactions between learner and the microworld in order to achieve learning have to be defined clearly in their surrounding context. The Microworld and its family are promising approaches for learning. Our proposed Soft-Half-Baked Microworld begins the learning process by requesting learners to make their predictions of a given phenomenon, run a simulation and to then allow the learners to observe the simulated phenomenon. The learners then make comparisons between their predictions and the simulated results. They can modify the simulation parameters to shape up their hypothesis and new knowledge by using their modifications and observations. Different results from the comparison will cause them to monitor and to be more aware of their thinking process.

Sixthly, the learners in this research behave as an observer or with a 3rd-person perspective in a learning environment. Its main role is to predict and observe what happens in the simulated scenarios. For example, most of the rational agents have a better survival rate; and the average evacuation time of rational agents is higher than that of emotional agents. While other research studies provide a 1st-person perspective on the learning environment so that the learner can interact with the learning environment as a decision-maker. There are advantages and disadvantages with both approaches. The greatest advantage of a 1st-person perspective on the environment is that the learners can experience the situation for themselves. To focus on studying the responses of the learner is a good approach. However, its limitation could be how realistic a scenario are the instructors able to create. The more realistic the scenarios created, the more realistic the feelings with which the learners will respond. A good example of this learning domain is Virtual Reality (VR). On the other hand, a 3rd-person perspective does not focus on providing a realistic scenario, but it can provide opportunities for learners to take more time investigating their own thoughts since it is not focussed on a real-time response. Learners can take time for deep thinking on the learning content. This research is based on a 3rd-person perspective because a beautiful visualization might not be as important as the opportunities to make individuals have a deeper thinking and a greater awareness of their own thoughts.

Seventhly, the learning platform using surprise as its learning trigger and the Soft-Half-Baked Microworld are independent. In this research, the Soft-Half-Baked Microworld is introduced since the phenomenon of emergency behaviour is required for observation. Simulation is one of the most promising approaches to represent this phenomenon.

LIST OF PUBLICATIONS

Student name: Chaianun DAMRONGRAT

Title of dissertation: A Learning Model for Cultivating Learner's Self-Awareness on Human Decision-Making in an Emergency Situation.

- ***Papers published in journals***

[1] Chaianun Damrongrat, Mitsuru Ikeda, Alisa Kongthon, and Thepchai Supnithi, "A Learning Model for Cultivating Self-Awareness on Human Decision-Making in an Emergency Situation.", in *Journal of Education and Learning (EduLearn) 11, no.3*, pp. 235-243 (2017)

- ***Oral presentations at conferences***

[2] Chaianun Damrongrat, Mitsuru Ikeda, Alisa Kongthon, and Thepchai Supnithi. "A Microworld for Cultivating Learners' Self-Awareness on Human Decision-Making in an Emergency Situation", In *Edulearn 16*, pp. 884-893, 5 July 2016, Barcelona, Spain

[3] Chaianun Damrongrat, and Mitsuru Ikeda. "Ontology Based Simulation Framework: Studying of Human Behavior Changes Impacted by Accessibility of Information under Building Fire Emergency", In *International Conference on Distributed, Ambient, and Pervasive Interactions,* pp. 253-261, Springer, Charm, 27 June 2014, Crete, Greece

[4] Chaianun Damrongrat, Hideaki Kanai, and Mitsuru Ikeda. "Increasing Situational Awareness of Indoor Emergency Simulation using Multilayered Ontology-Based Floor Plan Representation", In *Proceedings of the 15th Interconference on Human Interface and Management of Information: Information and Interaction for Health, Safety, Mobility and Complex Environments Volume Path II*, pp. 39-45, Springer-Verlag, 21 July 2013, Las Vegas, USA

- ***Others***

[5] Chaianun Damrongrat, Hideaki Kanai, and Mitsuru Ikeda. "Multilayered of Ontology-Based Floor Plan Representation for Ontology-Based Indoor Emergency Simulation", In *The 2nd Joint International Semantic Technology Conference, JIST 2012*, Nara, Japan, December 2012, Poster and Demonstration Proceedings, pp. 13

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APPENDIX A. DECISION-MAKING RULES

```
# ==============================
# 0       UTILITY
# ==============================
distance_to_exit
   use distance_to_exit($agent, $path, $dist)
   when
      situation.considering_person($agent, $path)
      situation.there_is_exit($path, $dist)

distance_to_handi
   use distance_to_handi($agent, $path, $dist)
   when
      situation.considering_person($agent, $path)
      situation.there_is_handi($path, $dist)

# ==============================
# 3       CRITERIA
# ==============================

#   ----------------------
#   3.1 SIMILAR DISTANCE
#   ----------------------
handi_fire_similar_distance
   use handi_fire_similar_distance($agent, $path)
   when
      situation.there_is_handi($path, $h_dist)
      situation.there_is_fire($path, $f_dist)
      situation.accept_range($agent, $range)
      check abs($f_dist - $h_dist) <= (4-$range)

fire_handi_similar_distance
   use fire_handi_similar_distance($agent, $path)
   when
      handi_fire_similar_distance($agent, $path)

handi_exit_similar_distance
   use handi_exit_similar_distance($agent, $path)
   when
      situation.there_is_handi($path, $h_dist)
      situation.there_is_exit($path, $e_dist)
      situation.accept_range($agent, $range)
      check abs($e_dist - $h_dist) <= $range

exit_handi_similar_distance
   use exit_handi_similar_distance($agent, $path)
   when
      handi_exit_similar_distance($agent, $path)
```

```
fire_exit_similar_distance
   use fire_exit_similar_distance($agent, $path)
   when
      situation.there_is_fire($path, $f_dist)
      situation.there_is_exit($path, $e_dist)
      situation.accept_range($agent, $range)
      check abs($e_dist - $f_dist) <= (4-$range)

exit_fire_similar_distance
   use exit_fire_similar_distance($agent, $path)
   when
      fire_exit_similar_distance($agent, $path)

#   ------------------------------
#   3.2 POSSIBLE ESCAPING/HELPING
#   ------------------------------
possible_to_escape
   use possible_to_escape($path)
   when
      situation.there_is_exit($path, $e_dist)
      situation.there_is_fire($path, $f_dist)
      situation.exit_fire_distance($path, "closer")

possible_to_escape_2
   use possible_to_escape($path)
   when
      situation.there_is_exit($path, $e_dist)
      situation.there_is_no_fire($path)

possible_to_help
   use possible_to_help($path)
   when
      situation.there_is_handi($path, $h_dist)
      situation.there_is_fire($path, $f_dist)
      situation.handi_fire_distance($path, "closer")

possible_to_help_2
   use possible_to_help($path)
   when
      situation.there_is_handi($path, $h_dist)
      situation.there_is_no_fire($path)

# ==============================
# 5        PREDICTION
# ==============================

#   ------------------------------
#   5.1 RISK ESCAPING ESTIMATION
#   ------------------------------
risk_escaping_is_low
```

```
   use risk_escaping_is_low($agent, $path)
   when
      situation.considering_person($agent, $path)
      possible_to_escape($path)
      notany
         exit_fire_similar_distance($agent, $path)

risk_escaping_is_low_2
   use risk_escaping_is_low($agent, $path)
   when
      situation.considering_person($agent, $path)
      possible_to_escape($path)
      situation.there_is_no_fire($path)


risk_escaping_is_a_little_dangerous
   use risk_escaping_is_a_little_dangerous($agent, $path)
   when
      situation.considering_person($agent, $path)
      possible_to_escape($path)
      exit_fire_similar_distance($agent, $path)

risk_escaping_seems_dangerous
   use risk_escaping_seems_dangerous($agent, $path)
   when
      situation.considering_person($agent, $path)
      situation.there_is_fire($path, $f_dist)
      situation.there_is_exit($path, $e_dist)
      situation.fire_exit_distance($path, 'closer')

#   ------------------------------
#   5.2 RISK HELPING ESTIMATION
#   ------------------------------
risk_helping_is_low
   use risk_helping_is_low($agent, $path)
   when
      situation.considering_person($agent, $path)
      possible_to_help($path)
      notany
         handi_fire_similar_distance($agent, $path)

risk_helping_is_low_2
   use risk_helping_is_low($agent, $path)
   when
      situation.considering_person($agent, $path)
      possible_to_help($path)
      situation.there_is_no_fire($path)

risk_helping_is_a_little_dangerous
   use risk_helping_is_a_little_dangerous($agent, $path)
```

```
    when
        situation.considering_person($agent, $path)
        possible_to_help($path)
        handi_fire_similar_distance($agent, $path)

risk_helping_seems_dangerous
    use risk_helping_seems_dangerous($agent, $path)
    when
        situation.considering_person($agent, $path)
        situation.there_is_handi($path, $h_dist)
        situation.there_is_fire($path, $f_dist)
        situation.fire_handi_distance($path, 'closer')

#   -----------------------------
#   5.3 HELPING EFFORT ESTIMATION
#   -----------------------------
take_no_effort
    use take_no_effort($agent, $path)
    when
        situation.considering_person($agent, $path)
        situation.there_is_handi($path, $h_dist)
        situation.there_is_exit($path, $e_dist)
        situation.handi_exit_distance($path, 'closer')

take_some_effort
    use take_some_effort($path)
    when
        situation.considering_person($agent, $path)
        situation.there_is_handi($path, $h_dist)
        situation.there_is_exit($path, $e_dist)
        situation.handi_exit_distance($path, 'further')

take_a_little_effort
    use take_a_little_effort($agent, $path)
    when
        situation.considering_person($agent, $path)
        take_some_effort($path)
        handi_exit_similar_distance($agent, $path)

take_big_effort
    use take_big_effort($agent, $path)
    when
        situation.considering_person($agent, $path)
        take_some_effort($path)
        notany
            handi_exit_similar_distance($agent, $path)

# ================================
# 6       SELECTION
# ================================
```

```
#   -------------------------
#   6.1  RISK ACCEPTATION
#   -------------------------
#       escaping risk
#
risk_escaping_acceptation__rational
   use risk_escaping_acceptation($agent, $path)
   when
      situation.in_rational_state($agent)
      risk_escaping_is_low($agent, $path)

risk_escaping_acceptation__selfish
   use risk_escaping_acceptation($agent, $path)
   when
      situation.in_selfish_state($agent)
      risk_escaping_is_low($agent, $path)

risk_escaping_acceptation__brave
   use risk_escaping_acceptation($agent, $path)
   when
      situation.in_brave_state($agent)
      risk_escaping_is_low($agent, $path)

risk_escaping_acceptation__brave_2
   use risk_escaping_acceptation($agent, $path)
   when
      situation.in_brave_state($agent)
      risk_escaping_is_a_little_dangerous($agent, $path)

#
#       helping risk
#
risk_helping_acceptation_rational
   use risk_helping_acceptation($agent, $path)
   when
      situation.in_rational_state($agent)
      risk_helping_is_low($agent, $path)
      notany
         take_big_effort($agent, $path)

risk_helping_acceptation_selfish
   use risk_helping_acceptation($agent, $path)
   when
      situation.in_selfish_state($agent)
      risk_helping_is_low($agent, $path)
      take_no_effort($path)

risk_helping_acceptation_brave
   use risk_helping_acceptation($agent, $path)
```

```
   when
      situation.in_brave_state($agent)
      risk_helping_is_low($agent, $path)

risk_helping_acceptation_brave_2
   use risk_helping_acceptation($agent, $path)
   when
      situation.in_brave_state($agent)
      risk_helping_is_a_little_dangerous($agent, $path)
      notany
         take_big_effort($agent, $path)

#    -----------------------------
#    6.2  CANDIDATE PATH
#    ------------------------------
top_candidate_path
   use top_candidate_path($agent, $path)
   when
      risk_escaping_acceptation($agent, $path)
      risk_helping_acceptation($agent, $path)

candidate_path
   use candidate_path($agent, $path)
   when
      risk_escaping_acceptation($agent, $path)
      notany
         risk_helping_acceptation($agent, $path)


candidate_path_2
   use candidate_path($agent, $path)
   when
      risk_helping_acceptation($agent, $path)
      notany
         risk_escaping_acceptation($agent, $path)

ignored_candidate_path__no_exit_no_handi
   use ignored_candidate_path($agent, $path)
   when
      situation.considering_person($agent, $path)
      situation.there_is_no_exit($path)
      situation.there_is_no_handi($path)

ignored_candidate_path__next_to_fire
   use ignored_candidate_path($agent, $path)
   when
      situation.considering_person($agent, $path)
      situation.there_is_fire($path, 1)

the_rest_path
   use the_rest_path($agent, $path)
```

```
    when
        situation.considering_person($agent, $path)
        notany
            top_candidate_path($agent, $path)
        notany
            candidate_path($agent, $path)
        notany
            ignored_candidate_path($agent, $path)


#   -----------------------------
#   6.3  THE BEST IN CANDIDATE
#   -----------------------------
#   thinking about implement it python

best_path_helping_intention__top_candidate
    use best_path_helping_intention__top_candidate($agent, $path)
    when
        top_candidate_path($agent, $path)
        situation.there_is_handicapped($path, $h_dist)
        has_helping_intention($agent)
        forall
            top_candidate_path($agent, $other_path)
            check $path != $other_path
            situation.there_is_handicapped($other_path, $other_dist)
            check $h_dist < $other_dist

best_path_escaping_intention__top_candidate
    use best_path_escaping_intention__top_candidate($agent, $path)
    when
        top_candidate_path($agent, $path)
        situation.there_is_exit($path, $e_dist)
        has_escaping_intention($agent)
        forall
            top_candidate_path($agent, $other_path)
            check $path != $other_path
            situation.there_is_exit($other_path, $other_dist)
            check $e_dist < $other_dist

best_path_helpling_intention__candidate
    use best_path_helping_intention__candidate($agent, $path)
    when
          candidate_path($agent, $path)
          situation.there_is_handicapped($path, h_dist)
          has_helping_intention($agent)
          notany
              top_candidate_path($agent, $path)
          forall
              candidate_path($agent, $other_path)
              check $path != $other_path
```

```
            situation.there_is_handicapped($other_path, $other_dist)
            check $h_dist < $other_dist


best_path_escaping_intention__candidate
   use best_path_escaping_intention__candidate($agent, $path)
   when
        candidate_path($agent, $path)
        situation.there_is_exit($path, e_dist)
        has_escaping_intention($agent)
        notany
           top_candidate_path($agent, $other_path)
        forall
            candidate_path($agent, $other_path)
            check $path != $other_path
            situation.there_is_exit($other_path, $other_dist)
            check $e_dist < $other_dist

best_path_helpling_intention__ the_rest_path
   use best_path_helping_intention__ the_rest_path($agent, $path)
   when
        the_rest_path ($agent, $path)
        situation.there_is_handicapped($path, h_dist)
        has_helping_intention($agent)
        notany
           top_candidate_path($agent, $other_path)
        notany
           candidate_path($agent, $other_path)
        forall
            the_rest_path ($agent, $other_path)
            check $path != $other_path
            situation.there_is_handicapped($other_path, $other_dist)
            check $h_dist < $other_dist

best_path_escaping_intention__ the_rest_path
   use best_path_escaping_intention__ the_rest_path($agent, $path)
   when
        the_rest_path ($agent, $path)
        situation.there_is_exit($path, e_dist)
        has_escaping_intention($agent)
        notany
           top_candidate_path($agent, $other_path)
        notany
           candidate_path($agent, $other_path)
        forall
            the_rest_path ($agent, $other_path)
            check $path != $other_path
            situation.there_is_exit($other_path, $other_dist)
            check $e_dist < $other_dist
```

```
best_path_helpling_intention__ ignored_candidate_path
   use best_path_helping_intention__ ignored_candidate_path($agent, $path)
   when
        ignored_candidate_path ($agent, $path)
        situation.there_is_handicapped($path, h_dist)
        has_helping_intention($agent)
        notany
           top_candidate_path($agent, $other_path)
        notany
           candidate_path($agent, $other_path)
        notany
           the_rest_path($agent, $other_path)
        forall
            ignored_candidate_path ($agent, $other_path)
            check $path != $other_path
            situation.there_is_handicapped($other_path, $other_dist)
            check $h_dist < $other_dist

best_path_escaping_intention__ignored_candidate_path
   use best_path_escaping_intention__ignored_candidate_path ($agent, $path)
   when
        ignored_candidate_path($agent, $path)
        situation.there_is_exit($path, e_dist)
        has_escaping_intention($agent)
        notany
           top_candidate_path($agent, $other_path)
        notany
           candidate_path($agent, $other_path)
        notany
           the_rest_path($agent, $other_path)
        forall
            ignored_candidate_path($agent, $other_path)
            check $path != $other_path
            situation.there_is_exit($other_path, $other_dist)
            check $e_dist < $other_dist
```