CHAPTER 2
Literature Review

Since this new research approach to stimulating creativity thinking is based on an interdisciplinary background, we will review several subjects related to this work. These topics include creativity theory, Collaborative Support Computer Learning (CSCL), epistemic game, and bounded rationality.

2.1 Theoretical background of creativity

Many researchers have proposed various models of creativity. Many psychologists consider that creativity is an individual's intra-psychic process. However, after a longitudinal research [18], researchers found that many creators with amazing creative talent did not pursuit the production of creation eventually while somehow other creators still insisted on their creations that turned out to be important achievement. On the other hand, Stein [39][40] and Simonton [37][38] observed that the economic, society, and political events had a large effect on the production of creativity. Hence, we think environmental factors are important when we observe the happenings of the invention.

Csikszentmihalyi [5] argued that the social nature of creativity should include identifying social benefits from the consultations of other domain experts, emotional supporters, and the dissemination within the field. He mentioned that individual creativity can not leave the society alone. As a result, he proposed a system view of creativity, as shown in Figure 2-1. In his explanation, the Domain means culture, symbolic system, and the composition of different subjects and the Field denotes society, public opinion and same generation. The individual also plays an important role in the creating process because each individual has different personality, background and latent energy. The interactions among these three factors compose the system model of creativity and make the creativity happen more easily. The individual can learn specific knowledge and professional rules from the Domain and re-create the content from the Domain with his innovative thinking, and finally examine this invention in the Field.

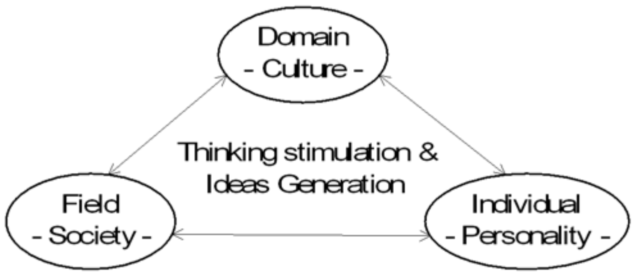

Figure 2-1: Csikszentmihalyi's model of creativity [5]

Csikszentmihalyi also suggested that the best state for creativity was the flow state [6]: “The flow is the mental state of operation in which the person is fully immersed in what he or she is doing, characterized by a feeling of energized focus, full involvement, and success in the process of the activity.” In addition, he agreed that a group could work together and each individual member could be in the flow state. However, how to make people go into the flow state or enhance their intention for certain task is another issue. The form of game we will describe in the next section shed some lights on how to achieve it.

2.2 Game for learning

In general, an interesting game can make people, especially for children or students, engage in playing like the flow state we mentioned in the last section. Thus, it is reasonable to exploit the form of a game to support creativity thinking.

“Play is the beginning of knowledge,” anonymous said. Not only for fun, but also for learning or creativity thinking, there is a new form of the game, named *Epistemic Game*. Collins [9] explained that in this game they really involve the construction of new knowledge or concept and play to make sense of phenomena in the real world.

Furthermore, Shaffer [33] leads epistemic game into the computer world. He described it as the way to make students learn to think like professionals through engaging practical activities and action-based learning experience. Many game-based learning approaches [32] suggest that computer game is helpful not only for enhancing students' intention but also for knowledge or ability learning.

Much research has been done on game-based learning by computer support, but few studies have been done on the game-based support environment for creativity thinking ability. That is what we would like to contribute to this field. Especially, we consider that the concentration and skill learning from the property of the game can facilitate creativity thinking ability. We will describe the computer support environment for creativity learning in next section.

2.3 Computer support collaboratively for creativity learning

An ideal human-computer interaction should make a user not only be more productive, but also be more innovative [33]. Designing tools to support creativity production is becoming a popular research topic in recent years. A core issue in supporting creativity production is how to design intriguing activities that can uncover the creative mind of the user and to increase the potential of a user in creative thinking.

The development of computer software or system to support creativity is not a clearly defined task because we know the creativity is an intangible human mind for creation. There are still many researchers, scientists, and developers pursuing this vague goal started a long time ago. Here, we will introduce some of them in the following subsections as the foundation of our research.

2.3.1 Group Support System

Many studies in creativity were conducted in the field of Group Support Systems (GSS) [17]. GSS is considered as an effective technology to generate ideas of a greater quantity. Bostrom [2] suggested four important factors to consider when designing GSS: *Person, Proc-*

ess, *Press*, and *Product*, as shown in Figure 2-2. They also have developed a measure for creativity evaluation.

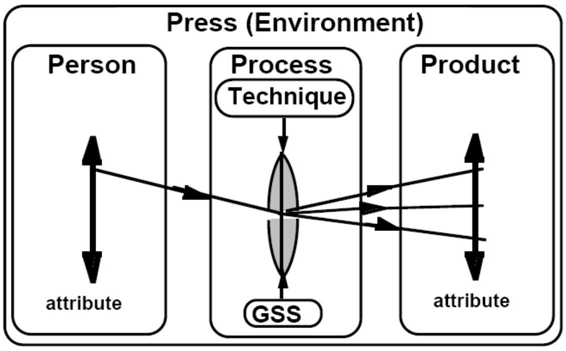

Figure 2-2: GSS-Creativity research model [2]

The measure was based on Paradigm-Relatedness, which includes *Paradigm-Preserving* (PP) and *Paradigm-Modifying* (PM) thinking. According to Bostrom's explanation, PP concept denotes that people think within the bounds of the problem context, and PM concept denotes that their thinking shifts away from the context. Alternatively, we can say that PM concept is a divergent way of thinking for solving a problem.

Guilford [19] considered that the most popular form of creativity is the divergent thinking ability. Hence, how to enhance the divergent thinking ability is an important issue in creativity learning. However, in Bostrom's experiments, they found that GSS are more advantageous to support the generation of PP ideas than the PM ideas. We think that this is a main drawback that the current GSS tools should be improved.

Functional design of GSS is another issue that needs to be considered in designing an effective system for supporting creativity production. GSS can roughly be separated into two types: *informative* and *communicative*. The information type focuses on the way of information sharing for supporting each other, and the communication type highlights the function of immediate communication or opinion exchanging. Ocker's study [30] compared these two types of GSS with a computer conferencing system and a issue-based information system. He found that the team using the computer conferencing system produced more creative solutions than the other team using the issue-based information system. This result suggests that the immediate communicative system in GSS should be able to assist users in producing more creative solutions, or we can infer that instant interaction and feedback is helpful for divergent thinking in a group.

2.3.2 Creativity Support Tool

Many methods for fostering creative work have been proposed, and these methods include brainstorming, free association and lateral thinking [13]. Couger [11] reviewed these "creative problem solving methodologies" and generalized a plan with five phases:

- opportunity, delineation, problem definition;
- compiling relevant information;
- generating ideas;
- evaluating, prioritizing ideas; and
- developing an implementation plan.

However, we need a practical framework to build this type of support system. A report [35] sponsored from a U.S. National Science Foundation declared that creativity support tools is a research topic with high risk but potentially very high payoff. "*The goal of designing creativity support tools is to make more people more creative more often, enabling them to successfully cope with a wider variety of challenges and even straddle domains*", Shneiderman [34] said. He also proposed a framework [33] of creativity production focusing on software implementation in support of the following four activities:

- collect: searching digital libraries and visualizing data and processes,
- relate: consulting with peers and mentors,
- create: thinking by free associations and exploring solutions,
- donate: disseminating results.

With this framework, we can have a clearer view of how to define good creativity support tools: it is a tool for peers to collect useful information, consult with cross-disciplinary teams, produces new ideas in a two-way communication with others, and then continuously disseminates these ideas. It needs to be able to support the application of domain knowledge, finding related information, and providing collaborative stimulation and thinking.

Although this kind of information system may benefit users in exchange of ideas, it may also bring up another problem, which is *Information Entropy* (i.e., the uncertainty of the information), because the abundant information from all directions surpass human's capacity in thinking. This is called the *Bounded Rationality*, as defined by Herbert Simon. We will discuss it further in the next subsection.

2.3.3 Bounded Rationality

In an unstructured knowledge creation environment, Cyert [12] regarded that in the thinking process, people only have sequential and limited attention and processing capability toward goals and sub-goal. The notion of local rationality, or bounded rationality was employed to describe this circumstance. According to Herbert Simon's explanation [36], people have only finite resource and time to find a satisfying path, not the optimal, and it will permit satisfaction at certain situation. It causes people's inability to handle all expectations over future states, and inability to utilize all information that had been received.

We argue that the current technologies developed for large-scale information retrieval (IR) (e.g., web searching) are still far away from an ideal supportive artifact for creativity. How the system provides user- and context-sensitive supports, and how we factor out the task characteristics are all key issues in dealing with bounded rationality [36], which are underemphasized in the current IR systems.

Therefore, we need a mechanism to help a user with bounded rationality to focalize when he faces an unstructured problem. On the one hand, it may be solved by designing good user interface. For example, the Hyperlink structure of the internet is a good strategy for browsing information because you always view only tolerable articles on one page and then see more when you click on the links for other information.

On the other hand, current artificial intelligent (AI) technology can also provide a solution to solve this problem. Some of technologies like Data Mining, User Modeling or Machine Learning are usually used as the information filter to hide useless information and present only essential messages to the users. For example, the email filing technology, aims to remove the messages that the users do not want and only keep the useful information for them. Thus, it is possible to build a user- and context-sensitive system in order to reduce information noise for creativity thinking support.

2.4 Pervious and related study

Based on our previous works [3] in this series, we have investigated theoretical and empirical students' Creativity Problem-Solving (CPS) ability in sciences, and designed a paper-based assessment for CPS [47]. That is an important foundation for us to explore creativity.

In order to support creativity thinking by computer, we have adopted some IR technologies to develop related systems. For example, the User Problem-Solving Ability Modeler (UPSAM) [43] was designed to depict user profile for abstracting and modeling students' ideas and responses in scientific problem-solving tasks. For building user profile, we use a modeling framework that adopts a semi-structure format with a pair structure of ideation and explanation for the students to write the answers. By the ideation-explanation model, we can explore student's ideas and the reasons in support of the ideas.

We have developed an automated scoring system by comparing the user model within the semi-structure format between experts and students [44]. For evaluating the scoring system, we have built an online version of it to collect students' answers directly and tested the reliability of the automated scoring ability of the system. By comparing the results between automated scorer and two human graders, the result revealed that the Pearson's correlation *r* achieves .87 and .92, which indicated a high and positive correlation [20].

Based on these studies, we also have developed another system for idea generation which is called Virtual Brainstorming Agent (or VIBRANT for short) [45]. VIBRANT is an automated tutoring system that brainstorms with students to support problem solving and presented like an automatic MSN robot that chats with students in an MSN conversation. We have acquired some results of collaborative idea generation in scientific inquiry, and these results give us a direction [46] to develop other collaborative creativity support tools.

Comparing with VIBRANT, we initiate a new research line for a different purpose. The new design of creativity support tool pays more attention to enhancing user's intention and generating divergent thinking [22]. In this work, we will utilize the principles of collaborative support, game-based learning environment, and the design of creativity support tool, to propose a new form of creative thinking support system as described in the next chapter.