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A Comparative Study of Relay Thinking Activities in Degree and Secondary Level Students

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"Relay thinking" was first piloted at two Hong Kong tertiary institutions, with students required to generate ideas through relay thinking in order to solve problems. To explore applicability and compare the possibilities and limitations of relay thinking at different levels, a comparative study was carried out. In the study, two groups of secondary level design and technology students, along with two groups of university industrial design students, were selected to use relay thinking in generating design ideas to solve a problem. The study did not aim at problem solution, but simply at the experience of relay thinking. In this paper, the idea behind relay thinking is briefly described, and the results of the two sets of student activity are discussed. The discussion focuses on three major aspects: (a) the students' experience, (b) the settings and requirements of the relay thinking activities, and (c) the students' performance. The study indicates that relay thinking is suitable for both levels, and that it provides an alternative individual and group thinking experience for students, though modifications to the thinking activities for the two levels are necessary, and there are different problem requirements.

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Basic Concepts of Relay Thinking

It is quite common in industry that problems are tackled in groups. Thus, group thinking experience is important for students, particularly design students. However, group thinking also has its limitations and disadvantages. Besides the difficulties in organising and managing group working activities, generating ideas and fresh directions is another major limitation of group thinking. As mentioned by de Bono (1993), "individuals are much better at generating ideas and fresh directions" (p. 41), and "people do enjoy working in groups and usually feel they have achieved much more than they really have . . . but groups are very slow" (p. 229). Other scholars also agree that creating initial and raw ideas under group conditions takes up a lot of time in communication but not thinking (Belbin, 1993; Bligh, 1986; Smith & Arinsworth, 1989). This situation is more obvious when the group is large. By contrast, individuals working on their own can look at lots of different possibilities (Smith, 1986). There is no need either to talk or listen most of the time (de Bono, 1993).

To try to gain the double advantages of individual thinking and group working, "relay thinking" borrows the basic concept of the relay race, and modifies its type of co-operation for use in "group thinking" projects (Siu, 1998). By following the features of a relay race, a small number of people (that is, three to five) get together to solve a problem within a period of time. Unlike in traditional group thinking activities, not all of the group members start to think about the problem or generate ideas right from the beginning (or even at the same time). Instead of trying to solve it by group discussion or individually, the problem is tackled by a group/team. In relay thinking, one member starts to think and generate ideas alone after receiving the outline of the problem. After a pre-set period of time (each pre-set period of time is roughly equal to the entire solution-required-time divided by the number of members), another member takes up the first member's

duty and continues to develop the ideas-and so on, with the individual ideas passed from one to the other, and the last member proposing the final decision/solution. The nature and concept of relay thinking can be summarised as follows (see Siu, 1998):

Same Goal

In Effective Group Discussion (1989), Brilhart states that a good set goal gives us a clear direction in thinking, and an equally clear definition and scope to work with, although many good ideas are created unintentionally and fortuitously. Some may argue that a predetermined scope decreases flexibility in thinking. However, in a practical working environment, we are always requested to generate ideas according to goals. Particularly when we are working in groups, a clearly defined goal can minimise argument among group members and shorten the time for idea development (Couger, 1995; Gulley, 1972; Jones, 1980).

As stated earlier, in relay thinking, ideas are generated by individuals working independently at different periods of time. Idea transmission happens only between two group members at a time. Without a well-defined final target or goal, a relatively longer period is necessary for the time allowed for communication, and there may also be misinterpretations and misunderstandings (Brilhart, 1989; Phillip, 1986; Prince, 1970). Therefore, before starting to generate ideas in relay thinking, the expectations of the thinking activities need to be clarified. This means that all the group members should clearly understand the targets and goals at the beginning, though some of them may not start their own work.

Started and Continued by Individuals

At the beginning of the idea generation process, one member of each group works as the "originator." Once he or she receives the problem, then work can start. Each originator can think individually and creatively when and where they want. In relay thinking, there are no limitations or constraints on the originator: they can start off in any direction, and approach the problem

using any method they like. The only requirement is to aim for the final goal.

Building on Ideas

Individuals are much better at initiating ideas and opening up new directions. Groups, however, may have an advantage once the idea has been initiated (de Bono, 1993). The members of the group may be able to flesh out the new idea and also develop it in directions that might not have been considered by the originator of the idea. In brief, another person can enrich the ideas, and a team can turn them into something really useful.

Adair (1990) elaborates his team creativity approach and the concept of "building on ideas" by using American football as an example. He points out that waiting and listening for ideas is fundamental to the success of teamwork. When team members see an idea, they do not shoot it down. If they see some merit in it, they will build on it. The idea-generating or working environment is like a game of football, with a "touch-down" being scored at the bottom end.

Adair's method was tried three times with design and technology students in three secondary schools during 1995 and 1996, with results indicating that students could be stimulated to discuss and build on ideas. However, during the discussions, students always liked to "build" their own ideas without listening carefully to others first, and without waiting for their team-mates to finish their explanations. Rather than each group member waiting for the "ball-holder" to pass the ball, it might be better to say that each member expected to take the ball and touch it down in his/her own way. Students also pointed out that the atmosphere was not conducive to concentration, particularly when they were creating new ideas.

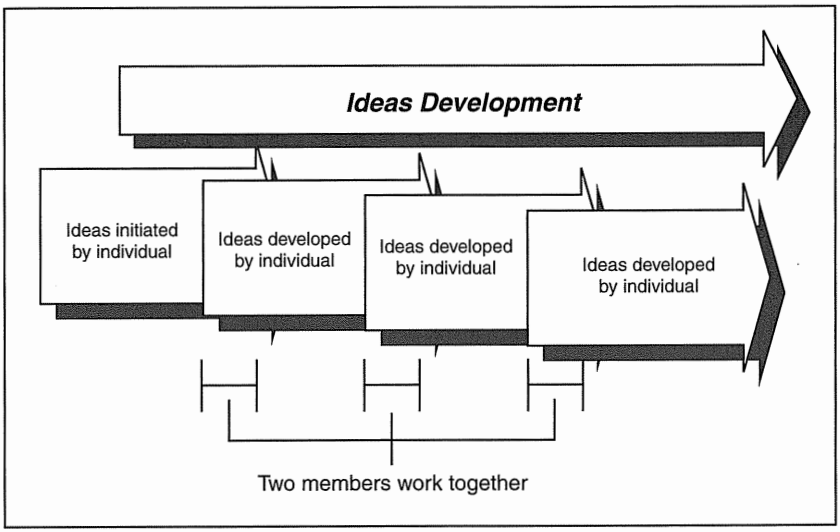
Relay thinking, however, allows individuals more personal time to generate ideas without disturbance. Although their ideas are still built on others' ideas, they are individually controlled. This organised manner does not imply the addition of more constraints; quite the contrary, more freedom of elaboration and thinking is available in each individual thinking period.

The time for communication is only at the moment when one group member passes their idea to another.

Smooth Transition and Continuing Movement

Relay thinking is different from individual or traditional group thinking. In relay thinking, neither of these thinking methods (individual and group) appears by itself. They are iterated all the time (see figure 1).

Figure 1 Relay thinking process (Siu, 1998)



In a relay race, before passing the baton, a runner keeps his or her speed going. At the same time, the next runner is also moving. This means that two people are sometimes running together. The main concern at that point in time is to have a "smooth" transition and a "continuing" movement. When the second runner starts to receive the baton, that is the time for him or her to start running at his or her fastest speed. In the same way, in relay thinking, the first group member, after individually developing his/her ideas, tries to "develop" and "share" those ideas with the second member in the last portion of allotted time. At that point, neither works alone, and idea development is proceeding. However, the second member is not allowed to start idea

generation in a new and different way, but must follow the first person's direction of thought. The main function of this transition period is to allow the second member to fully understand the developed ideas and then continue their development — building on ideas individually. This form of transmission will continue until either the goal is met or the time limit reached.

Without Rigid and Fixed Thinking Methods

Relay thinking is not a way of thinking but a process. During individual idea development or thinking, each person may use his/her favourite method of generating ideas, such as traditional logical vertical thinking, or lateral thinking (de Bono, 1971). The only constraint is that they are not encouraged to discuss their thought processes with anyone else until they move into the transition period.

Relay thinking not only allows more time for individual idea development, it also allows a freer atmosphere and environment in which each person can start to develop his/her thinking at any time and on any occasion. Certainly, the freedom to think is not laissez-faire. During relay thinking activities, group members need to follow a time schedule in order to pass their ideas or insights on to the next member.

Method

To explore applicability and compare the possibilities and limitations of relay thinking at different levels, a comparative approach of study was adopted. Two groups of secondary 4 design and technology students from a grammar school, and two groups of industrial design degree students from The Hong Kong Polytechnic University were invited to use relay thinking to solve an identical pre-set problem. Each group consisted of four students. As more than 99 percent of design and technology students in Hong Kong are boys, only male industrial design students were selected at the university. (The limitation of this selection is discussed in later paragraphs.) The reason for selecting students from these two subjects and two levels was that the

subject natures were quite similar, and the students from these two levels already had experience in individual idea generation in the subjects.

The problem that the students were given was to design a bottle opener for a disabled adult whose forearms were missing. The problem allowed different difficulties to come up, and room for the two different levels of students to think. They were required to think about the solutions in as detailed a way as possible and did not have to submit working drawings, only sketches.

Each student was given one-and-a-half hours for their own thinking, and 15 minutes for the transition period (for the time arrangement, see figure 1). In order to control the time accurately, prevent the students taking the problem home to discuss with other people (as another form of group discussion), and so that the evaluation could be done right after the thinking activities, the activities were scheduled for conclusion all on the same day, working from 9:00 a.m. to 3:45 p.m. (90 min x 4 + 15 min x 3).

Before starting, the students were introduced to the structure and procedures of relay thinking. The reasons for them to use it to solve the problem were not explained, so that their attitude and performance would not be affected.

The thinking activities were conducted at the students' own school or university. For rigid time control, rooms were provided for the students during the transition periods, and they had to pass on their ideas in those rooms within the given period of time. While they were thinking on their own, they could use the provided rooms or any other place that they felt they could work (inside the school or the university); the only requirement was that they had to return to the provided rooms on time, in order to pass on their ideas.

During the thinking activities, the performance of the students was observed, and at the end, each group of students was gathered together and interviewed. The objective of the observations and interviews was not to evaluate the success of the outcome (that is, the final solution(s) for the provided problem), but to seek an understanding of the students' performance

during the thinking activities, and the students' comments on their experience of relay thinking. This was not explained to the students before they finished their thinking activities, however, so that they would concentrate on thinking about the problem itself, rather than evaluating the advantages and limitations of relay thinking while they were using it to work on their problem.

The data collected in the observations and interviews, and then later for analysis, can be classified by three major aspects:

(a) the students' experience: the performance and response of students with respect to their previous experience in individual thinking, group work, and integrated individual and group thinking experience;
(b) the settings and requirements of the relay thinking activities: the performance and response of students with respect to the environment and time for the thinking activities, and the number of group members;
(c) the students' performance: the performance of the students in different stages of relay thinking — idea initiation, idea development, and idea transmission.

Results

Limitations of the Study

Two limitations of this study should be noted. Because of the practical constraints stated above, all of the selected students were boys, which means that there is no indication that girls would respond in the same way. However, the study should generate some ideas on how we could structure and prepare a relay thinking activity for students so that they can benefit from it. Another limitation is that all of the students were working with people that they knew (colleagues), and it does not show how they might work with strangers. Both of these limitations suggest that further study is necessary.

Students' Experience

Experience in individual thinking and group work

The secondary students pointed out that they seldom had any other kind of group thinking experience besides some common and limited group working

experience (that is, group project without specified roles for individual members). In fact, group thinking amongst design and technology students in Hong Kong is limited to class discussion led by teachers. Students generally only respond to questions posed by teachers. Group thinking and discussions conducted by students themselves are rare in design and technology lessons (Siu, 1994). Group projects are also seldom incorporated into the design and technology curriculum, and only sometimes in extra-curricular activities (Siu, 1998). Without regular and well-planned group discussions or thinking activities, students need more time for group project activities once they reach higher level learning. As Prince (1970) reminds us in *The Practice of Creativity*, this kind of limitation stunts the development of their ideas when tackling problems.

The degree students already had group discussion experience. They said, however, that the main purpose of past group discussions had been data collection and information gathering (such as brainstorming), or progress reporting. They all agreed that group discussion was ineffective for in-depth idea development, although it might create more inspiration, and allow a more objective decision.

Experience in relay thinking

All four groups of degree and secondary students said that it was the first time they had integrated individual and group thinking in such a way. All of them agreed that this "alternative" thinking process was new for them, and that it had created *excitement* — motivating them to tackle the problem. They would like to use relay thinking again, or try to use it in their group projects, but agreed that it might not be so exciting the next time. They might use it as an alternative thinking process.

Although both the degree and secondary students agreed that relay thinking was not complicated and that it was easy for them to handle, some of the secondary students experienced some difficulty in understanding the process, particularly the transition period. More time was therefore spent explaining the regulations to the secondary students. Therefore, more time

should be given to the relay thinking transition period, particularly for students who are at a lower level in their studies and do not have much experience of teamwork or idea transmission. As agreed by most of the secondary students, opportunity for group discussion should be provided for them, and it should be conducted in a more organised and meaningful way, so that it allows not only data collection, but also in-depth thinking.

Settings and Environment

Location and environment

As stated by many scholars and thinkers, environment is a significant factor affecting the quality of thinking (see Dacey, 1989; LeBoeuf, 1994; Ruggiero, 1995; Scott, 1995). In the same way, the environment (for example, location, setting, choice, relaxibility, comfortability) is a considerable factor in this study, that is, whether it affects the students' performance in relay thinking. In this study, the initial intention behind asking the students to do the relay thinking task in their school or university was so that they would be working in a familiar environment. The rooms that they were provided with also had good facilities and ventilation. The observations during and the interviews after the activities aim at exploring whether the environment affected the performance of students in relay thinking, and how they responded to the environment provided.

Amongst the secondary students, only one student went to the basketball court to do his individual thinking, and even he came back to the provided room after approximately half-an-hour. His reason was: "I want to find a better table." Although the students were told that they need not submit neat working drawings, and that they could pass their ideas to their group members in any form, the secondary students still wanted tables to help them sketch. They also said that, besides their homework, they were generally used to sitting around benches/tables when they worked at school.

Unlike most of the secondary students, seven out of the eight degree students insisted on not staying in the provided room while they were working alone, preferring to go to canteens or their usual places in their studios.

Their main reason was that they wanted a more "relaxed" thinking environment. One point to note is that some of the degree students stated that the provided room was good and well prepared. However, since it was specifically "prepared" and "assigned" as a place for thinking, it also implied "pressure" and looked like an examination hall. All of them agreed that a "comfortable" and "familiar" environment was a crucial factor in allowing them to think — but they also agreed that a new environment (one that was outside the university, for instance) might sometimes stimulate their thinking. They concluded that the choice of place for individual work was entirely subjective.

Whether being under pressure or in a relaxed atmosphere benefits the "productivity" of a designer is a question that still has to be answered, but six degree and eight secondary students pointed out that they preferred an environment without any "physical" and "psychological" pressure for them to think. On the other hand, most of the students commented that it might be better if they had been able to take the problem home to conduct their individual thinking. The secondary students added that they felt as though they were taking an examination, and could not get free of that feeling for long enough to develop their ideas.

However, the experience of one pilot study of relay thinking in 1995 came up with different results. In that study, the students were allowed to do their individual thinking at home. The results showed evidence that the students became "too relaxed," and were possibly not able to concentrate on their thinking at home, because it was full of distractions (Siu, 1998).

Although exploring the relationship between individual thinking and environment was not an objective of the current study, the 1995 results and those of this study both indicate that environment affects the performance of students in relay thinking, particularly the individual thinking portion. A more relaxed and comfortable environment may benefit thinking, but it may also result in loose time control, particularly for those who have problems with this anyway. Therefore, while relay thinking claims to allow group members to use their own thinking methods, it seems that an environment decided by the individuals themselves may benefit their individual thinking.

For the lower-level students, thinking should not be seen as a fixed task in a fixed physical and psychological setting — it should be arranged as a different, interesting opportunity for students to explore and experience.

Time

Besides environment, time is a crucial factor affecting thinking (Brilhart, 1989). Therefore, as relay thinking is an iterative mixture of individual thinking and ideas transmission between members, the time-length of each portion and the entire activity should be carefully considered. Whether time arrangements can be congruent to all levels of students, or students at different levels with different experience would respond differently to the time arrangements, and in turn how the arrangements should be in order to suit the students, is one of the key concerns in this study.

According to observation and the secondary students' comments, one-and-a-half hours was a little bit long for individual thinking, although they were familiar with exams that lasted for a long time. Some secondary students pointed out that they could not concentrate after about an hour. When they moved to the transition period, though, they could refocus their thinking and transmit their ideas to their co-workers.

Unlike the above feedback from the secondary students, all eight degree students thought that the thinking time was appropriate, claiming that they were able to concentrate for the whole allotted period of time. They added that taking a rest/break (and not working) did not imply a poor performance at the end, rather that "inspiration" might come suddenly, or a break might prevent them from going into a dead zone of idea development. For instance, two of them reported that they went to get some water and take a short break during their individual thinking time. They agreed that it could be advantageous (or at least not harmful) to their thinking. All of the degree students also reminded us that the appropriateness of the thinking time depended on the "difficulty" and "complexity" of the problem, and on the "final submission requirements" (such as the format of the drawings or the completeness of the ideas).

In this study, there was no strong evidence to prove that the concentration span of one type of student (degree or secondary level) was any better than the other. In fact, "time" is the most difficult factor to control in relay thinking, particularly when setting the correct length of time for individual thinking. The time arrangements not only depend on the concentration span of different age-groups, and the experience and training of the students, but also on the nature and difficulty of the problems and requirements, and, as mentioned above, the environment. As in the 1995 pilot study, some of the students (who were given one day for individual thinking) said that one day was too long, but some disagreed.

Both the degree and secondary students also stated that they could not concentrate on their work when there was a time limit on it. In general, a longer time may allow greater flexibility in thinking, and more chance to obtain outside stimulation — but, as mentioned earlier, it may also result in an uncontrolled thinking environment in which students would easily be distracted by other external items. Further, in the commercial and industrial world, deadlines usually depend on a client's requirements rather than the thinker's expectations. Thinking under time pressure is common.

Most of the students stated that a short period of time did not allow them to research and collect outside data. It also limited stimulation and resources for them to think. The degree students added that more time for the originators was very important, as it would benefit the development of the initial concept(s), which was in turn important for the development of the idea by the other group members.

Group members

As Adair (1990) and Belbin (1993) indicated with regard to group work, the number of members of a group/team, the combination and the arrangement of members' roles, and the personal characteristics of members are crucial factors for the success of group work.

Since relay thinking is a mixture of iterative activities of individual thinking and ideas transmission, whether the number of members — number

of repeated events of individual thinking and ideas transmission — affects the performance of students should be considered. According to the interview, all of the degree and secondary students were satisfied with the size of the group. All agreed that three to five was a good number.

The degree students pointed out that sometimes the number of members was not important as long as they were thinking alone. Based on past experience, they suggested that, if the group consisted of people from different disciplines, the result might be different, pointing out that design students might have better techniques in design, but that students/people from other disciplines might sometimes provide better ideas. Three and five degree students "strongly agreed" and "agreed" that ideas were more important than experience (but it should be noted that they still thought that experience was very important).

The secondary students did not come up with the idea of group members from other areas. When asked about bringing in people from other subjects (for example, art and design, home economics, and physical education), all of them agreed that it might be good, but seven of them could not see how it was important for solving the given problem — designing the bottle opener. They agreed that they could handle the problem in their group.

When the students were asked whether they minded working with people they didn't know, the degree students said that they didn't care one way or another, because they had already worked with students from other faculties. The secondary students responded that they might feel a little uncomfortable. Particularly referring to group work, they thought that they might get more effective results if they worked with people they knew. Three and five "strongly agreed" and "agreed" that they were the "most suitable" students in the school to design a bottle opener, because they had design experience.

Although this study cannot say whether or not people working in other areas would benefit from relay thinking, the results indicate that higher-level students take a more positive attitude to it than others. One of the main influencing factors is the students' previous experience of working in a group.

Students' Performance

Idea initiation

The originators in the two secondary groups felt uneasy about being the first thinker in the process. Although the thinking sequence was randomly arranged, two students originally selected asked not to be originators, saying that they felt pressurized.

For the degree groups, the two originators stated that they found no difficulty in initiating ideas. They felt no pressure, and believed that the other group members (their classmates) could handle and continue the idea development. They stated that they were familiar with individual thinking and working under time pressure, and could not see that there was any difficulty in any one of them being the originator.

In fact, the feelings and performance of the degree and secondary group originators were quite different. Although all of the students agreed that idea initiation was not an easy task, the originators in the degree groups did not feel any pressure about whether or not the ideas that they passed on were any good, or whether they had got off to a good start. However, the originators in the secondary school groups pointed out that they were afraid of how their colleagues would look at and comment on their ideas.

According to the results of a "ranking question" in the evaluation interview, seven out of eight secondary students thought that the originator was the "most important person" or "leader" in a group because they deeply believed that a good start was half the success. One secondary student said that the final thinker was the "most important," while seven said that the final member was the "second most important." The students took athletic relay races as their example, stating that, most of the time, the "best" and "most important" runners were the first and the final ones.

By contrast, all of the degree students stated that all group members were equally important, though they agreed that a good start could benefit the development of ideas. They pointed out that an initial idea might not be the only direction, but agreed with the secondary students that idea development greatly depended on the ideas coming from the originator.

Six of them did not agree that the final thinker should be seen as another "most important" person in the group, seeing that person simply as one group member. The only difference between the various members of the group was the "roles," not the "importance."

According to observation, the originators in the secondary groups spent a lot of time getting started. Even though the problem was not particularly difficult, the students said that they felt under a lot of pressure, as they knew that they had to pass on their ideas, and that their initial thinking would have a significant influence on the development of those ideas.

When starting off, the two secondary group originators started with only one or two ideas. They tended to develop this small nucleus of ideas, rather than coming up with more choices for the next person to work on. In contrast, the degree-group originators did not feel under as much pressure in their roles as first thinker. They spent most of their time coming up with a large number of ideas. They said that it might not be their usual way of tackling a problem, but as they knew in this case that their team-mates would be carrying on with the ideas, they preferred to present as much as they could to the next person. The degree students agreed that this way of thinking might help the other group members make decisions and develop the ideas, rather than if the ideas were limited right from the start.

These phenomena cannot significantly show which method of idea initiation is the best for relay thinking. They simply reflect the different methods or approaches to thinking among students of different grades, and also how the students saw their personal roles in a relay thinking group. Although roles had not been defined and discussed before the relay thinking work, and the students were not given time to discuss how each member should work, the study results indicate that the degree students paid more attention to the group working attitude than the secondary students did. The degree students realised and expected that the final solution would be reached "at the end" by whole group work rather than personal work (within their personal period of time). The originators preferred, as mentioned above, to set up a wider scope and initiate as many ideas as they could at the

beginning, in order to allow the other members to eliminate, compare, develop, and make decisions. The two originators also agreed that they did not intend to set a correct direction for their group-mates.

The secondary students expected to set up a clear direction at the beginning. The two originators believed that once a correct direction was set, their team could stay on the right track and develop and elaborate on their ideas. Although the two originators said that they did not think of their thinking as the "correct" one, they agreed that they had intended to finalise and pass on a correct direction for their colleagues.

Idea development

Instead of waiting for the chance to initiate, add to, or modify others' ideas, and to then listen, accept, or defend others' comments in a group discussion, relay thinking provides a much freer, easier and concentrated situation in which group members can develop their ideas individually. However, it also has limitations. During idea development (but not initiation), the students found that it was sometimes difficult for them to follow another person's idea. Students, particularly the degree students, pointed out that they were not willing to follow, develop or modify one person's ideas if they thought that they were wrong or "not on the right track." As stated earlier, the degree students understood that relay thinking was a "group" thinking activity. The originators also set up a wider scope of ideas for the others to develop or make other decisions about. However, this did not imply that the others necessarily wanted to follow the ideas if they thought that the received idea(s)—the baton—were going in the wrong direction. They preferred to "start over" from a new direction, although they denied that they had done so, and argued that it was only one method of "modification. " They also stated that "designers" always thought that they themselves were the most creative ones. Developing other people's ideas was not a "comfortable" job, and it was one with low "motivation."

The secondary students did not have this problem. They followed the regulations of relay thinking and developed their ideas strictly according to

the ideas of the previous members. Compared with the degree students, the secondary students on average needed a longer warm-up period for their individual work. After the transition period, some secondary students needed five to ten minutes to fully grasp the ideas passed on by their colleagues before starting their thinking.

Both degree and secondary students pointed out that they might have more creative ideas after their individual thinking time and the transition period. However, there was no opportunity for them to rejoin the relay-team. This indicates that relay thinking, in some senses, does not have the advantage of traditional group discussion. At the very least, it lacks ad hoc feedback and the re-direction of idea development.

In relay thinking, just as with other thinking processes with time constraints, the final solution cannot be guaranteed. In this study, the four groups of students were able to come up with final solutions. And most of them, particularly the secondary groups, were well satisfied with their proposed solutions, although they agreed that there were some areas for improvement. However, the degree students claimed that this satisfaction might not exist in all situations, and that most of the time it depended on the nature of the problem (for example, difficulties, requirements, time constraints).

Idea transmission

While the secondary students had little experience of group work, passing their own "complete" ideas to others for follow-up work was a new experience, and one that caused difficulties. During idea transmission, one of the secondary students could not understand his group-mates' idea, even after the 15 minutes were up. This was why some of the secondary students requested a longer transition time. On average, the secondary students needed five minutes longer than the transition period to reorganise the ideas that they had just received, indicating that they could not use the transition period well, and couldn't proceed at maximum speed after the transition, as is supposed to happen in relay thinking. As well as lacking group experience,

there were two additional reasons for these difficulties: (a) it was the first time that the students had used relay thinking, and they were unfamiliar with the procedure, and (b) ideas were not organised well during development, and this created comprehension difficulties for the others.

Although there was not enough time for idea transmission, and the secondary students had problems in proceeding afterwards, there were no arguments/disagreements among the members. They followed the rules of relay thinking in that, during the transition period, the idea-receivers worked only as helpers and allowed the other person to continue the idea development until their time was up. The receivers' work was also certainly built on that work. The results also showed that the secondary groups were able to produce final solutions that satisfied most of the group members.

The degree groups had no idea transmission problems. They commented that everyone knowing the problem and the requirements at the beginning was good, as they could all clearly understand the overall target/goal. It was also advantageous for transmitting ideas. However, this early understanding also created problems in that it was difficult to guarantee that people would not think about the problem before they started their duties — received the "baton" from their team-member. Once a member had thought about the problem, it was also difficult to guarantee that he would build on the previous member's ideas and start up a new one, rather than tuning the transmitted ideas back to his initial thinking. As some degree students stated, they were unhappy with group members who totally changed their direction of thinking, or terminated their ideas in order to start a new one. However, some students argued that it was very difficult to define the difference between a "brand-new" idea and a "built-on" idea.

Conclusion

Traditionally, problem-solving is carried out by individual thinking or group discussion. While individuals are much better at generating ideas and fresh directions, a group (or a team) is better able to develop an original idea and take it in more directions than an individual (Adair, 1990; Smith &

Arinsworth, 1989). Relay thinking is an alternative process that tries to access the advantages of the individual and group thinking approaches. Its success relies on the accumulation — co-operation — of members' work: it provides an environment that encourages individual creative thinking whilst driving different individuals to build individual ideas on top of others (Siu, 1994, 1998).

Relay thinking has limitations. This does not imply that it should be neglected, or is not worth improvement. According to this study, relay thinking is suitable and worthwhile for secondary and university students, although it must be modified to suit students at these two different levels. When providing relay thinking activities for students, according to this study, the main consideration is to make different arrangements (for example, time, place/environment, and members) for students at different levels, because students vary in their individual thinking and group discussion experiences, education backgrounds and levels of knowledge, and personal characteristics. These differences result in different requirements, expectations, and interpretations in tackling a problem, particularly when students are working in a group.

In this study, that the secondary students strictly followed their group-mates' ways of thinking does not imply that they had a group spirit. It only shows that the students did not display their personal opinions and preferences as the degree students did, who would sometimes totally ignore other members' work. This performance by the secondary students sometimes creates advantages for their teamwork, but may sometimes limit the opportunities for better development or terminating mistakes. This issue is definitely worth further investigation, particularly when the pre-set problem has a definite and concrete solution, and we can compare the "success" of students with different performances.

Nevertheless, according to the overall performance and response of the secondary students, more group work should be provided for school students, particularly in the normal curriculum. This experience will allow students to gain knowledge, and give them the spirit to tackle a problem as a group.

Also according to the study, even though the degree students had group discussion experience, this did not necessarily imply that they were good team members, or had good decisions in a group. In teaching and learning these days, group discussion is mostly just used for data collection. Arrangements besides relay thinking should also be initiated to suit different situations and needs.

The degree students had more thinking experience than the secondary students. However, the students' personal confidence in their problem-solving abilities also created disadvantages, as well as benefits, in teamwork. To strike a balance between personal and group opinions, we must provide opportunities for students to understand their own strengths and limitations, as well as to respect others and pay attention to others' opinions.

As mentioned earlier, groups have a wider scope and can develop ideas and take them in more directions than an individual can. To have successful relay thinking, good quality individual thinking is essential. To a certain degree, the success of individual thinking — an entirely personal activity- relies on a student's own experience. Therefore, in common practice, we should not put up barriers to students' thinking, such as environment, time, facilities or team members. Rather, we should give students more opportunities, starting from the lower levels of education, to face different constraints, so that they can enrich their experience. In fact, these two requirements are not contradictory. Only when students, based on multiple experience in varied situations (with different kinds and degrees of constraints), clearly understand their performance in a particular situation, can they (singly, or with others) learn how to set requirements for themselves and others to tackle future problems.

In this study, the idea originators in the secondary groups tended to initiate a small number of ideas with a narrow scope of direction, and the others used these ideas for development. Obviously, this way of thinking can eliminate distractions, but it also limits the opportunities for better exploration. In the degree groups, more ideas were initiated, but the members still tended to give their own initiations more weight, and to develop the

direction by themselves. This can sometimes re-direct the thinking towards a correct approach, but it may lose the advantages of relay thinking. In fact, in relay thinking, there are no strict requirements for the originator or the subsequent thinkers. However, in the industrial and commercial worlds, thinkers must usually arrive at a concrete solution. According to continued studies of relay thinking (Siu, 1994, 1998), a concrete result can be more easily obtained if more ideas can be initiated at the beginning, and then more precise and detailed thinking can be concentrated on these ideas towards the end. The studies have not proved significantly that a concrete solution is congruent to the best solution. Nevertheless, just like other group thinking activities, students should try to understand themselves better in order to know which position suits them best in a relay team. This kind of trial and error and self-understanding experience should start in early learning, with different levels of requirement and difficulty.

Relay thinking claims that a smooth transition of ideas not only increases the efficiency of idea development, but also minimises misunderstandings in ideas transmission. Smooth transition is also the main strength of this thinking process over other individual or group thinking processes/methods. However, in implementing relay thinking, students at different educational levels experienced different problems during the transition periods. Thus, while we should increase the opportunities for lower-level students to familiarise themselves with this thinking process, we should also help our higher-level students to develop their individual thinking in the context of team spirit and co-operation.

During the interviews, some students suggested having a final group discussion section after the relay thinking was finished. The function of this discussion would be to review and conclude the solution proposed by the final member. In fact, this additional section was proposed and tried in the 1995 pilot study. That study indicated that a final discussion could minimise a biased solution, especially if the solution was answering a problem that was likely to prove controversial, such as an ethical problem. However, the results also indicated that this additional section could cause

similar problems to a traditional group discussion, in that arguments between members are difficult to settle, and a final discussion can easily demolish all of the individual work in the previous stages (Siu, 1998).

To conclude, relay thinking is still at a new stage of exploration. Like other thinking activities, it needs more work before it is put into the curriculum and to real practical use. While it cannot be treated as a golden solution to all problems, but as an alternative process that is on trial, we need to discuss it further to find out how it might "co-operate" with other thinking methods or processes in order to, as Adair (1990) says, bring our creative ideas towards being innovative solutions.

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