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THE EFFECTS AND PROCESS OF USING DIFFERENT STORY-INDEXING STRATEGIES WITHIN A CASE LIBRARY ON COLLEGE STUDENTS' ABILITY TO SOLVE ILL-STRUCTURED PROBLEMS

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Wen-Lan Hsieh

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The thesis of Wen-Lan Hsieh was reviewed and approved* by the following:

Brian K. Smith
Associate Professor of Information Science & Technology and Education
Thesis Advisor
Chair of Committee

Francis M. Dwyer
Professor of Education

Susan M. Land
Associate Professor of Education

Spiro E. Stefanou
Professor of Agricultural Economics

Edgar P. Yoder
Professor of Agricultural and Extension Education

Alison Carr-Chellman
Associate Professor of Education
In Charge of Graduate Program in Instructional Systems

*Signatures are on file in the Graduate School

ABSTRACT

The emphasis on and importance of solving realistic and complex problems have increased in both education and industry. Realistic problems are usually ill-structured due to the lack of a convergent solution, unclear problem statement, or incomplete information for solving the problem (Chi & Glaser, 1985). Therefore, educators are exploring how to engage students in solving authentic and ill-structured problems through techniques such as anchored instruction, apprenticeship learning, problem-based learning, cased-based learning, goal-based scenario, and so on.

Most students fail to apply what they learn from school contexts to the problems they encounter (Bransford et al., 1987). Since students have difficulties in transferring knowledge, supports should be provided to students during problem-solving processes.

Case-based reasoning (CBR) focuses on analogy in the context of solving real-world problems ".... by encoding, retrieval, and adaptation in analogical reasoning process" (Kolodner, 1997, p. 57). It is suggested that learners build their own case libraries of experiences through working with "expert" experiences. The evidence indicates that stories within a case library significantly help learners improve their skills in solving ill-structured problems (Hernandez-Serrano, 2001). However, Gick and Holyoak (1980, 1983) found that students failed to apply knowledge from one context to another without providing them with explicit clues.

Indexing is the process of organizing experiences so that people know where they can find relevant information when needed (Schank, Berman, & Macpherson, 1999). The

ways that people interpret a story will affect the ways that they index the stories into memory and reuse the story in the future (Kolodner, 1997).

Novices may have difficulties in indexing and reusing their experiences well because they lack a good understanding of how to encode their experiences. In contrast, experts can index their experiences in many ways and retrieve the right story to solve new problems (Schank et al., 1999). If we help novices make connections between experiences by providing them with pre-generated story indices, they may develop stronger understandings of problems and interpret cases similar to experts.

The purposes of this study are to investigate the effects and process of using the following story-indexing strategies within a case library to support college students' abilities in solving ill-structured problems: (1) no story-indexing strategy, (2) surface-indexing strategy, and (3) thematic indexing strategy. A mixed-method design is conducted to collect both quantitative and qualitative data. Eighty-nine students participated in the experimental design and six subjects (3 freshmen and 3 seniors) participated in the qualitative design––a think-aloud activity.

The results of the quantitative data analysis showed no significant differences in using the thematic-indexing strategy to help college students solve ill-structured problems and engage in analogical reasoning. No significant difference was found for the three sub-skills (identify problems, define problems, and explore solutions) of problem-solving ability among the control, comparable, and treatment groups.

Three findings from the qualitative data analysis are described below.

1. *In different stages of problem solving, students tend to look for stories with appropriate functions that achieve their goals.*

2. *Students vary the complexity of their analogies in different stages of problem solving.*
3. *The complexity of students' analogies changes as they change their problem solving goals and seek for stories with different functions.*

The results of the quantitative data indicated that students did not use the story indexes provided. Through closer analyses of the qualitative data, students tended to look for stories that helped them achieve their problem-solving goals. That is, if they had to summarize problem issues, they looked for surface-level features in stories. If they had to engage in higher-order thinking such as justifying a decision, they looked deeper within the case library to pull out relevant stories. This suggests that pre-generated story indices need to account for more than the content of a story: They must also suggest ways that cases can be used to solve problems by analogy. Since problem solving takes on many forms, the indices may need to also describe the ways that cases can be used to make different types of analogies.

Since people vary their analogy when using stories to solve problems, the indices have to be flexible enough to cover most ways that people use stories in a case library. Therefore, case libraries must allow students to ask questions that serve as multiple indexes and help them browse related stories. The multiple indexes should be built upon the abstract task knowledge that can serve as the common ground between the students and the teachers (Ferguson, Bareiss, Birnbaum, & Osgood, 1992).

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Chapter 1

Introduction

The importance of solving complex, real-world problems has increased and been emphasized in education (Bransford, Sherwood & Sturdevant 1987; Bransford & Stein, 1984; Jonassen, 1997). These emphases are reflected in innovative course designs, such as problem-based learning (PBL), cased-based learning, project-based learning, and so on. One goal of these innovations in courses is to teach students how to solve complex problems and deal with real-world problems.

Realistic problems are usually ill-defined or ill-structured due to the lack of a convergent solution, unclear problem statement, or incomplete information (Chi & Glaser, 1985). The solutions to ill-structured problems are not predictable or convergent, and may also require integrated knowledge from several content domains (Jonassen, 1997). In addition, it is possible that there is no solution at all (Kitchner, 1983). Well-structured problems are usually found in the practice sections in textbooks. *In well-structured problems*, problem descriptions and information are constrained; rules and operators are known; and solutions are convergent and specific (Jonassen, 1997).

The complicated essence of problem-solving has driven many researchers and educators to study the nature of problem-solving tasks, to develop learning environments, and to develop instructional strategies to improve students' abilities in solving ill-structured problems. Similar to the motivation described above, this study is expected to

increase students' abilities to solve real-world problems by providing them with an analogical source—a case library that contains systematically indexed stories.

Problem Statement

Most students fail to apply what they learn from school contexts to the relastic problems they encounter (Bransford et al., 1987). Students who graduated from school and faced realistic challenges are novices in solving real-world problems. Gick and Holyoak (1980, 1983) found that students failed to apply knowledge from one context to another context without providing explicit clues.

In analogical problem-solving, the use of cases allows learners to interpret open-ended and ill-defined concepts, focus reasoning on important parts of a problem, and be aware of taking action to avoid repeating past mistakes (Kolodner & Leake, 1996). Case-based reasoning (CBR), a learning theory, is a special kind of analogical reasoning (Kolodner, Owensby & Guzdial, 2004). It focuses on analogy in the context of solving real-world problems ".... by encoding, retrieval, and adaptation in analogical reasoning process" (Kolodner, 1997, p. 57). The process of using CBR to solve problems is not like other problem-solving methods. Whereas analogical reasoning focuses on remembering abstract operators, composition of rules, and plain texts, CBR helps learners to bring previous experience and knowledge to interpret new situations, recall concrete instances, and adapt appropriate solutions (Kolodner & Leake, 1996; Kolodner et al., 2004). CBR suggests collecting stories from experts and providing a case library as the source of cases. A case library is a systematic collection and organization of experts' experiences

presented in the form of stories to the learner, as the learner interacts with a task environment (Edelson, 1993).

The evidence supports stories that promote elaboration of the listener's personal experience; through a story, the recitation of experience becomes a more memorable and more effective carrier of knowledge (Swap, Leonard, Shields, & Abrams, 2001). In the study of Hernandez-Serrano, Stefanou, Hood, and Zoumas (2002), the empirical results of the multiple-choice tests indicated that stories within a case library have significant effects on the improvements of learners' ability to solve ill-structured problems. Hernandez-Serrano (2001) also conducted in-depth interviews with several novice practitioners who were involved in technical tasks related to new product development (NPD) at a major U.S. food corporation. These novice practitioners preferred to have explanations in the form of stories and they recognized that stories are a legitimate form of learning.

Indexing is the process of organizing experiences so that people know where they can find relevant information when needed (Schank, Berman, & Macpherson, 1999). In a case library, indexing is the process of assigning labels to stories based on specific rules or interpretations (Kolodner, 1993). Good indexing allows individuals to locate the right cases at the right time. If the indexing scheme is defined well enough, it will facilitate the recreation of an index for a case that may be reused in another situation (Kolodner et al., 2004; Leake, 1996).

Novice and experts organize, label, and index information differently. Experts classify and retrieve experiences through abstract rules and deep features. A novice may not be able to assign discriminating labels or may assign these labels on the basis of

superficial features of the case (Kolodner, 1997, p. 60). Novices lack experience to draw on; even if they do have experience, they may have difficulties using these experiences well because they lack a good understanding of how to encode their experiences well. In contrast to novices, experts have a lot of experiences in their areas of expertise stored in their "library" of memory, and they can retrieve the right story to solve new problems (Schank et al., 1999).

In the study of Gick and Holyoak (1980, 1983), most students came up with the idea of using convergent low-intensity rays when provided with a hint to use the story. When students were not told to apply the prior fortress story, their transfer performance of generating analogous solutions declined. Therefore, merely exposing novice learners to ill-structured problems and providing a case library is still not enough to help students see similar features.

According to Ausubel (1968), advance organizers are different from overviews and summaries; the purpose of the advance organizer is to "…bridge the gap between what the learner already knows and what he needs to know before he can successfully learn the task at hand" (p.148).

To put it another way, providing story-indexing strategies as an advance organizer helps direct novice learners' prior knowledge to what is important in the problem situation and the analogical source (stories within a case library). By supporting a novice's reasoning process with pre-generated story indexes, a novice may better understand the problem situation and bridge the gap between how a novice interprets the problem situation and how an expert might interpret a similar case.

Purpose of the Research

Given the importance of problem-solving in our daily life (i.e., in an academic setting and in the workplace), and especially of ill-structured/ ill-defined problems, instructional materials and activities should be situated in a contextual learning environment. An ill-structured problem may lack a clear initial state, a set of permissible operators, or a clear goal state (Chi & Glaser, 1985). In addition, there are no absolute correct answers, so this type of problem lends itself to multiple viable solutions. Therefore, it is difficult to teach students how to solve ill-structured problems. Many researchers have shown that stories are more memorable, promote elaboration to personal experiences, and help in solving ill-structured problems (Hernandez-Serrano et al., 2002; Swap et al., 2001). However, research has not shown whether academic achievement in solving ill-structured problems is improved by using stories with pre-generated story indexes developed by experts in the representative field.

Kolodner (1996) described features of a good index for cases, which include making cases recallable, ensuring that they are concrete enough for users to recall recognizably and abstract enough for users to make connections between stories and a variety of future situations (Kolodner, 1996). Deep feature indexes or thematic indexes are features that are predictive and abstract, making a case useful for future situations. In contrast to deep feature indexes or thematic indexes, surface features can easily be found by learners in a case without further inference or meaningful interpretation (Kolodner, 1996), and they may not be able to predict results or lessons found in a case. However,

surface indexes are shown to be more useful when cases are under the same thematic category (Kolodner, 1993).

In this study, two story-indexing strategies were administered to control and experimental groups. The first strategy is the surface-indexing strategy: stories are indexed with surface features that have no inferential or meaningful interpretation and they are not predictive at all. The second strategy is thematic-indexing strategy: stories are indexed with deep features that are predictive of something important and abstract enough to make a case useful for future situation.

Thus, the main purpose of this study was to investigate the effects of using the following strategies within a case library to support college students' abilities in solving ill-structured problems: (1) no story-indexing strategy, (2) surface-indexing strategy, and (3) thematic indexing strategy. By manipulating the variable of story-indexing strategy (grouping participants into control, comparable, and experimental groups) and by having each group access to a case library with no indexes, surface indexes, or thematic indexes, we may see the effects on learners' performance in solving ill-structured problems.

Eighty-nine subjects were randomly assigned to three groups. The "Fresh-cut Fruit" case (see Figure **1-1)** was used as the problem case for all participants in the three groups. Three food product case libraries were created as three web sites and each group had access to one of the case libraries. The same nine stories (see Figure **1-2** for an example of a story) are organized in the three case libraries and the only difference is the way that the stories are indexed. The control group had access to stories without any index; the comparable group had access to stories indexed with surface features; the experimental group had access to stories indexed with thematic features.

Fresh-Cut Fruit

Everyone sat around the old oak conference table at Verdelli's headquarters waiting for Dan Verdelli to call the meeting to order. The topic was melons. More specifically, fresh-cut melons that could be marketed in grocery stores for the "ready-to-eat" crowd. Verdelli's had been successfully marketing fresh-cut pineapples, but the acidity of pineapples made them highly resistant to microbial degradation. Melons were a different story.

Verdelli Farms stands as one of the leaders for the fresh-cut vegetable industry. Their product line includes iceberg lettuce, escarole, red cabbage, radicchio, spinach and endive. They market an extensive range of salad mixes including All-American, Caesar, European, Fancy, Italian, Oriental, Taco, Three-Leaf and Spinach salads. As a result of innovative and functional packaging, Verdelli products have a 14 day shelf-life.

Verdelli had entered the cut fruit business in early 1994 by peeling and coring pineapples to make chunks, spears and rings and packaging them under the Dole label. Prior to then, supermarkets had been coring Dole pineapples in-house, but they had insufficient labor to keep up with the demand. As a result, Dole contracted with regional processors, such as Verdelli, to peel and core pineapples. Verdelli delayed expansion to other types of fresh-cut fruit because of concern about product spoilage and safety. They had many opportunities with the vegetable business.

In the early 80's, Giant Foods, a regional supermarket chain, commissioned surveys and focus groups that revealed a demand for home meal replacement items in their produce departments. As a result, they introduced a vegetable platter prepared in-store that was marketed as a holiday item.

In the early 90's, they began to look for similar alternatives in the fruit category. As a way to salvage the bruised fruit and satisfy consumer demand, the stores began peeling and cutting the fruit, putting it in deli cups and selling it within 24 hours. At the time fruit cups retailed for $1.50 and included cantaloupe, honeydew, watermelon and strawberries. They were packaged in 10-oz cups that could be consumed for breakfast or dessert. After the stores realized that there was a market for fresh-cut fruit, they designed a three-pound domed-container tray of fruit and sold them for $6.00 each. Within a very short time, they realized that there was more demand for this product than they could satisfy. Focus groups indicated that consumers liked the product, particularly in the melon section of the store, and that it added to the perception of freshness for the whole produce line.

The challenge was to package a high quality and safe fresh-cut fruit product and to control labor costs. Consequently, they sought a supplier who could provide the prepackaged fresh-cut product. At the same time, they either increased their capacity for ice in the produce section or upgraded to a deck type refrigerated case, enabling them to maintain the product temperature at 38°F.

Giant Foods approached Verdelli's sales and marketing department and asked them to cut and package the fruit for them. The two companies had been dealing with one another since the 1970's. Since Verdelli Farms had been successful in packaging fresh-cut vegetables and had a reputation for innovation and quality, Giant thought that it was a natural business relationship that only required some technical know-how. Giant told Verdelli that the customer wanted consistent quality (fresh and good taste) and true convenience (no preparation). The message was: "We want a product we can put on the shelves without a lot of hassle and one we can trust to be fresh and palatable."

Verdelli 's sales and marketing department immediately recognized the potential for fresh-cut fruit. However, Verdelli's quality assurance group suspected that cutting, packaging and marketing fruit such as melons would not be as simple as pineapple. Melons were much less acidic than pineapple and there had been documented cases of Salmonella food poisoning outbreaks from melon. At that time, Verdelli's products were in the distribution channels for at least ten days, plenty of time for pathogen growth.

*Figure **1-1**.* The fresh-cut fruit case.

Price Points and Retail Outlets Can Signal Quality

After Eight Mint

In the middle 1980's Hershey was looking for ways to enter the premium-priced chocolate market. Hershey brought the number-one selling product from the U.K., *After Eight Mint*. In the U.K., this was considered a super premium product that was sold in regular supermarkets. At the time, it was one of the best selling candy products in the U.K. However, Hershey decided to distribute it in exclusive stores in the U.S. (Bloomingdale's, etc.). Hershey knew that the Hershey brand has a strong association with affordable chocolate products. Therefore it refrained from putting the Hershey label on the product. *After Eight Mint* immediately started performing well. Thinking that the product had the potential to perform even better in the regular channels as it did in the U.K., Hershey decided to sell it in the mass markets (groceries, etc.). With this new selling strategy, the product encountered an abrupt death.

Hershey learned that Americans are not willing to pay a premium price on a chocolate product even if the product itself has all the right characteristics. Taste can hardly make up for price. People loved the *After Eight Mint* taste but once it went above a certain price they simply were not inclined to buy it.

*Figure **1-2***. A story example.

The other purpose of this study was to explore the analogical problem-solving process by having subjects talk aloud while they solved problems. A qualitative design was set out to gather verbal reports from the novice learners when they took the open-ended test in order to investigate and understand the process of analogy-making while solving ill-structured problems. Through the careful analysis of learners' verbal reports, it was expected that the nature and process of analogical problem-solving and the transferring process from experts' experiences/stories to novice learners would be unveiled.

Six subjects (3 freshmen and 3 seniors) were randomly assigned to each group to receive three different treatments, which were the same as were received in the experimental design. It was expected, through the verbal data analysis, that a learning model of analogical problem solving would be brought out to help explain the results of the quantitative data.

This mixed-method design with a quantitative design (control, comparable, and experimental group) and a qualitative design that applies a think-aloud protocol analysis is considered the most appropriate to use in tackling the research questions raised in this study.

Higher-order thinking, such as problem-solving and decision-making, emphasizes not only outcomes but also processes. Adding qualitative flesh to the quantitative bone is a good way to overcome some unanswered problems found in the quantitative design. The major advantages to adopting the mixed-method design are to provide richness and details, clarify and illustrate results, and test the consistency of findings obtained through

different instruments. These are what Greene (Greene, Craracelli & Graham, 1989) called expansion, complementarity, and triangulation.

Research Questions and Hypotheses

Based on this study's research purposes, answers to the following questions were sought:

Q1: What are the effects of using different story-indexing strategies within a case library on college students' (novice learners') ability to solve ill-structured problems?

Q2: How do novice learners use reasoning strategies between stories and targeted problems to solve ill-structured problems? Specifically,

Q2.1: How do students figure out the hints behind stories and make connections when following the strategies of "identifying problems, defining problems, and exploring possible solutions" to solve ill-structured problems?

Q2.2: What kind of functions or roles does a story play in the problem-solving process?

The first research question was designed to test the following hypotheses.

On an open-ended test that evaluates higher-order thinking skills, all groups (a comparable group who have access to stories with the surface-indexing strategy, a control group who have access to stories without any indexing strategy, and an experimental group who have access to a number of stories with the thematic-indexing strategy contained in a case library) will:

H1: perform equally in analogical problem-solving.

H2: perform equally in solving ill-structured problems.

H2.1: perform equally on three sub-skills (identifying problems, defining problems, exploring possible solutions) when they solve ill-structured problems.

It was also trying to test the other two hypotheses.

On an open-ended test that evaluates higher-order thinking skills, all groups:

*H3: with different **story-indexing strategies** and with related or unrelated **working experience** will perform equally in analogical problem solving*

*H4: with different **story-indexing strategies** and in different **academic years** will perform equally in analogical problem solving*

The sub-hypothesis of hypothesis 2 was developed based on the first three components of the IDEAL problem-solving model since the instrument was developed based on the first three sub-skills: identifying problems, defining problems, and exploring possible solutions. The researcher was interested in determining whether stories with different indexing strategies had any effect on the three sub-skills of solving ill-structured problems. See Chapter 3, Figure 3-4, for a story with the surface indexes and Figure 3-5 for stories with the thematic indexes as examples.

Hypotheses 3 and 4 were developed based on the emphasis in case-based reasoning (CBR) theory. In CBR, past experiences are cases that help individuals interpret a new situation and retrieve appropriate cases. Experts are people who have rich experiences in a representative field. Students who are in a higher academic year (junior and senior) were more likely to have more real-world project experiences than students in lower academic years (freshman and sophomore). For example, senior students who took

an advanced class in agricultural business management had to develop a marketing plan by identifying demands and demographic variables and analyzing other marketing conditions. Instead, freshmen who took the introductory class in agricultural business management learned principles and concepts of agricultural management. Therefore, students with relevant working experiences or in higher academic year are considered factors which might affect the dependent variables and interact with the independent variable.

The second research question and its sub-questions are designed to collect qualitative data to explore the process of analogical problem-solving process.

The goal of this study was to help students learn meaningfully by connecting new knowledge with what they already know, and to help students link the new problems to their relevant experiences or cases in deep-level features. People become smart by learning from their experiences, including failure experiences. Most people learn by repeating mistakes, which works but costs time and money. Sharing experiences and indexing them helps people to draw upon the right experience at the right time and helps novices to seek relevant examples and reduce learning difficulties easily. It is expected that providing story indexes as an advance organizer can support novices to make sense of ill-structured problem situations, see the similar features between problems and cases, retrieve relevant cases, compare differences or similarities between the problems and the cases, and adopt or adapt solutions or lessons learned from the cases.

At one level, this thesis sought to demonstrate the effect of using different story-indexing strategies on novices' problem-solving and analogy-making abilities through the analysis of the quantitative data; at the other level, this thesis sought to explore how

novices use stories in the problem-solving process through analysis of the qualitative data.

Chapter 2 provides a detailed review of case-based reasoning theory, cases, the story index, problem-solving, and the differences between experts and novices. It also contains a description of how these variables tie together to form the research questions.

Chapter 3 describes the sampling strategy, materials and instruments development, design procedures, and data analysis methods.

In chapter 4, the results indicated that students did not use the story indexes provided and they tended to use stories by functions. Both quantitative and qualitative results are presented with a detailed data analysis.

Chapter 2

Review of Literature

Numerous research studies suggest that people learn from prior experiences and cases. These experiences help humans explain and interpret new knowledge and information (Kolodner, 1997; Schank, 1990; Schank, Berman& Macpherson, 1999; Leake, 1996). If you have experienced taking a domestic flight, you would know more about booking flight tickets, confirming and changing flights, passing the security station, and transferring flights. With the domestic flying experience, you would be able to learn how to take an international flight more quickly and easily than those who don't have any flying experience at all. A doctor with many surgery experiences will be able to deal with a complicated and urgent medical situation more precisely and quickly than an intern. All of these personal experiences are made of story pieces. Given a situation or a problem, an expert can retrieve the right stories from his knowledge base at the right time to deal with the problem at hand.

This literature review will provide an overview of case-based reasoning, stories and cases, story indexes, the differences between experts and novices, and how they relate to learning and problem solving.

Case-Based Reasoning

The study of case-based reasoning (CBR) has been driven by two motivations and has focused on two areas. First, from the cognitive sciences, CBR is used to build reasoning systems to model human behavior; second, from artificial intelligence, CBR is used to incorporate intelligence into computer systems to make AI (artificial intelligence) systems more effective (Kolodner, 1993; Kolodner & Guzdial, 2000; Leake, 1996). In this study, from a cognitive science perspective, CBR is adopted as a cognitive model which focuses on encoding, retrieval, and applying prior cases to interact with human memory organization and reasoning.

Case-based reasoning, a learning theory, focuses on analogy in the context of solving real-world problems ".... by encoding, retrieval, and adaptation in analogical reasoning process" (Kolodner, 1997, p. 57). "CBR attempts to unify and explain the processing behind human memory, reasoning, learning, and performance" (Kolodner, 1997, p. 60). Case-based reasoning means reasoning from previous experiences and cases. It is a process of *recall, compare, and adapt*. Reasoning from reminding is the special feature of case-based reasoning because, in CBR, solutions are generated by retrieving the most similar or closest stories in memory. Thus, in CBR, reasoning is remembering and reminding (Leake, 1996). The process of using CBR to solve problems is not like other problem-solving methods. Rather than remembering abstract operators, composition of rules, and plain texts, learners recall concrete instances in the CBR process (Kolodner & Leake, 1996). For example, *algorithms* are specific procedures that are guaranteed to produce a solution to a problem as long as the algorithm is relevant to

the problem (Anderson, 1985); *means-ends analysis* is the process that moves the problem from the initial state successively closer to the final desired state by comparing the differences between them and using operations that are likely to reduce those differences (Newell & Simon, 1972). In contrast, in *CBR*, a learner applies knowledge from specific examples or cases to solve a new problem. Cases may suggest a solution to a problem or it may warn of a potential problem; the learner was able to solve the problem based on both types of suggestions (Kolodner, 1997).

CBR tasks are often divided into two categories: interpretive CBR, using prior cases as reference points for classifying or characterizing new situations, and problem-solving CBR, using prior cases to suggest solutions that might apply to new circumstances (Leake, 1996). Both of them involve situation assessment, case retrieval, and similarity assessment/evaluation. In addition, problem-solving CBR, which compares the similarities and differences between new and prior cases, is used to determine how previous solutions can be adapted to fit a situation. Learning in CBR is driven by both success and failures (Kolodner, 1997; Leake, 1996) because novices learn to revise solutions from failures, in which the solutions are unsuccessful, and they need to adapt appropriate solutions from successes, in which the solutions are workable. CBR suggests a model of reasoning that incorporates problem solving, understanding, and learning (Kolodner & Leake, 1996).

CBR has been designed for problem-solving tasks and has been founded on the assumption that cases and examples are useful for supporting problem solving through analogical reasoning (Kolodner, 1997). A case serves three purposes in case-based reasoning systems. First, cases provide the context for understanding a new problem

situation; second, cases provide suggestions of solutions to problems; third, cases provide contexts for evaluating suggested solutions (Kolodner & Leake, 1996). These are the major advantages provided by CBR.

Case-based reasoning allows the reasoner to propose *solutions* in domains that aren't completely understood. In CBR, learners don't depend on fully modeling the content of cases; instead, learners rely on knowledge of when to recall and use the cases (Kolodner & Leake, 1996; Mark, Simoudis & Hinkle, 1996).

Case-based reasoning gives the reasoner a means of *evaluating solutions* when no algorithmic method is available for evaluation (Kolodner & Leake, 1996).

For instance, suppose Ford Motor Company hires you to think about an idea to introduce a sports utility vehicle (SUV), *Explorer*, to the Chinese market; however, at that time, the SUV is a new type of vehicle in China compared to sedans. If you know nothing about marketing, it is a challenge for you to generate useful solutions. However, if stories about marketing were shown to you, such as *President's Choice Cola* and *After Eight* in Figures 1-1 and 1-2, you would probably propose the successful solutions used in the *President's Choice Cola* story, in which an authorized person is standing behind the brand, thus sending a quality signal to the consumer. In addition, you may also learn from the failure depicted in the *After Eight* story, in which the lesson is to avoid positioning the product at a premium price if the consumers are not willing to pay such a high price for the SUV. By reading the results and lessons from the two stories, you are also evaluating whether the methods used in the stories are appropriate for your work in marketing SUVs in the Chinese market.

Indexing Process in CBR

In the CBR system, a reasoner will use his or her prior experience and knowledge to retrieve old stories, analogize old stories and new problems, adapt old solutions or adapt them after modification, and finally generate his or her own solution to solve a new problem. Indexing is the process of assigning labels to stories based on specific rules or interpretations when putting stories into a case library (Kolodner, 1993), see Appendix < A > for the definition of a case library. Indexing consists of "labeling" an experience with the appropriate "title" and then "filing" it in the right place in memory, which is the process of organizing experiences so that people know where they can find relevant information when needed (Schank, Berman & Macpherson, 1999). In a case library, indexing means more than assigning labels to a case; it means to "assign important values to dimensions of a representation....label cases with their important or defining sets of features….setting up a memory and its retrieval process so that the right cases are retrieved at the right times" (Kolodner, 1996, p. 355).

We index our experiences not just based on a single method, rather we index our experiences by "…sights, sounds, smells, occurrences, etc. to categorize that which we see and do" (Schank, Berman & Macpherson, 1999. pp. 168). The extent to which an old situation is interpreted and elaborated upon will affect further reasoning (Kolodner, 1997) because people tend to remember and reason about meaningful experiences. We trigger relevant stories in our memory by the cues of current experiences. This means that the schema used to index or label the story will be the same schema used to recall or retrieve the story.

The importance of indexing in CBR brings us to the point, what features make a good index? Kolodner and Leake (1996, p. 44) described that "The indexing vocabulary must capture those dimensions of the domain that need to be captured for reminding." They also described the similar features of a good index for cases, which include making cases recallable whenever appropriate to a specific situation in the future, being concrete enough for users to recall recognizablely, and being abstract enough for users to make connections between stories and a variety of future situations (Kolodner, 1996). Kolodner (1997) and Schank (1990) indicated that indexing or labeling old cases/stories in a complex and discriminative form prior to storage in memory will allow for good judgments about reuse, and allow cases to be available in a large variety of ways in the near future. The reason Schank proposed this concept of labeling a story is that higher intelligence depends upon complex perception and labeling. We can see from these view points what a "good" index consists of and how it [Karen's note: "it" refers to the index, I presume?] should include predictive rules of some important values, concrete elements for the current understanding, and abstract principles for future recall.

A lot of literature mentions the structure of indexing strategies, such as surface features, deep features, thematic features, structural features, pragmatic features, and so on. Are they all good indexes? How are we going to tell the difference? From the view of case-based reasoning, Kolodner (1996, p. 356) used these words "…to choose good indexes: predictive (of something important or useful), recognizable, provide discrimination, and provide coverage…." See Appendix < C > for the definitions of surface indexes and thematic indexes used in this study.

Take surface indexes as an example; surface indexes are merely available features that can easily been found by learners in a case without further inference or meaningful interpretation (Kolodner, 1996), and they may not be able to predict any results or lessons found in a case. Therefore, surface features make little contribution in helping learners making analogies at an abstract level. Contrarily, deep feature indexes or thematic indexes are features that are predictive of something important and abstract to make a case useful for future situations. However, the role of surface features in reminding is not all negative. Kolodner (1993, p. 240) mentioned that "within a thematic category, cases which are similar on surface features might contribute more specific or refined expectations than cases that are less alike on the surface." Kolodner (1993) used an example in which someone knew about the story of *Romeo and Juliet* and also knew about a plot in which the workers of an organization planned to leave the organization and form another one. When this person heard about the plot, he was reminded of *Romeo and Juliet*. Both of the two stories share the same thematic feature, i.e., 'a mutual goal achievement in the face of outside opposition.' Then this person went to see *West Side Story*. When asked, whether or not *West Side story* reminded him of *Romeo and Juliet* or of the organization story, he was more likely to say *Romeo and Juliet*. The reason is that *Romeo and Juliet* and *West Side Story* are also similar on surface characteristics, though both *Romeo and Juliet* and the organization story are equally similar in the same thematic category: mutual goal achievement in the face of outside opposition. This example shows us that surface indexes are more useful only under the same thematic category, and that an indexing vocabulary needs to include both abstract and situation-specific vocabularies (Kolodner, 1993).

Cases in CBR

In case-based reasoning (CBR), cases are used to help understand a situation, evaluate solutions, and solve problems. Kolodner & Leake (1996, p. 36) defines a case as "a contextualized piece of knowledge representing an experience that teaches a lesson fundamental to achieving the goals of the reasoner." A case includes three major components: a problem/ situation description, solution, and outcome (Kolodner, 1993; Kolodner & Leake, 1996). However, not all situations that occur come into a useful case. The criterion for deciding if a situation or experience is useful enough to be recorded as a case is to ask: *Does the case teach a useful lesson*? (Kolodner & Leake, 1996). A lesson might be about how to achieve a goal, how to take action under certain circumstances, how to avoid making mistakes, or how to evaluate the results. The format and size of cases vary from a situation that lasts over time (i.e., experiencing the entire process of applying to a university), a snapshot (i.e., choosing a particular type of résumé for an application), a problem-solving episode, a situation description with an outcome, or some combination (Kolodner & Leake, 1996).

Sometimes cases take the form of stories. A story, if presented in the form of a narrative, should be structured in a few brief paragraphs that include the presentation of the problem situation and context, the dilemma being faced by the main character, and the resolution and lesson (Hernandez-Serrano, Stefanou, Hood & Zoumas, 2002). Stories are memorable and promote elaborations, heuristic predictions, and connections to personal experiences (Swap, Leonard, Shields, and Abrams, 2001). Kolodner (1997, p. 59) also mentioned that "a case is more than just an example; it is the interpreted

representation of a real experience. It includes a sought-after goal, a method for achieving the goal or solution to the problem, and the results (outcome) of carrying out that method (solution)."

It is said that we make sense of the world and communicate with others by understanding other people's stories and telling them our own stories (Randall, 1999; Schank, 1990). People accumulate experiences as they grow up, but not all of them make good stories from their experiences. The stories a person tells are meaningful experiences for him and, by storytelling, other people understand the storyteller's beliefs and points of view.

For a listener, understanding means making sense of the speaker's stories and then telling his own stories and experiences, thus "…understanding is really the process of index extraction (Schank, 1999, p. 92). When a person thinks deeply, "new ideas wander through our memories, causing us to revise beliefs, to make new generalizations, and to perform other unnatural acts" (p. 91).

Take the *haircut and steak* as an example (Schank, 1982). Schank said to his friend, Abelson, "I like my steak cooked rare. Whenever my wife cooks for me, she always overcooks the steak; even though, I tell her I like it rare." Abelson replied, "This reminds me of the time I couldn't get my hair cut as short as I wanted it, thirty years ago in England." Now, think about this response. Perhaps Abelson said, "Yes, my wife always burns my food, too!" or "Funny, my wife always undercooks my steak." These are surface reminders because the context doesn't change, although the wording is twisted a little. Perhaps someone responds to Abelson's story this way: "Yeah, I was in England last year and they had great beer!" This instance is probably a more superficial

example of reminding because the goals, plans, and results do not have anything in common.

However, Abelson's response of haircut in England is an example of deep reminding. How did he go from steak to haircuts? The goal in both stories is to get some direct thing- a rare steak or short hair. The goal is not achieved because some agents (wife/ barber) don't follow directions.

If people didn't map the new stories onto their own stories, it is likely to cause difficulties absorbing new information and understanding new concepts. Actually, this is what we do in our daily lives. People share experiences with their friends, colleagues, families, and even unknown audiences in narrative form, and many times they are not aware of it.

People are reminded of past experiences by current ones and then use those past experiences as a guide to help them process new experiences. When Schacter talked about the elaborated encoding of human memory, he mentioned that, "What we already know shapes is what we select and encode; things that are meaningful to us spontaneously elicit the kind of elaborations that promote later recall" (Schacter, 1996, p. 45-46). Our memories are retrieved by cues that our current experience provides. These cues are related to the context of the experience, the goal of the experience, or the lesson learned from the experience (Schank, 1982). Humans naturally check their memories and look for similar experiences to match current problems (Kolodner, 1997; Polya, 1957; Hernandez-Serrano, 2001). According to Schank (1990, 1977), memory is organized around personal experiences or episodes. However, experiences are different from stories stored in our memory. An experience becomes meaningful after attaching it to some

similar features in your old stories. For example, you may tell someone “I experienced getting a ticket because I was speeding on the highway.” By stating this, you are not sharing your personal belief or stories about speeding, rather it is a conversation about getting a ticket. If you tell someone “Speeding is dangerous to yourself and to other people. I would never speed again because I hit someone and broke his legs. He can never go back to his normal life,” then you are stating your own story about how the ”perception of driving safety is important.” In our daily life, we tell stories “…in order to tell about, comment upon, and analyze our own personal experiences” (Schank, 1999, p. 99).

It follows from what has been said that human memory is a story-based memory (Schank, 1990, 1997). If memory is structured as stories are, do experts differ from novices in telling the right story at the right time? Does story-based memory have a better effect on reminding us of things across different contexts? By answering these questions, we have to discuss human beings’ reasoning and analogical processes. Schank (1990, 1999) described that the most powerful effect of storytelling on learning is to make analogies across different structures/contexts of memory.

Schank (1995) described that an expert is someone who has a great many stories to tell in one particular area of knowledge and who has those stories indexed well enough to find the right one at the right time. Human memory contains a lot of indexes to organize experiences. “The more information we are provided about a situation, the more places we can attach it to our memory” (Schank, 1999, p. 90). The more meaningful the information to people, the more recognizable people can recall it in the same situation or in different contexts. If human memory is story-based, storytelling should be the most

natural and effortless way to learn. As the episode happens, stories are vivid, imaginable, and fruitful, such as the character's attitude towards problem solving, plots, quandaries, situational statements, operational conditions, goal descriptions, results, and lessons. The more indexes people are provided, the greater the possibility of comparisons to prior experiences, future retrieval, and learning (Schank, 1999). Therefore, storytelling provides a natural way to communicate both verbal and imaginary information with audiences.

From the perspective of instructional design, Lave and Wegner (1991) found that "apprenticeship learning is supported by conversations, stories, and problematic and especially difficult cases." Supports for teaching with cases also come from the area of cognitive science. From cognitive psychology, the evidence supports stories that promote elaboration of the listener's personal experience; through a story, it will become more memorable and more effective carriers of knowledge (Swap *et al.,* 2001). In the study of Hernandez-Serrano, et al., (2002), a case library was built to support the teaching of the New Product Development (NPD) process. Forty-four undergraduates were subjected to the experimental group (case library with stories), the comparable group (fact sheet with material comparable to the stories but presented as facts), or the control group (text randomly selected from a textbook unrelated to the material). The empirical results of the multiple-choice tests indicate that stories in a case library have significant effects on helping learners improve their unstructured problem-solving skills when compared to fact sheets or random text, and that it makes no differences between fact sheets and simply random text. Hernandez-Serrano (2001) also conducted in-depth interviews with several novice practitioners who involved technical tasks of NPD at a major U.S. food

corporation. These novice practitioners preferred to have explanations in the form of stories when eliciting expert advice and they recognized that stories are a legitimate form of learning.

In brief, stories or cases consisting of realistic background settings, characteristics, problem statements, and goal descriptions are suitable for teaching the skills of solving ill-structured problems.

Experts' and Novices' Abilities of Problem Solving

People have different levels of problem-solving abilities. Problem solving involves "…building a mental representation of a problem situation, including any inferences you make on reading the problem that will allow the solver to carry out some action" (Robertson, 2001, p. 22). Problem solving is a higher and complex cognitive skill, which involves understanding problem situations completely, analyzing and synthesizing data, and selecting effective solutions. Therefore, it falls into the highest level of Bloom's taxonomy of learning objectives (Anderson & Krathwohl, 2001). In CBR problem-solving systems, people do a situation assessment to generate a *problem description*, search for a similar case, and then adapt the *solution* of the most similar problem into one that fits the new circumstances (Leake, 1996). The interesting question is how people differ on their problem-solving abilities, including their assessment, reasoning, and adaptive abilities.

Chi & Glaser (1985) describes two factors that influence people's problem-solving abilities, which are *the kind of knowledge brought to the problem by the solver* and *the nature of the task*. The knowledge brought to the problem by the solvers varies depending on the amount of their knowledge of specific domain contents. Identifying the differences in domain knowledge and reasoning process levels between experts and novices offers a key to understand problem-solving processes. Chi, Blaser, and Farr (1988) mentioned that experts excelling mainly in their own domain and perceiving large meaningful patterns in their domain are faster than novices at performing the skills of

their domain. They exhibit superior short-term and long-term memory performance, have strong self-monitoring skills, and see and represent a problem at their domain at a deeper level. The cognitive processes, mental structures, and amount of knowledge make novices different from experts on their problem-solving ability (Chi & Glaser, 1985; Kolodner, 1997). Holyoak (1990) found out that experts' problem schema represent complex categories that are defined in part by patterns of relations between problem elements, rather than by the specific elements themselves. In a test of grouping typical physical entities, Chi et al., (1981) found a similar result. They found out that students who have completed introductory physics with an "A" grade tended to group problems that contained similar physical entities (superficial cues), whereas the physical instructors grouped problems based on complex principles or rules. In a proficiency test of mathematical problem solving, Schoenfeld (1985) found significant evidence that novices tend to classify problems by their *surface structure*, focusing on the words or subjects that are prominent in the problem statements; experts appear to base their perceptions of problem relatedness upon the problems' *deep structure*.

In analogical problem solving, through cases, learners can interpret open-ended and ill-defined concepts, focus reasoning on important parts of a problem, and be aware of taking action to avoid repeating past mistakes (Kolodner & Leake, 1996). The primary power of using cases for problem solving is that it allows the decision maker to deal with uncertainty and an unknown situation (Kolodner, 1997). In the experimental study of Gick & Holyoak (1980, 1983) and Holyoak (1990), college students were asked to use the fortress problem to help solve an ill-defined radiation problem. The desired goal of the radiation problem is specified at an abstract level and the strategies used to achieve

the goal are open ended. Without the fortress problem as a source analog, very few students proposed the idea of using low-intensity rays. For those who received fortress problems as a resource analogy, they performed differently in generating solutions. When a hint to use the story is provided, most of the students came up with the idea of using convergent low-intensity rays; when students are not told to apply the prior fortress story to help solve the radiation problem, their transfer performance of generating analogous solutions declined.

The nature of the task is the other key factor that makes people react differently in problem solving. Problems cluster into three kinds of problems: puzzle problems, well-structured problems, and ill-structured problems (Chi & Glaser, 1985; Jonassen, 1997). For *well-structured problems*, problem descriptions and information are constrained; rules and operators are known; and solutions are convergent and specific (Jonassen, 1997). For well-structured problems, the goal is clearly defined and you can easily recognize when you achieve the goal. Well-structured problems are usually found in practice sections in textbooks and these "…well-structured application problems require the application of a finite number of concepts, rules, and principles being situated to a constrained problems situation" (Jonassen, 1997, p. 68). *Puzzle problems* are a kind of well-structured problem, such as the Missionaries and Cannibals problem. However, problems that happen outside of the classroom are usually ill-defined or ill-structured. *Ill-structured problems* have vaguely defined or unclear goals and unstated constraints (Voss, 1988). The solutions of ill-structured problems are not predictable or convergent, and they may also require the integrated knowledge from several content domains (Jonassen, 1997). Even more, it is possible to have no solution at all, that is, no

consensual agreement on the appropriate solution (Kitchner, 1983). Three components are used to judge the ill-structured problems. In a framework, "…a problem has a clear initial state, a set of permissible operators, and a goal state. A problem qualifies as ill-defined if any one or all of the three components are not well specified" (Chi & Glaser, 1985, p. 246). For example, if you are a sales manager of a beverage company, and the market shares of the soda drinks have been low for the past several seasons, what would you do to increase the market share percentage? This is an ill-structured problem with all components unspecified. The initial state is not just about the market shares of the product; among other factors, the company goal setting, employee training, and marketing strategies are all part of it. The solutions for the problem of "increase market share percentage" are unpredictable and have no single right answer. The possible solutions may include extending the production amount, expanding product variety, conducting market and demographic research, positioning target consumers, and so on. Doing this may involve several content domains, such as marketing management, product development management, production and operation management, employee training, demographic statistics, economics, and so on.

Explicit Story Indexes and Problem Solving

An expert is someone who has a great many stories to tell in one particular area of knowledge and who has those stories indexed well enough to find the right one at the right time (Schank, 1995). How do we gather an expert's stories and how are we to organize them to help the novice to learn? The application of storytelling towards developing problem-solving skills is supported by case-based reasoning (CBR) and, as suggested by CBR, a case library is built to provide the resources of cases by collecting stories from experts. A case library is a systematic collection and organization of a number of experts' experiences presented in the form of stories to the learner as the learner interacts with a task environment (Edelson, 1993), see Appendix < H > for the concept of case library. Cases need to be collected according to the needs of the reasoner, that is, based on his or her goals and tasks. Such an organized approach to deciding what types of cases need to be collected can result in good initial coverage although not full coverage (Kolodner & Leake, 1996).

Experts' experiences and cases are encoded in story format, and they classify and retrieve experiences through abstract rules and deep features. Novice and experts organize, label, and index information differently. A novice may not be able to assign discriminating labels or may assign these labels on the basis of superficial features of the case (Kolodner, 1997, p. 60). Novices lack experience to draw on; even if they do have experience, they may have difficulties using these experiences well because they lack a good understanding of how to encode their experiences well. They are unable to make a

retrieval at appropriate times and cannot reuse experiences well (Kolodner, 1997). In contrast to novices, experts have a lot of experiences in their areas of expertise stored in their "library" of memory, and they can retrieve the right story to solve new problems (Schank, *et al.,* 1999). Schank (1995) tried three different methods of extracting stories from an expert in military history. The expert proved to be a repository of stories about various episodes in military history. He could see military stories in a variety of different ways because he had created for himself a set of complex indexes about military history.

Kolodner (1996, p. 352) clarified some misconceptions in several experiment statements about people indexing only on surface features. She found out that the subjects for these experiments were all novice subjects. Because novices don't have enough domain knowledge to do the situation assessment well, only surface features of reminding are available for them to recall previous cases or experiences. As we mentioned in the previous session, many novice-expert literatures show that the deeper features of similarities are recognized by experts when evaluating and classifying problems. "Thus, one would expect quite different remindings from those who are more expert in an area." (Kolodner, 1996, p. 357)

Comparing the differences of thinking between experts and novices is important to the real subject of this study. Novices without enough domain knowledge and cases stored in memory tend to see the surface features when asked to solve problems and interpret problems but experts classify problems by principles and specific rules. When we put novices in a situated context with ill-structured problems and then provide them a lot of analogical resources, i.e., experts' experiences in the format of stories, do we expect that they can see the deep features of points, understand the stories in the way that

experts intended to express, organize the stories well, and then tell their own stories after attaching meanings to the stories they heard? Do we expect that they get the key points and even comprehend the implicitly important information behind the stories without providing any appropriate index or label?

Using cases that represent real-world problems to help problem solving is proposed in problem-based learning (PBL), medical problem-solving environments, and anchored instruction but it is not enough. However, in CBR, it is not just about presenting cases but about presenting and indexing cases as well.

In Gick & Holyoak's study of radiation problems (1983), why did most of the subjects fail to notice the relevance of a story analogy to a target problem? In the discussion part, they justified that the difficulty may be related to the problem of identifying the optimal level of abstraction for representing the similar features. If using cases as a resource analogy is a good way to help novice learners understand problem situations and propose solutions, how do we help novice learners see the relevance? How do we help them see more than surface features?

The plausible respond was concluded, from what has been said in previous sections, that, through CBR, using stories collected from experts and indexing them within a case library by deeper features/ thematic features to explicitly show novice learners the relevance between target problems and stories.

Chapter 3

Design and Methodology

The purpose of this chapter is to explicitly lay out how this study was planned and conducted. A good place to start is to set out the rationale of the design. Then it follows up with the general quantitative and qualitative designs, which include detailed descriptions of the sampling strategy, materials and treatment design, instrument development, data collection procedures, and data processing and classification. Finally, the validity and trustworthiness issues are addressed briefly.

Overall Approach and Rationale

Current research discusses how problem-solving skills can be enhanced by situating learners in a contextual environment with realistic cases and by using story-format cases to extend and expand learners' reasoning resources and processes (Hernandez-Serrano, 2001; Kolodner, 1997; Lave & Wegner, 1991). However, there is less experimental evidence and qualitative data about using different story-indexing strategies to help learners understand problems and solve ill-structured problems. This research is a mixed-method design with a quantitative design (control, comparable, and experimental groups) and a qualitative design of think-aloud protocol.

A mixed-method approach is based on pragmatic assumptions, such as consequence-oriented, problem-centered, and pluralistic (Creswell, 2003). The strategies of inquiry that a researcher will use to collect data involve those that help to either "…simultaneously or sequentially to best understand research questions." (Creswell, 2003, p. 18). The methods that a researcher can use include closed-ended measures and open-ended observations to collect both quantitative and qualitative data. In addition, mixed methods sometimes are recognized as integrating, synthesis, quantitative and qualitative methods, multi-method, and multi-methodology (Creswell, 2003).

Creswell (2003) proposed six major strategies of mixed methods based on the four decisions (implementation sequence, priority of using method, integration of data, and use of a theoretical framework). This study uses the "concurrent nested strategy," one of the six mixed method strategies. In this study, the researcher collected both

quantitative and qualitative data simultaneously. However, the quantitative method is the predominant method that guides this project and the qualitative method is embedded within the project. In order to gain broader perspectives and enrich the description of quantitative data, the qualitative method is used to address different questions and seek different forms of information (Creswell, 2003). See Figure **3-1** for the mixed-method strategy.

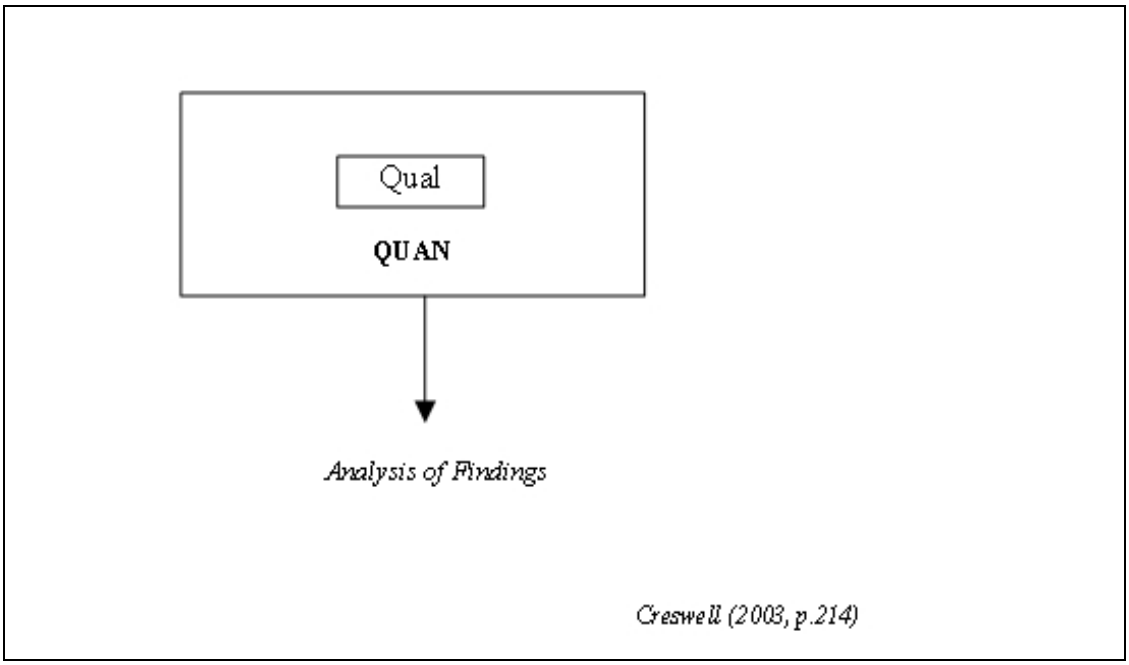

*Figure **3-1***. Concurrent nested strategy.

The mixed-method design intends to fulfill these two main purposes:

1. To utilize the theoretical foundations of narration, case-based reasoning, and analogical problem solving as presented in the literature review chapter to guide the design of experimental research. In other words, this theoretical basis will strengthen this study about the effects of using a thematic story-indexing strategy on solving ill-structured problems.

2. To utilize the same theoretical foundations as a *speculative* guideline to direct the qualitative design, the think-aloud protocol analysis is expected to provide a richer description to cultivate and refine the existing theoretical framework. Verbal analysis, a methodology of quantifying the qualitative coding of the contents of verbal utterances, was used to capture the representation of knowledge that a learner has and how that representation changes with acquisition (Chi, 1997) and to analyze verbal data. It is expected, through this data analysis, a learning model of analogical problem solving can be brought out to answer research questions 2 and 3.

There are several reasons for using the mixed-method design in this study. First, the unique essence of the research questions is that they investigate the higher-order thinking skill, problem solving. It is deficient to analyze the problem-solving outcome without understanding the problem-solving process. A purely quantitative design cannot disclose how the analogical process happens, how learners use stories to solve problems, and how learners use different story-indexing strategies to figure out the similar features between the stories and problems at hand. By adapting the think-aloud protocol, a verbal report format, it is assumed that verbal behavior is one type of recordable behavior and the cognitive processes that generate verbalizations are a subset of the cognitive processes that generate any kind of recordable response or behavior (Ericsson & Simon, 1993). Second, although the qualitative research provides in-depth descriptions and

explanations, it has several limitations, such as generalizability and subjectivism, which can be overcome by quantitative data.

By integrating these two research methods, I can complement and clarify the results from the quantitative data with the use of qualitative data, and test the consistency of findings obtained through different data collection methods: open-ended short answer tests, verbal reports, and the demographic questionnaire.

Quantitative Design

This is a one by three (one independent variable with three levels) with the post test only experimental design. The procedure includes random assignments, training sessions, treatment (different story-indexing strategies), and an open-ended test. The execution of the quantitative design proceeded through six phases. See Figure 3-6 and Table 3.2 for detailed quantitative design procedures.

Sampling Strategies

Qualified participants in this study are college students who register for relevant courses such as marketing management, food marketing management, or agriculture business. The total number of subjects for this data collection were 117, out of which 12 volunteered to participate in the think-aloud protocol. In the experiments, since 16 students left many questions unanswered, they are considered as missing data. The total number of subjects qualified for quantitative data analysis dropped to 89. The courses for which students registered varies from buyer behavior, marketing research, advertising/sales promotion management, global marketing, marketing management policy and programs, agribusiness management, and food product innovation management.

Participants were randomly assigned into three groups. Students in different groups would have access to their own case library.

Material

Before we discuss what materials are used in training and treatment, it is important to provide a background introduction about how the preparation tasks of creating a case library were accomplished.

The first step in implementing the case-based reasoning theory is to create a domain-related case library, a food product case library in this study. The second step is to collect stories from experts in the food industry; see Appendix < A > for the definition of an expert. Most of these tasks were largely accomplished by four faculty members. Two of them are from Penn State's College of Agricultural Sciences, and they specialize in agribusiness and agricultural economics. One of them is a retired senior manager who spent the last 28 years working for a big food company and now is a professor of agribusiness management. Another one is now a professor but he had been a doctoral student in the Instructional Systems program when he worked on this project.

The case library, see Appendix < A > for the definition, in this study was initiated and created by following Kolodner's suggestions (1993) regarding the construction of a case library. She mentioned that problem-solving tasks need to be broken into parts and the designer needs to consider the overall tasks for which the reasoner is responsible. Task analysis takes all these into account in determining how common problems in a specific domain can be broken down into component parts (Kolodner, 1993). Therefore, at first, the team conducted a comprehensive assessment of the tasks of New Product Development (NPD), which begins with defining the goal clearly. Then, after the goal is defined, it is broken into subtasks for achieving the goal, which then are broken into their

component skills. This process continues until the required skills are general skills and typically possessed by junior or senior undergraduates, such as evaluating, judging, and making recommendations (Hernadez-Serrano et al., 2002). See Figure **3-2** for examples of the hierarchical skill analysis map of NPD. The result of the skill analysis is like a road map and serves as a guide for our team to collect stories from experts in the industry field.

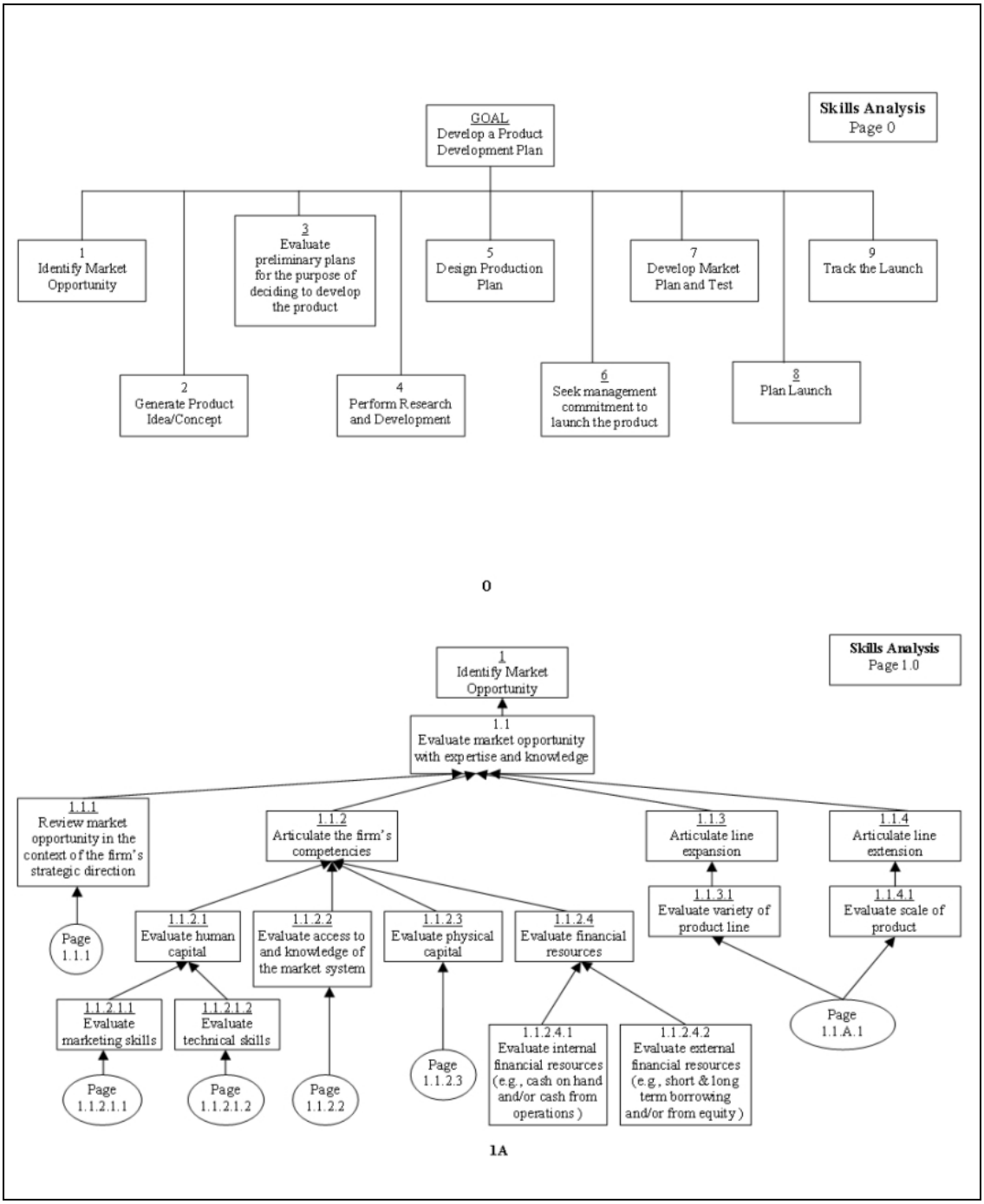

*Figure **3-2***. Hierarchical skill analysis of the new product development.

We interviewed experts and showed them the skill analysis map. It is usual to allow an expert to ramble for a few minutes until a draft story comes out. Then we have to make sure the story includes all of the essential components (characters, incidents, specifics, and lessons). Once the stories were collected, they have to be edited to fit the story format, see Appendix < A> for the story definition. By following the skill analysis map to collect stories, the designer will be able to find out "…the full range of tasks that have to be covered in a program to make it complete" (Kolodner, 1993, p. 538); the food product case library will then be able to cover every aspect of NPD.

In this study, the Fresh-cut Fruit case is a real-world case written by a former doctoral candidate from Instructional Systems and a faculty member from the Department of Agricultural Sciences. It was selected as a resource problem for students to solve because this case consists of ill-structured problems without clear operators and convergent solutions.

Once the problem case, Fresh-cut Fruit, was selected, the next step was to identify the learning issues happening in this case. For example, the learning issues in this case may range from identifying marketing opportunities to generating product ideas. Based on the learning issues, stories involving similar learning issues to the Fresh-cut Fruit case were selected by the researcher, verified by two professors, and put in the case library. See Appendix < B > for the identification of learning issues and selection of related stories in the Fresh-cut Fruit case.

After collecting stories, the next task is to index and label the stories with appropriate vocabulary in order to put them into a case library for future recalling and reminding. Kolodner (1996) mentioned different structures of indexing stories by using

different indexing strategies, such as surface features, deep structures, thematic structures, and so on. In this study, the surface story-indexing strategy and thematic story-indexing strategy (Schank, 1990) are used separately to index stories for the comparable group and experimental group. See Appendix < C > for a detailed explanation of the two story-indexing strategies.

Materials for Training

A short case, see Figure **3-3**, and two relevant stories were used as training material in the training session. The two relevant stories were selected based on the similar learning issues identified in the short case. The training session is to train students to look for similarities between stories and the main issues raised in this case.

A major U.S. food company really believed that they could make all people across the U.S. modify their preferences for potatoes. Their strategy was to make consumers' switch their traditional meals based on "meat and potatoes" to "meat and stuffing mix." They figured that if they succeeded, the rewards were going to be enormous so it was worth trying. Therefore, the company carefully conducted research on potential market size, marketing plans, pricing hurdles, and other aspects using BASES (a model to predict product demand), volume forecasting approaches. Results showed that a "stuffing mix" line of products could be successful. The company decided to press ahead and launched the "stuffing mix" products.

*Figure **3-3***. A short case for training.

Materials for Treatment

The "Fresh-cut Fruit" was used as the problem case for all participants in the three groups. Three food product case libraries have been created as three Web sites and each group has access to one of the case libraries. The same stories are in the three case libraries and the only difference is the story-indexing strategy.

- Control group: stories are not indexed with any labels.
- Comparable group: stories are indexed with surface indexes, which are descriptive information, such as the name of the product, the name of the company, the category of the product, and the process of the product development
- Experimental group: stories are indexed with thematic indexes, including theme, goal, plan, result, and lesson (Schank, 1990).

See Figure **3-4** for an example of a story with surface indexes and Figure **3-5** for an example of a story with thematic indexes.

Company	PepsiCo
Product Category	Beverage
Product Name	AquaFina
Processes	Generate Product Idea/Concept

Just "bottled water"

Just a few years ago, when most people wanted to have a drink of water, most likely they turned to a water fountain in the school, work or home. Nowadays it is more common to see the upscale crowd carrying bottled water. This phenomenon seems to be driven by demographics. People are becoming more health conscious. The attitude seems to be "I don't drink tap water because is chlorinated and I don't trust it. It's not good for my health."

Trying to cash in on this craze around bottled water, the PepsiCo corporation launched its popular water product AquaFina. The marketing managers behind this product knew that this demographic group would be willing to pay a certain price for this product if it matched consumers' notions and expectations of health. That has been paired to powerful images of spring waters from Colorado and France further highlighting notions about health, freshness and purity. The product has been a success.

The AquaFina product has been well positioned against a demographic group. The PepsiCo corporation has been successful by correctly applying demographic data to position a product in the consumer's mind, thus meeting the expectations of the more health conscious consumer of today.

*Figure **3-4**.* A story with surface indexes.

Theme	Generate Product Idea/ Concept
Goal	Generate and evaluate retail product concepts
Plan	Gather qualitative/ quantitative data on retail product concepts
Result	Successfully applying demographic data to position a product
Lesson	Evaluating demographic trends can develop new product concepts

Just "bottled water"

Just a few years ago, when most people wanted to have a drink of water, most likely they turned to a water fountain in the school, work or home. Nowadays it is more common to see the upscale crowd carrying bottled water. This phenomenon seems to be driven by demographics. People are becoming more health conscious. The attitude seems to be "I don't drink tap water because is chlorinated and I don't trust it. It's not good for my health."

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The AquaFina product has been well positioned against a demographic group. The PepsiCo corporation has been successful by correctly applying demographic data to position a product in the consumer's mind, thus meeting the expectations of the more health conscious consumer of today.

*Figure **3-5**.* A story with thematic indexes.

Instrument

Assessing students' answers and solutions for ill-structured problems is more difficult than assessing well-structured problem solutions because of their divergent and probabilistic answers. According to Jonassen (1997, p. 86), "evaluating learners' solutions for ill-structured problems must consider both process and product criteria." In

order to assess students' problem-solving skills, it is necessary to develop methods to systematically evaluate students' thinking about problem solving (Nitko, 2001).

The instrument in this study is developed based on Nitko's (2001) 17 assessment strategies for assessing problem-solving skills; these strategies are organized using the categories of the IDEAL Problem Solver (Brasford & Stein, 1984). See Table **3-1** for assessment strategies. Other problem-solving approaches, such as Patterns of Problem Solving (Rubenstein, 1975), How to Solve Problems (Wickelgren, 1973), and CoRT Thinking Materials (deBono, 1974) don't fulfill the expectation that they would work with ill-structured problems (Jonassen, 1997). These approaches have two major limitations in seeking divergent production approaches: students experienced difficulty in fluently generating alternative solutions, and the methods did not transfer to solve ill-structured problems (Jonassen, 1997). Since these approaches don't work out well for solving ill-structured problems, it is not appropriate to use them to develop an instrument for assessing skills in solving ill-structured problems.

The IDEAL Problem Solver model deals with general problem-solving skills, which may be organized into a five-stage process: identify and recognize problems, define and represent problems, explore possible strategies, act on the strategies, and look and evaluate at the effects. These five steps basically follow the same series as the seven processes for solving ill-structured problems mentioned in Jonassen's paper (1997), and these seven processes are summarized from a model of solving ill-structured problems induced by Sinnott (1989). In IDEAL, there is no emphasis on finding more than one solution that will work, but, by adding Nitko's 17 assessment strategies, this instrument is

able to overcome that problem through asking the problem solver to generate alternative strategies.

In this study, the last two strategies, acting on a strategy and evaluating the value of the strategy, are not appropriate due to the paper evaluation format and time constraint. Therefore, they were not adopted in this study; see Table 3-1. These questions are designed to focus on students' abilities to identify and recognize problems, define and represent problems, and explore possible solution strategies. See Appendix < E > for a detailed definition of these problem-solving components.

Table **3-1**
Definitions of Assessment Strategies

Category	Subcategory	No. of Q
Identify and Recognize Problem	• Construct of identify the problem • Using analogies[1]	2 2
Define and Represent Problems	• Posing questions • Linguistic understanding • Identifying irrelevancies • Identifying obstacles • Describing multiple strategy • Identifying assumptions • Using analogies	1 4 1 1 1 1 9
Explore Possible Solution Strategies	• Integrating data and justifying solutions • Producing alternate strategies • Using analogies	1 1 2
Act on	• Evaluating the quality of the	
Look back	• Systematically evaluate strategies	

Rubric

A rubric of general rules based on the problem-solving components was developed by a doctoral candidate in the Instructional Systems program and a professor of Agricultural Economics; see Appendix < F > for the complete rubric. Two raters used this rubric to assign scores for the students' answers to the open-ended questions. The

raters have to accept training on how to use the rubric to make sure they know how to use it correctly and consistently.

Design Procedure

The training sessions and experiments were conducted during the middle of the semester. All participants had to participate in Training I before they took the treatment. Training I was to train students to use the stories and ask them to look for the similarities between a short case (see Figure. 3-3) and two sample stories. The trainer who has experience in teaching or assisting in case-based instruction is not going to teach any reasoning, matching, searching, or ranking strategies.

When participants had their treatment, each group received a different instructional sheet. The function of the instructional sheet is to show participants how to use and navigate the assigned case library.

The treatment was conducted one week after Training I. Before the treatment, all participants took a demographic questionnaire, which was used to assess students' background information, such as major, gender, age, average GPA, and working experiences. The Fresh-cut Fruit case about food product development is used and designed as Web content within all three case libraries. Students had to read the Fresh-cut Fruit case and all nine stories in the case libraries before they took the test; the maximum time to finish reading was 30 minutes. They could take the open-ended test as long as they finished reading. Students were allowed to browse the case libraries to review the

problem case and stories back and forth when taking the test. The total time for writing the test is one hour. See Figure **3-6** and Table **3-2** for the quantitative design procedure.

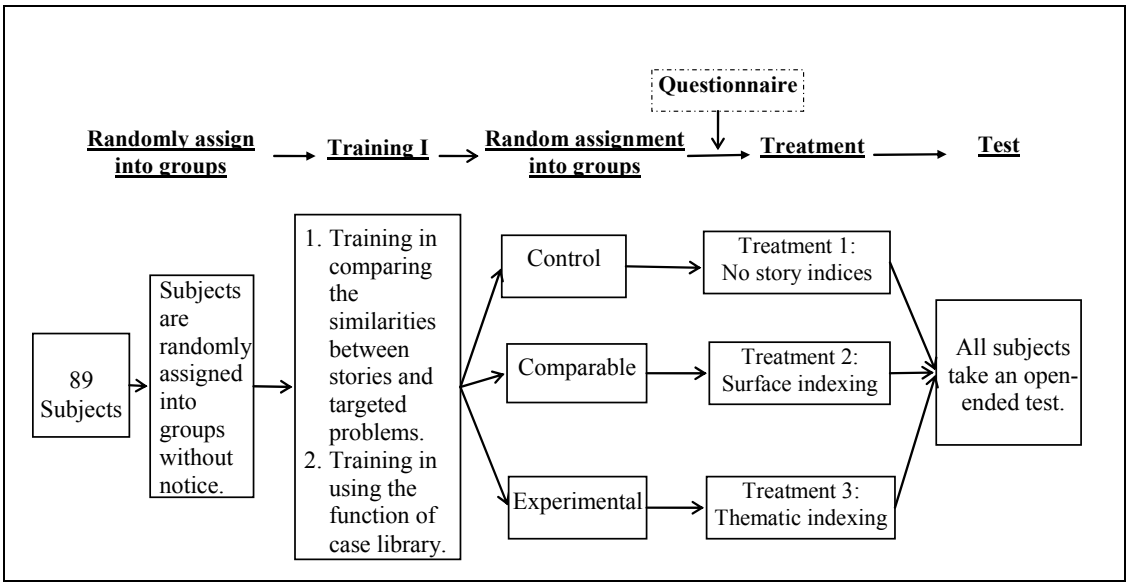

*Figure **3-6***. A flow chart of the quantitative design.

Table **3-2**
Experimental Design Procedure

	Group 1 (control)	**Group 2 (comparable)**	**Group 3 (experimental)**
Random assignment	1. Students were randomly assigned into three groups without realizing the differences in their treatment. 2. Treatment was randomly assigned to the control, comparable, and experimental groups.		
Training I	Material: 1. A short case and two stories without any index or label. Time: 1. 10 minutes: Students read the short case and one of the stories. 2. 10 minutes: Trainer A used one relevant story and asked students to compare the similarity with the short case. 3. 15 minutes: A practice activity was administrated to all participants to practice what they learned from the training.		
Questionnaire	All participants took a demographic questionnaire.		
Instruction	Participants in different group received separate instructional sheets. The instructional sheets instructed participants how to use the case library websites.		
Treatment	Material: 1. Fresh-cut Fruit Case 2.Stories in Case library A **without indexes** Time: 30 minutes.	Material: 1. Fresh-cut Fruit Case 2.Stories in Case library B with **surface-indexing strategy** (product category, product name, product company, development process) Time: 30 minutes.	Material: 1. Fresh-cut Fruit Case 2.Stories in Case library C with **thematic-indexing strategy** (theme, goal, plan, result, lesson) Time: 30 minutes.
Test	Instrument: This is an open-ended short answer test with a paper and pencil format. Time: The total time for participants to take the test is one hour.		

Qualitative Design

Sampling Strategies

There was a total of 12 volunteers who participated in the qualitative design for a think-aloud protocol activity. Seven of them were senior/junior students who took advanced marketing management or agricultural business management courses; five of them were freshmen who took basic agricultural business management courses. They were randomly assigned to three groups to take the open-ended test and talked aloud when taking the test. Due to students' verbal ability, the richness and the completeness of the verbal data that the subjects provided were varied a lot. The researcher selected subjects who verbalized more and completed most questions. The researcher is interested in investigating the influence of academic levels in problem solving ability. Therefore, one senior/ junior student and one freshman student were selected from each group and their data was transcribed for analysis. The total number of subjects used in the qualitative data analysis was reduced to six. See Figure **3-7** for the chart depicting the qualitative design.

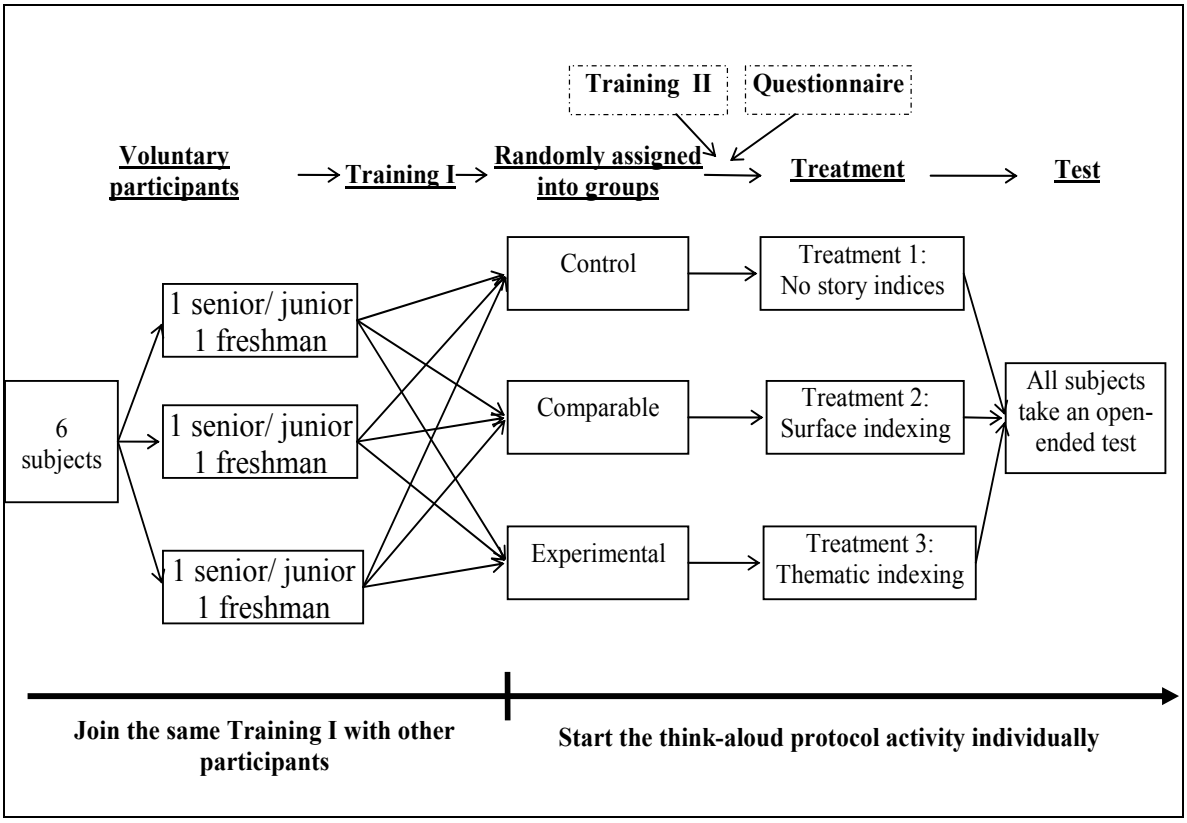

*Figure **3-7**.* A flow chart of the think-aloud protocol.

Methods

The think-aloud protocol, a verbal report format, will be used in this study to collect verbal data. In the think-aloud process, a subject is "…specifically asked to vocalize those self-generated symbols/thoughts while he performs his task" (Ericsson & Simon, 1993, p. 78). While collecting qualitative data, one basic assumption for the researcher to adapt during the think-aloud protocol is that he or she sees verbal behavior as one type of recordable behavior, which should be observed and analyzed like any other behavior.

Ericsson and Simon (1993) identify three levels of verbalization, depending on whether the verbalization requires intermediate processing and brings new information to the learner's attention. Level 1 is simply to verbalize the thoughts in the learner's mind. There is no intermediate process of thinking. Level 2 involves describing, or rather explicating, the thought content. This level does not bring new information to the subject's attention, but only explicates or labels information that is held in an internal format. In this study, it is the third level of verbalization, which requires the subjects to bring story contents to mind and to explain his or her thinking processes, ideas, assumptions or their motives. Subjects are requested to report information which does not come to their attention (Ericsson & Simon, 1993). This type of information is not simply encoded in short-term memory (STM) but requires linking to earlier ideas or information (Ericsson & Simon, 1993). For example, subjects are encouraged to connect the problems to personal experiences or stories they read earlier. They may explain their analogical process of seeing the differences or similarities between the problems and stories. They may talk about how they adapted the solutions used in the story and applied it to the new problem situation.

Data Collection Procedure

Students were asked to do the think-aloud activity voluntarily. Each participant was asked to schedule a two-hour time period to do the think-aloud protocol after the initial Training I. There were seven senior/junior students and five freshmen participating in this activity, and they were randomly assigned to the control group, comparable group,

or experimental group. However, only three senior/junior students and three freshmen were selected and their verbal data were transcribed. Then the researcher conducted the think-aloud protocol with each participant one by one in a quiet discussion room. See Figure 3-7 for the flowchart of the think-aloud protocol.

All participants solved the same problems and took the same demographic questionnaire used in the quantitative design. They read the same Fresh-cut Fruit case, the same stories, and the same open-ended test. The only difference was that participants were asked to take *the training II and then talked aloud* while they did the treatment and wrote the test. See Figure 3-7 for the flowchart of the think-aloud protocol design. Training II instructed them on how to think aloud and provided a warm up exercise to practice "thinking aloud"; see Appendix < D > for the think-aloud training. The processes that students engaged in during the problem-solving activity were video- and audio-recorded. In addition, the researcher took observation notes.

The qualitative data collection began from the moment that the participants started the treatment and did the test. The researcher reminded participants to keep talking if they stayed silent for a while.

Data Analysis Format

Ericsson and Simon (1993) used protocol analysis to analyze think-aloud or talk-aloud data. The focus of the protocol analysis is to see whether the process of problem solving corresponds to the sequence of some "ideal" models; in contrast, the goal of the verbal analysis method is to seek the model that a subject has, without pre-creating an

ideal template (Chi, 1997). For instance, one could take the means-ends analysis (Newell & Simon, 1972), a problem-solving method, as an ideal model in his protocol analysis. Then, his goal would be to see if his think-aloud protocol data fit that specific model.

In this study, instead of seeking the matching processes between some ideal models and the learners' problem-solving pattern, the goal of this think-aloud protocol analysis is closer to the goal of the verbal analysis method proposed by Chi (1997). It is to seek some patterns to capture the representation of knowledge that a learner has when they are doing analogical problem solving.

The data analysis follows the method of verbal data analysis from Chi (1997). The eight steps of coding and analyzing verbal data are listed and described below.

1. **Reducing or sampling the protocols.**
    - Decide on the sets of protocols to be coded.
    - In this study, 6 out of 12 protocols were selected based on the richness of information reported.
2. **Segmenting the reduced or sampled protocols (optional).**
    - Segment the verbal utterances to identify the unit of analysis.
3. **Developing or choosing a coding scheme or formalism.**
    - Choosing a coding scheme or formalism depends on the theoretical orientation of this research, the hypothesis or research questions, the task, and the content.
    - In this study, the first coding scheme "Structure-Mapping Theory" by Gentner (1983) is chosen in a top-down manner. It is found to be the best for coding the data in a meaningful and structural way. A more detailed

explanation and application of the structure mapping theory are described in the findings of qualitative data in Chapter 4.

- The second coding scheme "Analogical function" is developed in a bottom-up process fine-tuned on the basis of the think-aloud data. More explanations of the analogical function schema are described in Chapter 4.

4. **Operationalizing evidence in the coded protocols that constitutes a mapping to some chosen formalism.**
   - Decide what utterances in the verbal data constitute evidence that they belong to a specific category or can be translated into a specific code.
   - See the description in the findings of qualitative data in chapter 4.
5. **Depicting the mapped formalism (optional).**
   - Depict the results of the coding to present the data to audiences.
   - Depict the results of the coding to see if some patterns can be detected in the depicted data.
   - See the results of the qualitative data in Chapter 4.
6. **Seeking pattern(s) in the mapped formalism.**
   - If the coded data are coded into taxonomic categories, then we can see patterns by plotting as bar graphs.
   - If the coded data are presented in a node-link structure, then patterns of interlinkages should be sought.
   - See the results of the qualitative data in Chapter 4.
7. **Interpreting the pattern(s).**

- The interpretation of the patterns depends on the hypothesis being tested, the research questions being asked, and the theoretical orientation of the investigator.
- See the discussion of the qualitative data in Chapter 5.

8. **Repeating the whole process, perhaps coding at a different grain size (optional).**

Validity Issues and Trustworthiness

It is very important to describe the validity issues in both quantitative and qualitative design. The validation of the material and instrument used in this study is described below.

Validation of Material

Material Operationalization:

This process is to operationalize the treatment materials from concept to components/ingredients to validation.

- **Concept: Ill-structured Problem**

Three components are used to judge whether or not the problems in Fresh-cut Fruit (FCF) are ill-structured. This criterion is based on Chi & Glaser's (1985) definition of an ill-structured problem; see Table **3-3**. A problem qualifies as ill-structured or ill-defined if any one of the three components (a clear initial state, a set of permissible operators, and a goal state) are not well specified (Chi & Glaser, 1985). Table **3-4** shows the validity of the questions.

Table **3-3**
The Construct of Ill-structured Problems

Components/ Variables	Validation
Lack of a clear initial state	An expert panel consisting of two professors in the relevant food program and one doctoral student reviewed the Fresh-cut Fruit (FCF) case to see if the problems in the FCF case qualify as an ill-structured problem.
Lack of set of permissible operators	
Lack of goal state	

Table **3-4**
The Validity of Assessment for the Ill-structured Problems

Components/ Variables	Validation
Content complication	The same expert panel verified whether or not the content of FCF case was rich enough for questions to be asked, and whether or not these questions will lead students to generate divergent answers.
Questions	

- **Concept: Case library**

A case library is a systematic collection and organization of a number of experts' experiences presented in the form of stories as the learner interacts with a task environment (Edelson, 1993). See Table **3-5** for the component constructs of a case library.

Table **3-5**
The Component Constructs of a Case Library

Components/ Variables	Criterion	Validation
Stories	Stories should include the presentation of the problem situation and context, the dilemma being faced by the main character (company or expert), and the resolution and lesson (Hernandez-Serrano, 2002, p. 57).	An expert panel consisting of two professors in the relevant food program and one doctoral student reviewed whether or not stories in the case library have these characteristics.
Task environment	According to Hernandez-Serrano (2002, p. 56), the environment can be driven by the following scenario: a goal-based scenario, the case-based, a tutorial-based, exploration-based, and an online system.	The task environment in this study is case-based because students are going to solve problem based on a given case.
Indexing	Detailed criteria are described in Table 3-6.	See Table 3-6

- **Concept: Indexing methods**

The necessary components of an index must include certain contextual and content specifications (Kolodner, 1993; Schank, 1995). Context sets the stage (themes, goals) by describing the state of the world when the episode took place; content specifies salient pieces of what happened in the episode (plans, results, and lessons) (Schank, 1995). See Table **3-6** for the validity of assessment for the construct of thematic indexes. See Appendix < C > for the definition of theme, goal, plan, result, and lesson.

Table **3-6**
The Validity of Assessment for Thematic Indexes

Components/ Variables	Validation
Theme	An expert panel consisting of one professor in the relevant food program and one doctoral student reviewed and indexed each story based on theme, goal, plan, result, and lesson.
Goal	
Plan	
Result	
Lesson	

Validation of Instrument

Instrument Operationalization:

This process is to operationalize the instrument from concept to components/ingredients to validation.

The instrument is developed based on Nitko's (2001, p. 212-215) 17 assessment strategies for assessing problem-solving skills. Nitko's 17 strategies are developed based on Brasford's & Stein's (1984) IDEAL Problem Solver.

The IDEAL Problem Solver model deals with general problem-solving skills, which may be organized into a five-stage process: identify and recognize problems, define and represent problems, explore possible strategies, act on the strategies, and look at and evaluate the effects. These five steps basically follow the same series as the seven processes for solving ill-structured problem mentioned in Jonassen's paper (1997), and these seven processes are summarized from a model of solving ill-structured problems

induced by Sinnott (1989). In IDEAL, there is no emphasis on finding more than one solution that will work, but, by adding Nitko's 17 assessment strategies, this instrument is able to overcome that problem through asking the problem solver to generate alternative strategies.

One professor of agricultural economics and a doctoral student in the Instructional Systems program developed 13 questions based on these strategies; see Appendix < E > for the operationalization of the instrument from concepts to components.

Trustworthiness of data analysis

For the qualitative data, the following strategies are used to check the accuracy of the findings from the standpoint of the researcher, the participant, or the readers (Creswell, 2003).

- *Triangulate* different data sources of information by examining evidence from the sources (transcription, observation notes)
- Use *second reader-checking* to determine the accuracy of the qualitative findings. The data of two subjects are randomly picked up from each question for the second reader to review. The second reader has to accept a training to understand the coding schema of qualitative data <See Appendix I>. The accuracy rate that the second reader reviewed the coding is 87.5% and agreements are achieved after discussion with the first reader.

- Use *rich and thick description* to convey the findings. This may transport readers to the setting and shared experiences of the discussion.

Chapter 4

Results

This chapter presents the results of the data analysis from both the experimental design and the qualitative design of a think-aloud activity. The result of the experimental design that set out to address the first research question (Question 1) will be reported first. Following an overview of statistical data analysis from the multivariate analysis of variance (MANOVA), the hypotheses in chapter 1 will be examined, and the findings will be discussed.

Then the findings of the think-aloud activities, in response to second research questions, will be summarized and discussed. Two major purposes of the think-aloud results are to explore the processes of analogical problem solving and, by doing that, to display insight into the findings of the qualitative data.

Research Results Regarding the Effect of Different Story-Indexing Strategies

The purpose of this experimental design set out to answer the following research question and related hypotheses:

Q1: What are the effects of using different story-indexing strategies within a case library on college students' (novice learners') ability to solve ill-structured problems?

On an open-ended test that evaluates higher-order thinking skills, all groups (a comparable group who have access to stories with the surface-indexing strategy, a control group who have access to stories without any indexing strategy, and an experimental group who have access to a number of stories with the thematic-indexing strategy contained in a case library) will:

H1: perform equally in analogical problem-solving.

H2: perform equally in solving ill-structured problems.

H2.1: perform equally on three sub-skills (identifying problems, defining problems, exploring possible solutions) when they solve ill-structured problems.

The factors of employment experience and academic year are considered to interact with the independent variable and affect the dependent variables. Therefore, two hypotheses are sought.

On an open-ended test that evaluates higher-order thinking skills, all groups:

*H3: with different **story-indexing strategies** and with related or unrelated **working experience** will perform equally in analogical problem solving*

*H4: with different **story-indexing strategies** and in different **academic years** will perform equally in analogical problem solving*

The independent variable is a story-indexing strategy that is used to label and organize stories within a case library. The dependent variables are the abilities to make analogies and solve ill-structured problems. The data used in the statistical analysis were compiled from 89 subjects who were randomly placed in one of the three treatment groups. The three groups included: a control group (n=33), which received a case library containing nine stories without story indexes; a comparable group (n=29), which received a case library containing nine stories with surface-level indexes; and an experimental group (n=27), which received a case library with deep-level indexes.

There are 13 open-ended questions. Students are asked to give brief but elaborate answers. A survey is conducted to get students' demographic information. The sample had a gender ratio of 49/40 female/male. Forty out of 89 subjects were freshmen and the rest of them were junior or senior students. They all had business-related backgrounds. Forty students were registered in marketing management courses and 49 students were registered in agriculture business management courses. Students also reported their working experiences as either part-time or full time (see Table **4-1)**. Their employment experiences were grouped into related work experience (for example, marketing, management, finance, business, retail sales, food development, farming, related internships, or research) and unrelated work experience.

Table **4-1**
Student Work Experience

	Related Work Experience	Unrelated Work Experience	Missing
0	1	5	16
1-6 months	11	14	2
7-12months	10	5	0
13-18 months	3	3	0
19-24 months	1	3	0
2 years or more	10	7	0

This test is an open-ended test. A rubric was created for raters to use when they assigned scores to the open-ended answers. Two raters were trained to use the rubric by following the same training procedure and strategy. The skewness of students' scores is close to normal (skewness of analogical ability = -0.305; skewness of problem-solving ability = 0.155; skewness of analogical problem-solving ability = -0.073). It is very close to zero, which means perfect normal distribution. Therefore, the data are extremely fair and within a narrow range. In addition, based on Anderson's work (1964, 1976, 1977), Colaric justified why she treated her rubric scores as interval data in her dissertation. She explained that the scales of numerically coded category usually produced simple rules of combination that helps to explain the assumption of an approximate equal-interval. (Colaric, 2001). Accordingly, the rubric scores in this study were recorded as interval data.

To decide if Multivariate Analysis of Variance (MANOVA) should be used, two criteria were tested beforehand. They are distribution and relationships between the

dependent variables. The distribution of students' scores is close to normal. The correlation was run to see if the statistical correlation between the two dependent variables falls in the range of low to moderate level (r = 0.25~0.8) (Tabachnick & Fidell, 2001) or (r = 0.3~0.6) (Morgan & Griego, 1998). A multivariate analysis of variance (MANOVA) assumes that dependent variables are correlated. A moderate correlation (r = 0.462) between the two dependent variables in this study was found. Therefore, MANOVA was conducted to analyze the mean differences and the direction and size of correlations among the dependents.

The research findings from the open-ended test about the effects of different story-indexing strategies on novice learners' ability to solve ill-structured problems are presented next.

Statistical Results of Hypothesis 1 and Hypothesis 2

Statistical significance is used to mean something good enough to be believed; the most common level is 0.95, which means that the finding has a 95% chance of being true. However, instead of showing ".95," the statistical packages usually show ".05," which means that the finding has a 5% chance of not being true. In a general description, the result of an experiment is considered statistically significant if the probability of the observed difference among groups occurring by chance along is less than 5% (e.g., a p-value is less than 0.05).

As seen in the MANOVA results in Table **4-2**, the use of Phillai's Trace shows that there were no significant differences (p= .167) for the analogical problem-solving

ability among control, comparable, and treatment groups. The difference between the analogical problem-solving ability among the three groups is 16.7% due to chance and only 83.3% due to the treatment. Therefore, no significant difference was found. Hypothesis 1 was retained.

Table **4-2**
MANOVA Results of the Analogical Problem-solving Ability for the Story-Indexing Strategy

Pillai's Trace	df	F	Sig.(p)*
0.73	4	1.636	0.167

*P <.05

Table **4-3** shows the descriptive results of the two dependent variables: the ability to make analogies and the ability to solve ill-structured problems. Standard deviation is used to measure the variability of the data range. If the data range follows a normal distribution, approximately 68% of the data are within one standard deviation of the mean and 95% are within two standard deviations. Take the analogical ability for example; approximately 22 students (33*0.68) in the no-index group have scored between 48.8-64.7 points (56.74 plus and minus 7.93) and approximately 18 students (27* 0.68) in the thematic group have scored between 50-64 points (56.93 plus and minus 7.26).

The standard deviation in Table 4-3 shows that the data spread out a lot and the distribution curve is flat.

Table **4-3.**
Descriptive Results of Analogical and Problem-solving Ability

	Story Index	Mean	Stand Deviation	Number
Analogical[a] Ability	No Index	56.74	7.93	33
	Surface	57.05	4.8	29
	Thematic	56.93	7.26	27
	Total	56.9	6.77	89
Problem[b] Solve Ability	No Index	40.61	4.48	33
	Surface	38.33	4.45	29
	Thematic	38.11	5.88	27
	Total	39.11	5.01	89

[a]The full score of analogical ability is 78 points

[b]The full score of problem solving ability is 54 points

ANOVA is conducted to see if significant differences exist among individual dependent variables. In Table **4-4**, we can see the univariate analysis of variance (ANOVA) results. It did not show significant differences either for the analogical ability (F=0.016, p=.984) or for the problem-solving ability (F=2.44, p= 0.094). Therefore, the thematic-indexing strategy has no significant effect on both abilities. Hypothesis 2 was retained.

Table **4-4**
ANOVA Results for Two Dependent Variables

	Type III Sum of Squares	df	Mean Square	F	p*
Analogical Ability	1.505	2	0.753	0.016	0.984
Problem Solve Ability	118.553	2	59.276	2.435	0.094

*$P < .05$

Statistical Results of Hypothesis 2.1

The IDEAL problem-solving model (Bransford & Stein, 1984) is used to design the open-ended questions to assess the students' problem-solving ability in this study. The first three sub-skills are identifying problems, defining problems, and exploring solutions.

A multivariate analysis of variance (MANOVA) assumes that dependent variables are correlated. A moderate correlation (r = 0.25~0.8 or r = 0.3~0.6) was found among the three sub-skills of solving ill-structured problems (see Table **4-5**). Therefore, MANOVA was conducted to analyze whether significant differences exist among the three groups.

Table **4-5**
Correlations among the Three Sub-skills within the Problem-solving Ability

	Identify Problem	Define Problem	Explore Solutions
Identify Problem	1	0.57	0.272
Define Problem	0.57	1	0.471
Explore Solutions	0.272	0.471	1

Table **4-6** below shows the descriptive results of the three sub-skills for problem-solving ability.

Table **4-6**
Descriptive Results for the Three Sub-skills within the Problem-solving Ability

	Story Index	Number	Mean	Standard Deviation
Identify[a] Problem	No Index	33	9.64	1.21
	Surface	29	8.98	1.5
	Thematic	27	8.7	1.71
Define[b] Problem	No Index	33	24.41	2.88
	Surface	29	23.33	2.85
	Thematic	27	23.35	3.79
Explore[c] Solution	No Index	33	6.56	1.55
	Surface	29	6.02	1.02
	Thematic	27	6.06	1.52

As seen in the MANOVA results in Table **4-7**, Phillai's Trace shows that there were no significant differences (p= .261) for the three sub-skills within the problem-solving ability among control, comparable, and treatment groups. The differences between the total three sub-skills among the three groups show 26% due to chance and 74% due to the treatment.

Table **4-7**
MANOVA Results for the Three Sub-skills

Pillai's Trace	df	F	p^*
0.88	6	1.297	0.261

*$P < .05$

The results of the separate ANOVA (see Table **4-8**) for each sub-skill also did not show any significant difference between the two sub-skills within the problem-solving ability (define problems, F=1.181, p= .312; explore solutions, F=1.489, p= .231). It did show significant differences for the first sub-skill, identifying the problem (F=3.225, p= .045). Table 4-6 shows that the mean score of the control group is the highest among the

three groups in identifying the problem. It means that the difference between the ability to identify the problem among the three groups is only 4.5% due to chance and 95.5% due to the different treatments, which achieve a statistically significant level. Since the No-Index Group scores the highest, it means that students can do better in identifying a problem without receiving any story indexes. Therefore, Hypothesis 2.1 was rejected. However, the effect size of identifying problem shows 0.07 which is very small. It means that the intervention of different story-indexing strategy has very little effect on the ability of identifying problems in different groups.

Table **4-8**
ANOVA Results for Individual Sub-skills within the Problem-solving Ability

	Type III Sum of Squares	df	Mean Square	F	p*	Effect Size
Identify Problems	13.987	2	6.994	3.225	0.045	0.07
Define Problems	23.772	2	11.886	1.181	0.312	0.027
Explore Solutions	5.741	2	2.871	1.489	0.231	0.033

*$P<.05$

Statistical Results of Hypothesis 3

A two-way analysis of variance (MANOVA) was conducted to see if the related employment experience and different story-indexing strategies have effects on students' ability to solve analogical problems. As seen in the MANOVA result in Table **4-9**, Phillai's Trace shows that there was no significant difference (p= .325) for the employment experience and story-indexing strategy on novice learners' ability to solve

analogical problems. The difference in the ability to solve analogical problems among the three groups is 32.5% due to chance and 67.5% due to the interactive effects of the employment experience and the story-indexing strategy.

Table **4-9**
MANOVA Results of Employment Experience and Story-indexing Strategy

Pillai's Trace	df	F	p^*
0.07	4	1.174	0.325

*P<.05

Statistical Results of Hypothesis 4

A two-way analysis of variance (MANOVA) was conducted to see if students' academic year and different story-indexing strategies have an effect on students' ability to solve analogical problems. As seen in the MANOVA result in Table **4-10**, Phillai's Trace shows that there was no significant difference (p= .497) for the academic year and story-indexing strategy on novice learners' ability to solve analogical problems. Therefore, the difference in analogical problem-solving ability among the three groups is 49.7% due to chance and 50.3% due to the interactive effects of the academic year and the story-indexing strategy.

Table **4-10**
MANOVA Results of Academic Year and Story-indexing Strategy

Pillai's Trace	df	F	p^*
0.017	2	0.705	0.497

*P<.05

Instrument Reliability and Rater Reliability

A reliability analysis was run to ascertain the instrument reliability. There were a total of 26 items (13 major questions consisting of 26 sub questions) in the instrument. The instrument reliability was 0.80.

The individual reliabilities from two raters were 0.77 and 0.78. A paired samples t-test was used to test the inter-rater reliability between two raters. The paired samples t-test compared the means of two variables. It computed the difference between the two variables for each case (Archambault, 2000). The two raters who assigned two sets of test scores were considered two variables in this case. A positive and high correlation ($r = 0.811$) was found between the scores assigned from two raters.

Research Findings Regarding the Analogical Problem-Solving Process

The total number of subjects for this data collection was 117, and 12 out of 117 were volunteers who participated in the think-aloud protocol. They randomly received three different story-indexing strategies (no index, surface index, and thematic index). Six out of the 12 subjects' verbal data were selected according to the richness of the information they provided, the story-indexing strategy they received, and their academic year. The verbal data are transcribed, and coded by the researcher. Three of them were senior students and three of them were freshmen in a public university. The way of their identities was coded as Subject C, D, F, H, J, and L. See Table **4-11** for their academic levels and the different treatments they received when they did the think-aloud activity. They were all defined as novice learners in this study as compared to professionals with years of experience in the food product development field.

Table **4-11**
Subject Information

	Academic Level	**Treatment**
Subject C	Senior	Stories with thematic indices
Subject D	Senior	Stories with no indices
Subject F	Senior	Stories with surface indices
Subject L	Freshman	Stories with thematic indices
Subject H	Freshman	Stories with no indices
Subject J	Freshman	Stories with surface indices

The qualitative data were expected to complement the quantitative data. The analogical problem-solving process cannot be understood without exploring how knowledge is represented and how stories are used to help interpret situations and generate solutions. This think-aloud activity set out to collect verbal data and address the following research questions:

Q2: How do novice learners use reasoning strategies between stories and targeted problems to solve ill-structured problems? Specifically,

Q2.1: How do they figure out the hints behind stories and make connections when they follow the strategies of "identify problems, define problems, and explore possible solutions" to solve ill-structured problems?

Q2.2: What kind of function or roles does a story play in the problem-solving process?

In the following sections, the formation and use of two coding frameworks are discussed. The first coding scheme, a structure-mapping theory by Gentner (1983), was found to be the best way to code the data in a meaningful and structural way. It relies on the exact mapping of propositional representations between target and base domains, which helps the researcher to capture the representation of knowledge that a learner has when he or she is doing analogical problem solving. The second coding scheme emerged as the coding process went on.

Following the coding schema, the findings from the qualitative data are presented following the sequence of the research questions.

Coding Scheme: The Structure-Mapping Theory

A theory of analogy, the structure-mapping theory as developed by Gentner (1983), was used as a coding scheme in this study to understand how the rules of knowledge is mapped from a base domain into a target domain when novice learners solve ill-structured problems. This theory has two important features. First, the rules depend only on the syntactic properties of the knowledge representation; second, the theoretical framework distinguishes cleanly from literal similarity statements, abstractions, and other analogies (Gentner, 1983).

However, this theory is not about using stories to help problem-solving. As the coding process went on, it became clear that stories had several utilities throughout the problem-solving process. Since there is no such framework to use in analyzing the functions of a story during the process of solving ill-structured problems, the researcher let this framework emerge while coding the data. It became interesting to investigate novice learners' reasoning processes by analyzing how analogies are connected to answers at different analogical structures (see Table 4-12) and examining how stories are retrieved and adapted with different functions (see Table 4-13) for different purposes. Through examining the syntactic rules of making analogies when novices receive story indexes, we are able to find out how the different structures of an analogy and the different functions of a story play under different levels of analogical mapping structures.

Before we discuss the findings, it is necessary to explain briefly how to interpret the rules of structure-mapping theory. They are summarized below from Gentner (1983).

Preliminary Assumption

The idea of structure-mapping theory is that an analogy is a mapping of knowledge from the base domain onto the target domain. Domains and situations are viewed as systems of an object, object-attributes, and relations between objects. Knowledge is represented as propositional networks of nodes and predicates. Nodes represent concepts; predicates express propositions about the concepts. There are two essential syntactic distinctions among predicate types. They can be distinguished from the predicate structure: attributes are predicates taking one argument and relations are predicates taking two or more arguments (Gentner, 1983). For example, FRESH (fruit) is an attribute, while DELIVER FRESHNESS (Giant Supermarket, consumers) is a relation.

Interpretation Rules for Analogy

The following interpretation rules are summarized from Gentner (1983). For example, the analogy "a T is like a B" is a mapping from B (base domain) to T (target domain). B is called the *base* because it serves as a resource of knowledge; T is called the *target* because it serves as the target item, object, or situation. The base domain has object nodes $b_1, b_2, \ldots. b_n$ and the target domain has object nodes $t_1, t_2 \ldots\ldots, t_n$. The analogy maps the objects nodes of B to the object nodes of T:

Mapping: $b_1 \rightarrow t_1$

The predicates are expressed as **A** (attributes) or **R** (relations). The mapping rules are

1. Discard attributes of objects:

$$\mathbf{A}_1\ (b_1) \neq \mathbf{A}_2\ (t_1)$$

2. Try to preserve relations between objects:

$$\mathbf{R}\ (b_1, b_2) \leftrightarrow\ \mathbf{R}\ (t_1, t_2)$$

3. (The Systematicity Principle) To decide which relations are preserved, choose systems of relations:

$$\mathbf{R}'[\mathbf{R}_1\ (b_1, b_2), \mathbf{R}_2\ (b_3, b_4)] \leftrightarrow\ \mathbf{R}'[\ \mathbf{R}_1\ (t_1, t_2), \mathbf{R}_2\ (t_3, t_4)]$$

Categories of Analogical Structures

Based on the analogical structure framework of Gentner's structure-mapping theory, the verbal data for six subjects were examined and coded. The purpose was to organize how students make their analogical structure. At the beginning, the coding only focused on the syntactic structures of students' answers and the stories they connected. Later, the functions that a story plays became obviously. A second coding scheme then emerged. It is discussed later.

In the structure-mapping framework, different kinds of domain comparisons are distinguished by comparing the variables of objects, predicates, and object-attributes, and the relations between objects from base domain to target domain. The mapping could

match either only objects, object-attributed, and object relations, or all of them. The differences in mapping these structures are considered to be different analogical structures. Five analogical structure levels are found during the coding process. They are anomaly, surface/non-structural mapping, structure-mapping (first-order and high-order), and deep-level mapping. The mapping that is not found in objects and predicates is defined as an "anomaly", such as *shelf-life/bacteria problem (products) ≠ Not-confident-in-cutting/packaging (Verdelli's R&D, melons)*. The mapping that is found only in objects is defined as a "superficial" or "non-structure mapping", such as *Problem-keep-fresh (Company I,* ***Product)*** *↔ Cannot-provide-demand-of-fresh (Giant,* ***Product)***. The mappings found in relational predicates and object attributes are defined as a "structural mapping". If the structural mapping takes objects as arguments, it is a first-order analogy, such as ***Figure-out-Repackage*** *(Company E, crackers) ↔* ***Figure-out-Repackage*** *(Giant, melon)*. If the structural mapping takes the proposition as arguments, it is a higher-order analogy, such as *Cause [Create safety/****successful-product*** *(Company F, carrots),* ***shortage*** *(Company F, carrots)]↔ Cause [Create tasting/****successful-product*** *(Verdelli, Fresh-cut fruit),* ***Shortage*** *(Giant, FCF)]*. The comparison between Story F (Company F) and the fresh-cut fruit case (Verdelli) is described below. The fact that Company F creates a safe and successful product cause they are running out of carrots, which is compared to the fact that Verdelli creates a tasty and successful product cause Giant has a shortage of fresh-cut fruits. If the comparison is more like a proverb describing a situation than a regular analogy between the base and target, it is considered a "deep-level mapping".

The definitions of analogical structure are described below. Mapping rules and examples are provided in Table 4-12.

- **Anomaly**: The mapping cannot be found in objects, object-attributes, or in relations between objects.
- **Non-structure Mapping** (literal similarity mapping or superficial level mapping): It is a comparison in which only objects are mapped from the base to the target domains.
- **Structure Mapping** (include first-order and higher-order mappings): The structure-mapping category includes first-order relations and higher-order relations. In the structure-mapping theory (Gentner, 1983), the difference between a first-order analogy and a higher-order analogy is the complexity of the arguments in the predicates. The first-order predicates take objects as arguments and the second- or higher-order predicates take propositions as arguments. For example, "***Have-high-demand*** *(consumers, cracker)*" is first-order predicate, which take consumers and crackers as argument; "***Cause*** *[Have-high-demand (consumers, cracker), partner-with (Company E, co-packer)]*" is a second-order predicate, which takes the cause-effect proposition between the first-order predicates as arguments.
- **Deep-Level Mapping (Abstract)**: Few object-attributes between the base and target domains are matched. Deep features connections that are predictive of something important and abstract enough to make a rule to apply for future situations. This deep comparison is more like a proverb describing a situation than a regular analogy between base and target domains. This proverb may

predict unexpected problems, give warnings, avoid mistakes, or hint of solutions. Schank (1999) thought that a proverb is a kind of completed TOPs (thematic organization packets) and comes with an explanation for the complex behavior contained within it (p. 149). TOPs can predict an outcome for a situation and explain why something happened the way it did (Schank, 1999). See Table **4-12** for the syntactic definition and example of different analogical structures.

Table **4-12**
Mapping Rule and Examples of Analogical Structures

Analogical Structure		**Mapping Rules**	**Example**
Anomaly		•$R_1 \neq R_2$ and $(b_1,b_2) \neq (t_1, t_2)$ •$A_1 \neq A_2$ and $(b_1) \neq (t_1)$	• Attracts (sun, planet) ≠ More-massive-than (earth, moon) • Yellow (sun) ≠ Hot (fire)
Non-Structure Mapping (Superficial)		•$R_1 \neq R_2$ but $(b_1,b_2) \leftrightarrow (b_1,b_2)$* •$A_1 \neq A_2$ but $(b_1) \leftrightarrow (b_1)$	• Attracts(sun,planet) ≠ More-massive-than (sun, planet) • Yellow (sun) ≠ Big (sun)
Structure Mapping	First-order	•$R_1(b_1,b_2) \leftrightarrow R_2(t_1, t_2)$ •$A_1(b_1) \leftrightarrow A_2(t_1)$	•Attracts(sun, planet) ↔ Attracts (nucleus, electron) • Yellow (sun) ↔ Yellow (banana)
	Higher-order	•$R'[R_1(b_1,b_2) , R_2(b_3, b_4)] \leftrightarrow R'[R_1(t_1,t_2) , R_2(t_3, t_4)]$ *R_1 or R_2 can be replaced by A_1 or A_2	• Cause [Attracts (sun, planet), revolves around (planet, sun)] ↔ Cause [Attracts (nucleus, electron), revolves around (electron, nucleus)] •Cause{AND[Puncture(vessel), Contain(vessel, water)], Flow-From (water, vessel)}
Deep Level (Abstract)		• Deep features connections are predictive of something important and abstract enough to make a rule to apply for future situation. • When the comparison **is more like a proverb** to a situation (this proverb may predict unexpected problems, give warning avoid mistakes, or hint solutions) than a regular analogy between base and target, it is concerned as abstract mapping.	• The atom is a central force system. • Different products need different production lines to avoid dangerous products.

As the coding process continued, the other coding framework, “Analogical Function”, emerged. Therefore, the verbal data were coded and analyzed under two coding schemes at the same time. Thus, the results and findings can be cross-examined from both frameworks.

Categories of Analogical Function

In this study, all subjects who participated in the think-aloud activity were asked, “what stories come to mind? And how are the stories connected to your answers?” before they gave answers to each question. Stories in the Food Product Development Case Library served as the resource knowledge (base domain) for novice learners to make analogies and to help them solve problems. Personal experiences or knowledge were used as reasoning resources, too.

The framework of analogical function emerged from bottom to top. Lower levels of categories were found first based on what function a retrieved story played. Is this story adopted here to help understand a problem statement or to provide a direct solution to a problem? Is this story revised and adapted here to provide an alternative recommendation or to warn of potential problems? Then the higher levels of categories were sought to include sub-levels of categories with similar meanings and functions. See Table **4-13** for the categories and definitions of analogical functions.

Table **4-13**
Categories and Definitions of Analogical Function

Category	Definition
Object Similarity	A story only provides the function of recalling objects with literal similarity.
Illustration	An illustrative analogy is designed as a comparison of one idea with another. It appears to be metaphorical in nature rather than directed at problem solving. The purpose is merely to facilitative understanding rather than advance solution development. (Bearman, 2002).
Prompting	A story inspires learners to think of next stages, propose new question, or to challenge some ideas under a given situation.
Strategy	A story provides solutions or approaches to a specific question or problem.
Strategy Logistics	A story gives hints to explain why this solution works or how to implement this solution.
Prediction	• A story gives warning about potential problems and provides solutions or suggestions. • A story gives warning about potential problems and may hint learners to avoid repeating mistakes. • A story predicts possible results and may warn learners to avoid making same results.

Research Findings of Verbal Data

The qualitative findings and examples of quotation are presented in the following paragraphs.

How Can Stories Help Solve Problems? (To display data results from RQ 2)

RQ2: How do novice learners use reasoning strategies between stories and targeted problems to solve ill-structured problems? Specifically,

RQ2.1: How do they figure out the hints behind stories and make connections when they follow the strategies of "Identify problems, Define problems, and Explore Possible Strategies" to solve ill-structured problems?

RQ2.2: What kind of functions or roles does a story play in the problem-solving process?

Six novice learners in this study read nine stories from the case library and the fresh-cut fruit case, which is an ill-structured problem. They were prompted to use stories to help them identify problems, define problems, justify their rationale of strategies, and make final recommendations for Verdelli by following the problem-solving procedure of identifying problem, defining problem, and exploring solutions (IDE).

The following paragraphs present how students dealt with the fresh-cut fruit case by following the IDE problem-solving procedure and making analogies from stories stored in a case library.

Identify and Recognize Problems

Students in this study were asked to answer two questions that were designed to evaluate students' ability to identify the construction of problems and opportunities for both Giant Food Supermarket and Verdelli Foods in the fresh-cut fruit case.

When stories were used to help learners identify problems, it was found that 71% of these stories played an illustrative function, including illustrating lower-order and higher-order relations. Twenty-two percent of stories failed to play any function in helping to identify problems (see Table 4-14). As for the analogical structure, 60% of analogies were described in a first-order structure to help learners identify problems; 23% of analogies were described as totally off the mark (anomaly); only 13% were described in a higher-order structure; no story analogy was made in a deep-level structure (see Table 4-15). See Tables 4-12 and 4-13 for the definitions of analogical structure and analogical function. The following paragraphs include an example with quotations cited from the student's verbal data.

Following the quotation, the codes of analogical structures and analogical functions are explained.

Q1: Are there problems or opportunities facing Giant Foods in providing fresh-cut melons to customers at Giant Food Supermarkets? What are they? What stories remind you of the problem/opportunities that Giant is facing?

Q2: Are there problems or opportunities facing Verdelli Foods in providing fresh-cut melons to customers at Giant Food Supermarkets? What are they? What stories remind you of the problem/opportunities that Giant is facing?

Subject J

Giant's problem was that after **Verdelli created a very good-tasting fruit snack, Giant Foods started to run out, and had a shortage, so Giant's problem was a shortage of food snacks**, so they had to order more. Shortages of fruit snacks. So examples could be the bottled water one because, actually, no not the water bottle one. Shortage The shortage was the carrots, which was story (F) because after the carrot company figured out how to sell their product safely, so after that consumers basically bought it out. Carrots sold out rapidly. Another example was the (A) Aquafina water bottle, actually no, Aquafina water because a new product was introduced that was successful just like the fruit cups, because consumers liked the small size 6 oz fruit cups.…… **Giant's problems, Giant had to deal with other companies in order to deem a good product.** Giant has to interact with other companies…To make money...well...I think that is about it. Actually, I guess Story (E) could go with opportunities because the cracker industry had to team up with other industries in order to create a small product. A pack that consumers like. So a cracker company had to interact with other companies.

Subject J identified Giant's problems as "*CAUSE {Cause [Create tasting/successful-product (Verdelli, FCF), Shortage (Giant, FCF)], has-team-up-with (Giant, other company)}*." It means that Verdelli creates a very tasty and successful product that causes Giant to run out of fresh-cut fruit. Therefore, Giant has to team up with another company. He compared Giant's problems to story A: "*Create new/successful-product (Company A, Aquafina water)*" and story E: "*Team-up-with (Company E, other partner).*" These two comparisons are recognized structurally as first-order analogies and functionally as illustrations. He also compared to story F: "*Cause [Create safety/successful-product (Company F, carrots), shortage (Company F, carrots)]*." This comparison only matches the first part of the cause-effect relation of Giant's problem, and it is recognized as a structurally higher-order analogy and functional illustration.

As you can see from the example, the stories subject J recalled to help him identify problems were more like metaphors. In Bearman's study (2002), it was concluded that analogies with an illustration function appeared to be metaphorical in nature. Instead of facilitating directly with generating a new solution idea, the purpose of this kind of analogy is to exemplify or illustrate an existing idea.

Table **4-14** shows the relations between the problem-solving process and analogical function.

Table **4-14**
Relation between the Problem-solving Process and Analogical Functions

	No function	Object Similarity	Illustration	Prompting	Strategy	Strategy Logistic	Prediction	Total
Identify Problem	22%	4%	**71%**	2%	0%	0%	0%	100%
Define Problem	11%	4%	**49%**	2%	18%	0%	17%	100%
Explore Solution	21%	3%	0%	0%	**31%**	24%	21%	100%

Table **4-15** shows the relations between the problem-solving process and analogical structure.

Table **4-15**
Relation between the Problem-solving Process and Analogical Structures

	Anomaly	Superficial	First Order	Higher Order	Deep Level (Abstract)	Total
Identify Problem	23%	4%	**60%**	13%	0%	100%
Define Problem	11%	4%	**47%**	31%	7%	100%
Explore Solution	22%	4%	26%	**37%**	11%	100%

Define and Represent Problems

When stories were used to help define a problem, it was found that 49% of stories played an illustration function, 18% of stories played a strategic function, and 17% of stories played a prediction function (see Table 4-14). As for the analogical structure, 47% of analogies were described in a first-order structure to help learners define problems; 31% of analogies were described in a higher-order structure; and 11% of stories were not connected at all (see Table 4-15). See Tables 4-12 and 4-13 for the definitions of analogical structure and analogical function.

Students in this study were asked to answer nine questions to demonstrate their ability to define a problem. The following paragraphs include the nine questions that are divided into six sub-categories of defining a problem. These six sub-categories are posing questions, linguistic understanding, identifying irrelevancies, identifying obstacles, describing multiple strategies, and identifying assumptions. The following section includes nine questions and nine examples with quotations cited from the students' verbal data. Then following each quotation, the codes of analogical structures and analogical functions are explained.

Posing Questions

Q3. Image yourself as Dan Verdelli. What kinds of questions will you ask yourself to help you define the scopes of the problems facing Verdelli? Please list your questions. What stories remind you about what Dan Verdelli has to ask himself when he deals with the problems?

Subject H:
Verdelli would want to know **what the demand is for the fruit product**, **how much will it cost to keep the product fresh to overcome the problem with pathogen growth**...what the demand is and what the cost per unit would be…I guess **A**, there is a high demand for the product that is realized…**D** Indulgent phenomenon with Nabisco, I think would definitely be because we are talking about a product with high demand, doesn't really deal with freshness or anything…**G**, General Foods Ready to Eat meals, I think it is because he is wondering about there is a problem with freshness that they noticed a demand for freshness. He is wondering about the cost per unit would be, and here we are told the cost per unit is very high when they are keeping due to the distribution scheme that is developed to keep it fresh.

Subject H posed two questions for Verdelli: "*What-demand-for (Verdelli, FCF)?"* and "*How-much-cost-to-overcome (Verdelli, bacteria) and How-much-cost-per-unit (Verdelli, freshness).*" He suggested that Verdelli asked himself questions like what is the demand for fresh-cut fruit? How much does it cost to overcome the bacteria problem and how much does per-unit freshness cost? He compared these questions to stories A and D: "*High-demand (Company A/D, products).*" Companies A and D have high demand for their products. Therefore, these two comparisons are recognized structurally as first-order analogies and functionally as illustrations. He compared the second question to story G: "*How-much-cost-per-unit (Company G,*

freshness)". This comparison is recognized structurally as a first-order analogy and functionally as an illustration.

Linguistic Understanding

Q4. What are the quality assurance (QA) and safety issues to be addressed?

Subject L
Problems with **micro bacterial growth and also to keep that safe and also in the packaging.** With Story **G** it has to do with the safety and the shelf-life. There was time for **pathogen growth** and then with that another factor was the salmonella food poisoning outbreaks from the melons because the melons were less acidic than the pineapples. So there was salmonella poisoning factors.

Subject L addressed the quality assurance and safety issues for Verdelli: "*Safety/Bacteria-concern (Verdelli, melons)*" and "*Packaging-concern (Verdelli, melons).*" She only compared one of the concerns with story G: "*Safety/Bacteria-concern (Company G, ready-eat-meals).*" This comparison is recognized structurally as a first-order analogy and functionally as an illustration.

Q5. Why is the packaging of this product an important concern for Giant Foods?

Subject F
Because this reminds me of the peanut story **because you don't want to get your customers sick**. The peanut story was **H**. Why is this packaging of this product an important concern for Giant Foods? Because you don't want to infect customers. And **you want to avoid customers' complaints**, just like the kids that got sick that were allergic to peanuts in the Hershey snack, the peanut granola bars, well it was the cinnamon ones, the peanut oil leaked into the cinnamon. You have to be careful, because that could potentially hurt your company, hurt your company

greatly, either you lose a lot of business or if you do have to do something about it, then you could spend millions of dollars correcting the problem.

Subject F addressed how packaging is an important concern for Verdelli: "*Good-Package-can-avoid-hurt (Consumers)*" and "*Good-Package-can-Avoid-complaints (Consumer).*" He only compared one of the concerns with story H: "*Poor-package-can-hurt (consumers, company) = Not [Good-Package-can-avoid-hurt (consumer and, company)].*" This comparison is recognized structurally as a first-order analogy and functionally as an illustration.

Q6. Why is the cutting and packaging of this product an important concern for Verdelli?

Subject H
It is also important because these are some of the factors that affect freshness and product safety…So I would say F packaging affects product quality and freshness.

Subject H addressed how packaging is an important concern for Verdelli: *"Cause [Good-package (fresh-cut fruit), Safety-Freshness (fruit)].* He compared it with story F: "*Cause [Good-package (carrots), Safety/Quality-Freshness (carrots)].*" This comparison is recognized structurally as a higher-order analogy and functionally as an illustration.

Q7. After processing this product, what marketing concerns is Verdelli facing?

Subject D
Going back to the fresh fruit cut case, so, I didn't really talk about this, but it brings to mind **story C** the Friendly's restaurant situation because this is a **relatively new thing, fresh cut fruit, and who knows if it is going to continue.** Consumers are notorious for changing their mind on just on a whim. Friendly's was doing really, really well and the economy turned around and Hershey just started to realize that they hadn't done enough research into this. So Verdelli is really going to have to, I guess their whole business is fresh cut fruit from what I remember from the case, oh yeah they do iceberg lettuce and other such things,

> **they have to be sure that the market is not just going to change on them. And if it does change on them, they need to have some type of I guess kind business continuity plan** where they would be able to meet this challenge and have some kind of plan to deal with it and maybe have some back up products ready to be developed or just do a massive marketing campaign to kind of help the consumer back into the fold.

Subject D proposed a market concern for Verdelli: *"Cause {New-product (FCF business), AND [Market-trend-change-concern (FCF business),* ***Backup-product or plan-for (FCF business)]}****.*" He thought fresh-cut fruit was a new product and the marketing trend was not always the same. Therefore, story C gave him the clue to suggest that Verdelli should have a back up plan. Story C: "*Cause [New-product (Restaurant business), Market-trend-change-concern (Restaurant business)]* → *suggest Verdelli to have back up plan for FCF business.*" This comparison is recognized structurally as a higher-order analogy and functionally as a prediction (predict problems and provide solutions).

Identifying Irrelevancies

> *Q8. What is the irrelevant/less important information in the FCF case for you when you try to come out with solutions for Verdelli?*
>
> **Subject D**
> Let's see. I think probably one of **the lesser issues is cutting into the market share of pineapple**, I mean that is really Verdelli is their main fresh cut fruit product, and they certainly would want to keep it going, but I mean pineapples and melons are very different tasting. I really don't like pineapples, but I do like melons so I think that is one of the lesser issues…A similar situation is A the Pepsi in the Aquafina is not really going to cut into Pepsi's market share at all. Aquafina is a totally separate product and it is, Pepsi got into a different market, and if it does cut into Pepsi's market it will not be very large because the Pepsi product is such a strong product.

Subject D thought the less important information for Verdelli was the issue of whether or not melons cut into the existing market of pineapples: *"Issue-of-Cutting-into-existing-market-share (Melons, pineapples)"* and he compared this with story A: "*Issue-of-Cutting-into-existing-market-share (bottled-water, soda drinks).*" This comparison is recognized structurally as a first-order analogy and functionally as an illustration.

Identifying Obstacles

Q9. Why is it difficult for Verdelli to cut and package fresh-cut melons for Giant? What are the obstacles? What additional information does Verdelli need to overcome these obstacles?

Subject F:
For additional information he needs new packaging ideas and hopefully he can find one. What are the obstacles and why is it difficult for Verdelli to cut and package the fresh cut melons for Giant. Well **obviously the problem is bacteria**, and let me go back to the case. Yeah the problem. And **they are less acidic**. …and additional information that he needs – **a different distribution channel, distribution channel information and he needs** that because it might be related to the refrigerated food case, which I believe it is **G**, because maybe **they can't do it and the reason why the refrigerated foods doesn't work in U.S....but the food in England, reason it worked there was because it was much smaller**, so they could prepare the foods in the morning and deliver they would sell them, but **in the U.S. it didn't work because it is such a vast territory**.

Subject F identified the difficulty for Verdelli in cutting and packaging melons: *"Cause [Less-acidic-than (melon, pineapple), Bacteria-grow-problem (Verdelli, melons)]"* and the information he needed is "*Different distribution channel information (melons, pineapples)]."* He compared this with story G: "*Different geography with*

different distribution channel leads to different sale result." This comparison is recognized structurally as a deep-level analogy and functionally as a prediction (predict result and avoid mistakes).

Describing Multiple Strategies

Q10. What strategies/approaches can you suggest to Verdelli to deal with the constraint on the limited shelf-life of fresh-cut melons?

Subject C
So again we are looking at the constraints of limited shelf-life and any strategies that may help this. I think **Story F** is very similar in the carrot case, the actual case, what strategies did they employ, they changed around a little bit add ice cube, and found how much was too much water, how much was not enough, how can they optimize the shelf life, so again what strategies so they are going want to have to move this product pretty fast which was a problem for **story G** General Foods, where the product had a somewhat limited life span but wasn't successful, so they really had a dilemma on their hands and they also want to worry about costs because they want to **make it as fresh as possible and get it to the consumer as quick as possible**, but how much will they have to alter their existing distribution channels, so it will be a big constraint on them. So compared to Story G as well…So **my recommendation would be to shorten the distribution channel as much as possible**

Subject C suggested that Verdelli shorten the distribution channel "*Cause [Shorten-distribution-channel (Verdelli, melons), deliver-fresh (melons, consumers)]*." He got the idea of shortening the distribution channel to keep the fruit fresh from story F and story G. Story F provides an alternative of maximizing shelf-life by adding ice cubes: "*Cause [Add-ice cube (Company F, carrots), Maximize-shelf-life (Company F, carrots)]*." Story G suggests changing the existing distribution channel to deliver freshness: "*Cause [Alter-existing-distribution-channels-of (Frozen meals, Refrigerated meals), deliver-fresh (refrigerated meals, consumers)]*." The comparison with story F is

recognized structurally as a higher-order analogy and functionally as providing an alternative solution (adding ice cubes to maximize shelf-life is an alternative solution for optimizing shelf-life and freshness). The comparison with Story G is recognized structurally as a higher-order analogy and functionally as providing a solution.

Identifying Assumptions

Q11. What are the assumptions that you used to answer Q10?

Subject C
I guess first my main assumptions I am making are **that consumers will not accept a product that doesn't taste and appear completely fresh**, because side by side will be fresh melons. **They want the convenience, but they don't want to sacrifice freshness**……..Okay I guess looking at the story **D**, Nabisco, looking at the actual story, Nabisco saw that there was this trend towards healthy eating. And that there was definitely a niche for it and they went ahead and marketed a whole new brand. And rolled it out and then all of a sudden people, they weren't buying the product. Because they were eating healthy for 5 days and then just what they called the "indulging" phenomenon. So I would go ahead and compare to this because Verdelli and Giant are making the assumption that people want this fresh cut fruit and they want this convenience so maybe people are only eating fruit for big parties, maybe they don't want the single servings, or maybe the cost is gonna be too much to outweigh the convenience that people may expect. So are they misjudging what the consumer wants.

Subject C assumed that consumers would not sacrifice freshness for convenience: "*Cannot-sacrifice-freshness-for-convenience (Consumers, melons).*" He compared it with story D: "*Misjudge assumptions of eating trend/behavior can fail a product.*" By comparing it with story D, subject L wondered if Verdelli made the wrong assumptions about consumers' eating behavior. Maybe consumers cannot sacrifice freshness for convenience. Like story D, the company misjudged the eating trend, causing the sudden death of this product. The comparison with story D is recognized structurally as deep-

level analogy and functionally as prompting and prediction (provide problems and avoid mistakes).

Explore Solutions

When stories were used to help explore solutions, it was found that 31% of the stories played the function of providing a strategy; 24% of the stories played the function of providing a strategy logistic; 21% of the stories played the function of prediction; no stories are used to illustrate examples. As for the analogical structure, 37% of analogies were described in higher-order structures to help learners explore solutions; 26% of analogies were described in first-order structures; 11% of stories were described in deep-level structures, and 22% stories are not connected at all (anomaly). See Tables 4-14 and 4-15 for detailed information.

Students were asked two questions to explore possible solutions for Verdelli according to the problems and opportunities they defined for the company. They had to integrate information and justify their rationales for their recommendations. The following section includes the two questions and two examples with quotations cited from two students' verbal data. Following each quotation, the codes of analogical structures and analogical functions are explained.

Integrating Data and Justifying Solutions

Q12. There are several possible solutions to the problem of the fresh-cut melon idea. Verdelli may want to conduct more research and study, wait for several years, launch the product immediately by cloning the process and operation used by Giant produce employees, or other solutions. What is your recommendation for Verdelli? Please justify this recommendation by identifying your rationale/reasoning and what information you used to reach this recommendation.

Subject C

I think the launch could be somewhat soon, I would start it on a smaller scale, like Nabisco did, in Story **E** in the packaging, where they had this new idea for smaller servings but they just launched it in a limited Philadelphia in just a 3 or 4 stores and then when that was wildly successful they did a more national launch, I think that might be a good idea. To you know test the waters to see how this product sells, how fresh it stays, who is buying it, and then they would have a much better indication as to how it plays out on the national market. The process and operation used by Giant, well that would be optimal, but how much will it cost for Videlli? That may be something that is just too expensive. I'm not really sure how they distribute the pineapple, right now and things like that, but melon again is a different story and they are going to need to figure out things like that so I guess **my recommendation would be launch, they can launch it soon, but again limited line**. Work out any kinks that may be present. Work out, so again who do I see this being similar too, again Nabisco very similar in their limited launch in the Oreo cookies, just reviewing the case, looking at **A** the Pepsi case, haven't used that yet, but it is not totally similar. Evaluating demographic trends [**Lesson**], I think they can do that by putting in a limited launch they will be able to have a better idea as to what is going on……..Well they already had this product idea and concept idea they just want to make sure **they can apply it to a certain demographic and position it well**. So I guess then that would be similar to **A** bottle water story.

Subject C recommended launching this new product carefully on a small scale:

"*Cause [Different/new (new product, old product), Limited-launch-not-national-roll*

(Verdelli, melons)]." He compared it with story E: "*Cause {Different/new-idea (small package, big package), IF-then [limited-launch-smoothly (company E, crackers), Nationally-launch (company E, crackers)]}*." In story E, they didn't launch the new package size, i.e., a small package, nationally until it was successful in a launching in the local area. By comparing it with story E, subject C recommended that Verdelli launch the new product (fresh-cut melon) in a limited area first because fresh-cut melon is a different product from fresh-cut pineapples. The comparison with story E is recognized structurally as a higher-order analogy and functionally as providing a solution. He also compared it with story A: "*Evaluate demographic trends with limited launch can position a product well.*" Subject C picked up the lesson learned from story A. He thought if Verdelli placed a limited launch, Verdelli would be able to evaluate certain demographic trends. By doing so, Verdelli could position a new product well. The comparison with story A is recognized structurally as a deep-level analogy and functionally as strategy logistics (explain why implement limited launch) and prediction (predicts problems and avoids mistake of failing to position a product).

Producing Alternate Strategies

Q13. What should be Verdelli's Plan B?

Subject J
…it seems that Verdelli is doing well in that field and just getting greedy in trying to sell melons, **so Plan B would be just go back and sell what they were selling before**, because it seems that was an adequate, enough money making. An example could be, I guess Story **G**, since they did marketing research, they figured out they could not sell it, so I guess they did bring it back to their point of view which is to sell their regular General Foods. So Story G is similar <u>because</u>

they went back to selling their regular foods. Another one could be, I think that is about it. Okay.

The recommendation that Subject J proposed for Verdelli is to conduct more research. As for plan B, Subject J suggested that Verdelli give up the new idea and go back to sell the old product as the back-up plan: "*If-then [Give-up-new-product (Verdelli, melons), Back-to-old-product (Verdelli, pineapples)]*." He compared it with story G: "*Cause {Did-Marketing-research (refrigerated meals), If-then [Give-up-new-product (Company G, refrigerated meals), Back-to-old-product (Company G, frozen meals)]}."* The comparison with story G is recognized structurally as a higher-order analogy and functionally as providing a solution.

Stories Are Used for Multiple Functions (To address the findings for RQ2)

Now having displayed the detailed verbal data and having made this point that analogical structure and analogical function are related to the stages of the problem-solving process, we may address the findings for the second research question.

Based on the discussion in the previous section, it seems reasonable to believe that novice learners are trying to use stories for multiple functions depending on the problem solving tasks they encountered. Thus,

- when they had to identify problems, they looked for illustrations. Stories with an illustration function give direct examples of how others encounter the same situations and are aware of their problem's situations. In the next example,

subject H compared Giant's opportunity with story G. He identified the opportunity in both cases is that the products are in great demand.

> Example:
> *Identify Problems/ Opportunities* (*Q1: Are there problems or opportunities facing Giant Foods in providing fresh-cut melons to customers at Giant Food Supermarkets?)*
>
> Subject H
> ….And **their opportunity is that there is a great demand** that could be realized if they found someone, another processor to cut the fruit for them. General Foods ready-to-eat meals and I think that relates because it is also talking about, **G**, I think relates because it is also talking about freshness. And even more **because it says that it is known that in England that there is a great demand** that the United States isn't able to realize.
>
> > Coding:
> > Story G: (**Provide Illustration**)
> > **Has-Great-demand-**in-England (ready-eat-meal)

- when they were asked to define problems, they looked for stories that provided illustrations, solutions, or even predictions. Stories with an illustration function show how others diagnose their problems; some stories even provide solutions or predict potential problems when a problem is defined. See the following paragraph as an example. One component used to assess the ability of defining the problem is the linguistic understanding of some important concept. Subject C thought that packaging is an important concern because you want to reach a variety of customers. He picked up the lesson learned from story E, which provides a solution for reaching customers.

> Example:
> *Define Problem-Linguistic Understanding (Q5. Why is the packaging of this product an important concern for Giant Foods?)*
>
> Subject C

…And also packaging them is an important concern for Giant because they need to find, through market research, what size exactly consumers want and what size would sell best. So. Looking through the cases to see similarity. Scroll down…hmm…Again, case E, Nabisco packaging for convenience. I would go…**I would go with the lesson here that was learned that you know you need to perform market tests** to reach the variety of customers, you need to go to find out who your core demographic would be in the supermarket, to see who is currently buying the pineapples or who is currently buying fresh salad, and things like that.

Coding:
Story E: **Lesson (→Provide Solution)**
Cause [Package-size-concern (Company E, consumers), Perform-market-test-find-out (Company E, consumers' preference)]

- when they were asked to explore solutions, they looked for stories that provided strategies/solutions directly, strategy logistics (how to implement the strategy or why this strategy works), or predictions (warnings). Subject J gave his recommendation by looking at story C (predict that a problem in which a lack of research may cause a product to fail) and story D (provide a solution: conduct more research to know the customers).

Example:
Explore Solution- (Q12. What is your recommendation to Verdelli? Please justify this recommendation.)

Subject J
So my recommendation would be to research and study the melon idea for a little bit longer...Stories that would come to mind would be **C** Friendly's restaurant since they acted on the idea that everyone was going to restaurants, **so instead of research a bit more, they really jumped on it and lost a tremendous amount of money**, so Friendly's should have researched more, I mean Hershey's since Hershey's bought them. Another example would be, well I guess the **D** Nabisco low-fat calorie story, even though they did research, I guess you just can't really predict what people are going to do. But **maybe if they actually went out and asked people, how fat they think they are, how much do they eat. So maybe Nabisco should research more**.

Coding:
Story C: **(Predict Problem, Avoid Mistake)**
Cause [Lack- of-Research (Company C, restaurant business timing), fail-investment (restaurant business)]
Story D: **(Provide Solution)**
Through [Conduct-more-Research-about (Company D, consumers), Know people's needs (consumers)]

The results of the quantitative data analysis showed that the thematic story-indexing strategy has no significant effects on helping solve problems and make analogies. From the results of the qualitative data analysis, it was found that students (a) used stories for different functions depending on the problem solving tasks, (b) made many first-order mapping during when their problem-solving goal is to identify problems and define problems, and (c) made more higher-order and more deep-level mapping when their problem-solving goal is to explore solutions. (See Tables 4-14 and 4-15.) Therefore, findings 1 and 2 are provided below.

1. **"In different stages of problem solving, students tend to look for stories with appropriate functions that achieve their goals."** When their problem solving goal is to identify problems, they looked for stories that provided similar illustrations; when their problem solving goal is to define problems, they looked for stories that provided illustrations, solutions, or even predicted mistakes and results; when their problem solving goal is to generate solutions, they sought stories that provided strategies/solutions directly, explained strategy logistics, or predicted mistakes and results.

Take Subject D for example: When the goal was to identify problems, he searched for an illustrative story to help him understand the problem situation faced by Giant Foods.

> Subject D:
> I think the main problem that Giant has is that **they really don't have the know how to do it themselves**. **They have to go through Verdelli** who has been dealing with fresh cut pineapples for years. …….The retail level with the salads (Story I) is similar too simply because the retailers themselves did not know what to do and so they had to… **like Verdelli, the maker of the salad had to step in and** show them what was going on in order to get it to work.

Take Subject C as an example: he tried to propose questions from Verdelli's perspective in order to help Verdelli define the problem of packaging. He thought that Verdelli should ask himself how big or small the package size should be. He adapted the solution used in story E to answer Verdelli's concerns. In story E, the package size is decided based on the convenience store size. Subject C suggested that Verdelli should balance the size based on consumers' needs and store convenience.

> Subject C:
> **how big or small they are going to package this** because, again, single serving for two people for family, you know…and….do they have different needs and keeping this fresh depends on the serving sizes…….. …… in the **E** packaging for convenience case,….. What they had to decide was **how big to make the product for a convenience store**. But, on the other hands, they wanna make sure that ..you know…**balance how much this is going to be individually serving food or family serving**. [The researcher: C adapted a solution from story E. It is "A convenience size for store and balance consumers' needs"]

2. "Students vary the complexity of their analogies in different stages of problem solving." They were prone to make lower-order analogies when identifying problems; they made lower- and higher-order analogies when defining problems; they tended to make higher-order analogies when exploring possible solutions.

Compare Tables 4-14 and 4-15; when the students identified or defined problems, they seemed inclined to think in simple way so that they could make analogies in a lower-order structure. Stories with an illustrative function contributed mostly to helping them define the scopes of the problems. When the students sought stories to help them generate solutions and justify their suggestions, novice learners were prone to think in complex relations so that they made analogies in higher-order structures.

It is also interesting to identify the existence of a relationship between the analogical structure and the analogical function. Table **4-16** shows that stories compared in the superficial (non-structure mapping) structure showed students the literal similarity between objects. Of the stories compared in the first-order structure, 84% played an illustration function. Of stories compared in the higher-order structure, 33% provided strategies or solutions, 33% illustrated examples, and 26% predicted potential problems and results. Of stories compared in the deep-level structure, 57% played a prediction role (predict problems/results and provide warnings to avoid mistakes), 21% provided logistics for implementing solutions or explained why the solutions worked, and 14% provided solutions.

Table **4-16**
The Relation of Analogical Structure and Function- by Structure

	No Function	Object Similarity	Illustration	Prompting	Strategy	Strategy Logistics	Prediction	Total
Anomaly	**100%**	0%	0%	0%	0%	0%	0%	100%
Superficial	0%	**100%**	0%	0%	0%	0%	0%	100%
First Order	0%	0%	**84%**	0%	11%	2%	4%	100%
Higher Order	0%	0%	33%	4%	**33%**	4%	26%	100%
Deep Level (Abstract)	0	0%	0%	7%	14%	21%	**57%**	100%

Regardless of the problem-solving process, students increase the complexity of their analogies from superficial, to first-order, to higher-order, to deep level as they use the function of an analogy from p

roviding object similarity, illustration, prompting, strategy, providing strategy logistics, and prediction. See Table **4-17** for information.

Table **4-17**
The Relation of Analogical Structure and Function- by Function

	No Function	Object Similarity	Illustration	Prompting	Strategy	Strategy Logistics	Prediction
Anomaly	**100%**	0%	0%	0%	0%	0%	0%
Superficial	0%	**100%**	0%	0%	0%	0%	0%
First Order	0%	0%	**80%**	0	31%	29%	12%
Higher Order	0%	0%	20%	**67%**	**62%**	29%	**56%**
Deep Level (Abstract)	0%	0%	0%	33%	7%	**43%**	**32%**
Total	100%	100%	100%	100%	100%	100%	100%

Based on finding 1, finding 2, and Table 4-17, finding 3 is provided below.

3. "The complexity of students' analogies changes as they change their problem solving goals and seek for stories with different functions." When the problem-solving goal is to identify problems, students seeks stories that provide similar illustrations and most analogies are made in first-order structure. When the problem-solving goal is to define problems, students look for stories that provide illustrations, strategies, and predictions and most analogies are made in a first-order and higher-order structures. When the

problem-solving goal is to explore solutions, students search for stories that provide strategies, strategy logistics, and predictions; most analogies are made in higher-order structures.

Detailed discussions of the findings are presented in the next chapter.

Chapter 5

Discussion

Preparing novice learners to reason like experts when they encounter ill-defined problems is the goal of this study and it is also one of the most important goals in education and in industry fields. Stories were found to be a method to teach problem solving. CBR (case-based reasoning) is supposed to be a good way of solving problems in context since analogical reasoning is natural in teaching people to solve problems (Kolodner, 1997). Some research was conducted to test the effects of analogical reasoning by using stories as source knowledge. Using surface and thematic story-indexing strategies to organize stories were administered in this study to different groups by using both quantitative and qualitative methods. This study was expected to facilitate understanding of the effects and process of solving ill-structured problems through (1) administering different levels of a story-indexing strategy to college students and (2) collecting and analyzing both quantitative and qualitative data.

An overview and discussion of the findings are presented first. Second, the implications for instructional design are summarized; the limitations of this study are discussed; finally, suggestions for future work are described.

Overview and Discussion of the Findings Regarding the Effect of Different Story-Indexing Strategies

One of the purposes of this study is to investigate whether stories labeled with thematic (deep-level) indexes and systematically stored in a case library would facilitate novice learners' skills in solving ill-structured problems.

It is based on the *belief-based indexes* theory in Schank (1990). Belief-based indexes include "Theme, Goal, Plan, Result, and Lesson." This study adopted these as its thematic indexes. The students' problem-solving performance was measured based on these three processes: (1) identifying problems, (2) defining problems, and (3) exploring solutions. The open-ended test consisted of 13 questions with 26 sub items, which required students to make brief but elaborate answers. They were also asked to make connections to stories and explain how the stories were connected with the answers. The effects of using the no-story-indexing strategy, surface-indexing strategy, and thematic-indexing strategy were examined by two raters who followed a rubric to assign scores.

The quantitative design is set out to answer the first research question, and four hypotheses are derived from it.

Q1: What are the effects of using different story-indexing strategies within a case library on college students' (novice learners') ability in solving ill-structured problems?

On an open-ended test that evaluates higher-order thinking skills, all groups will:

H1: perform equally in analogical problem-solving.

H2: perform equally in solving ill-structured problems.

H2.1: perform equally on three sub-skills (identifying problems, defining problems, exploring possible solutions) when they solve ill-structured problems.

The factors of employment experience and academic year are considered to interact with the independent variable and affect the dependent variables. Therefore, two hypotheses are sought.

On an open-ended test that evaluates higher-order thinking skills, all groups:

*H3: with different **story-indexing strategies** and with related or unrelated **working experience** will perform equally in analogical problem solving*

*H4: with different **story-indexing strategies** and in different **academic years** will perform equally in analogical problem solving*

Summary of Findings

As presented in Chapter 4, the MANOVA results (Table 4-2) showed that there were no significant differences (p= .167) for the analogical problem-solving ability among control, comparable, and experimental groups.

ANOVA was conducted to see if significant differences exist among individual dependent variables. It showed that the thematic-indexing strategy had no significant effect on both the problem-solving and analogy-making abilities. Hypotheses 1 and 2 were retained.

In the MANOVA results in Table 4-7, Phillai's Trace showed that there were no significant differences (p= .261) for the three sub-skills of problem-solving ability among the control, comparable, and treatment groups. Therefore, Hypothesis 2.1 was retained.

No significant difference was found in novice learners' analogical problem-solving ability due to their employment experience or academic year and different story-indexing strategies. Hypotheses 3 and 4 were retained, too.

Discussion Regarding the Findings of Quantitative Data

The findings support the hypothesis that stories labeled with different indexes do not help novices see the deep level of similarity features while they solve ill-structured problems. In other words, the thematic indexes do not help students improve their ability to make analogies and the ability to solve ill-structured problems.

We can recognize from the statistical results that students performed equally in the open-ended test. Students either did not use story indexes or they did not know how to use it. Several possible factors contributed to the insignificant differences and they are examined and described below from six perspectives.

1.**Experiment design factor**:

- **Laboratory setting is different from natural context:** Lave (1988) argued that tasks like Gick and Holyoak (1980) are contrived. Subjects were given oral instruction to try to use the first story problem (castles) as a hint in solving the second problem (laser beams). Experimenters coached subjects heavily to increase the use of the analogous base. Lave indicated "…they

ignored subjects' speculation about everyday problem solving in order to follow up the question of memory load" (Lave, 1988, p. 31). She suspected that their experimental designs seemed so decontextualized that "…situationally specific constitution of activity is a proposition that warrants study" (Lave, 1988, p. 32) and they may not work in naturalistic settings. Though the fresh-cut Fruit case is a realistic case, subjects were coached to use analogies and given instruction to use the story indexes; therefore, it was still close to those studies that are designed in the laboratory setting and the experimental set up may not get students in the right frame of mind.

- **Training**: Given a problem case and two stories, students received training on how to find similar features between stories and a problem case (see Appendix D). The trainer didn't teach them any strategies of reasoning or how to match the same features. The intention of this training was to make students aware of the value of stories as a reasoning source. By doing that, it was expected that students could take advantage of story indexes when they later received story indexes as a treatment. The training didn't coach students to use the story indexes to help them solve problems. Therefore, the implicit intention of using story indexes may not have been detected by students; it was found out that they did not use the story indexes to support problem solving.
- **Treatment time**: Students took the test right after they received the treatment. It is possible that the treatments didn't have enough time to take effect, especially for "complex" indexes such as thematic indexes. In the study of Hernandez-Serrano (2001), he allowed three weeks for participants to work on

the activities and for the treatment to take effect. Significant differences of using stories to solve problems were found in his study. Therefore, delayed time for treatments to take effect should be considered for future studies.

2. **Instrument factor**: The nature of an open-ended test lends itself to a lot of uncertain variables. Students wrote answers freehand though they were told to write down brief and elaborated answers. It is not like a multiple-choice test, in which students can just select one answer even though they don't know the correct answer. It was found that several students left some questions unanswered, which put these in the category of "missing data." The rating criterion became another concern, and it is discussed next.
3. **Rubric/Rater factor**: The rubric may not assist the raters appropriately to distinguish good arguments and bad arguments about the ill-structured problems. The rubric may not be able to cover all possible qualitative ranges of answers and satisfy the standard rulers in all raters' minds. The raters may review students' answers over a long period of time. The consistency of their grading standards is not always the same. Personal judgments still remain a big factor because of the different ways that different raters review the test answers.
4. **Learners' factors**:
   - **Comprehension of the treatment**: Students didn't receive any training on understanding the function of story indexes. Instead, they received a brief instruction on what the story indexes are used for in an instructional sheet right before they started the treatment. The instruction was highlighted and no examples were shown in the instruction sheet. Most of the students probably

didn't understand what story indexes meant with such a short and brief instruction.

- **Function of index**: Instead of using the presented stories with surface or thematic indexes, the qualitative data shows that students used stories with appropriate function in order to deal with the problem solving tasks they facing. Students seem use functional stories as indexes to search related stories in this study.

5. **The role of prior knowledge and experience in endocing and using stories**: The theories reviewed in chapter 2 support the premise that a story is a good way to help learners solve problems, and if students are prompted to use stories as analogical sources, they are more likely to make analogies. Case-based reasoning (CBR) suggests that experts' experiences or other cases can act as extended memory to improve problem-solving skills. Research shows stories can help students solve ill-structured problems better (Hernandez-Serrano, 2001). Research also suggests that experts, unlike novices, recall the right stories at the right time, and they can see stories from a variety of different ways (Schank, 1995; Schank, Berman, & Macpherson, 1999). In other words, experts are good at encoding stories with a lot of information and, therefore, retrieving the right stories from a lot of accessed information. They are good at reasoning and making analogies at an abstract level. Novices lack the experience to draw on, and they assign labels to stories based on superficial levels; experts have many experiences to draw on, and they encode and retrieve stories through abstract and deep features. No significant differences were found from the

quantitative data. It seems reasonable to conclude that the problem is not how to provide pre-generated indexes to novices but how to build upon their prior knowledge and extend their memory to help them in encoding and retrieving appropriate stories.

6. **Analogical Paradox:** The statistical results showed that students in all groups performed equally in analogical problem solving. Therefore, students didn't use the story indexes or they didn't know how to use them.

   From the theoretical point of view, Dunbar (2001) tried to figure out the analogical paradox: why is analogy so easy in naturalistic settings, yet so difficult in the psychological laboratory? Dunbar (1993; Dunbar, 1995, 1997, 1999) and Blanchette (Blanchette & Dunbar, 1997) have been investigating how scientists and politicians make analogies. Those studies demonstrate that people in a naturalistic context frequently use analogies based on structural features and higher-order relations. Their explanation is that when people generated analogies themselves (in naturalistic settings), they searched their memory for structural relations; but when they are simply asked to choose between sources (laboratory settings), they more easily focus on superficial features. It points out that generating one's own analogies can help one focus more on structural relations in reasoning than reminding one of someone else's analogies. It can help explain why students among the three groups performed statistical equally. In this study, students were reminded to use stories indexed with surface or thematic features instead of generating their own indexes. Without interpreting

stories and generating indexing vocabulary oneself, one cannot comprehend the story contents through being reminded of others' indexing vocabularies.

Overview and Discussion of the Findings Regarding the Process of Analogical Problem-solving

The other purpose of this chapter is to find explanations regarding the findings made in chapter 4 by analyzing the verbal data from six participants who "think aloud" during their problem-solving process.

There are six participants whose data were selected and analyzed. Three of them are freshmen and three of them are seniors. They were randomly assigned into three groups. Each group has one freshman and one senior student. They all received the same training and followed the same procedures as subjects who participated in the quantitative design. The only two differences were that they had to accept Training II on how to think aloud when solving problems and they had to talk aloud about what was going on in their minds from the moment they started the treatment until they finished the test.

Next, the findings concluded from the qualitative data in chapter 4 are briefly summarized.

Summary and Discussion of Finding One

To address the second research question, Three findings are made (Findings 1,2, and 3) in the following paragraphs.

Q2: How do novice learners use reasoning strategies between stories and targeted problems to solve ill-structured problems? Specifically,

Q2.1: How do students figure out the hints behind stories and make connections when following the strategies of "identifying problems, defining problems, and exploring possible solutions" to solve ill-structured problems?

Q2.2: What kind of functions or roles does a story play in the problem-solving process?

From the data results shown in Table 4-14, the trend of using stories for different functions is found in Figure **5-1** and Finding One is made below.

Analogical Function	Illustration (71%)	Illustration (49%) Strategy (18%) Prediction (17%)	Strategy (31%) strategy logistic (24%) prediction (21%)
Problem solving stage/goal	Identify Problems	Define Problems	Explore Solutions

*Figure **5-1.*** The trend of using stories for different functions in different stages of problem-solving.

1. **"In different stages of problem solving, students tend to look for stories with appropriate functions that achieve their goals."** When their problem solving goal is to identify problems, they looked for stories providing similar illustrations; when their problem solving goal is to define problems, they looked for stories providing illustrations, solutions, or even predicting mistakes and results; when their problem solving goal is to generate solutions, they sought stories providing strategies/solutions directly, explaining strategy logistics, or predicting mistakes and results.

Finding one, concluded from the qualitative data, tells us more information about how students used the story by receiving different story indexing strategies. From the data results shown in Table 4-14 and Figure 5-1, students tended to look for stories that could most satisfy the problem solving goals that they had faced. While their goal was to identify problems, they had to identify the unsatisfied situation or potential opportunities and they needed stories with similar instances to help them comprehend the problems' situations. While the goal was to define problems, they had to figure out the nature of the problem and contextual constraints to comprehend the complexity of the problem, and they had to perceive and reconcile different opinions of the stakeholders in the problem situation (Jonassen, 1997). They needed stories providing illustrative views or predicting potential problems to apprehend multiple perspectives of the stakeholders and to back up their judgments. While the goal was to generate solutions, they searched for ideas for solutions with concrete logistics or warnings of potential problems to help them justify their recommendations of solutions. Therefore, for story indexes to be useful, they need to help learners achieve their problem-solving goals.

In order to help students achieve their problem-solving goals, perhaps the indexes should be aligned with the problem-solving tasks. This would help to explain the design rationale for stories indexed in multiple ways such as the index systems used in ASK System (Ferguson *et al.*, 1992).

Ferguson (Ferguson et al., 1992) argue that "understanding stories about other people's efforts to perform aspects of a task depends on exactly the same memory structures as would be used to carry out the task oneself. " The Aesopic conversation (the student asks questions and the teacher answers by telling stories) of the ongoing task

between the student and teacher provides a structure with which to track the dialog and its embedded stories. In order to design educational software, they have to search an abstract level of task knowledge that is almost universal and can serve as common ground between the teacher and student. The abstract task is characterized in terms of the goals and processes of executing the problem tasks (Ferguson *et al.*, 1992). Therefore, the index systems used in ASK System is grounded on a shared level of abstract task.

Summary and Discussion of Finding Two

From the data results shown in Table 4-15, the complexity of using analogies is found in Figure **5-2** and Finding Two is made below.

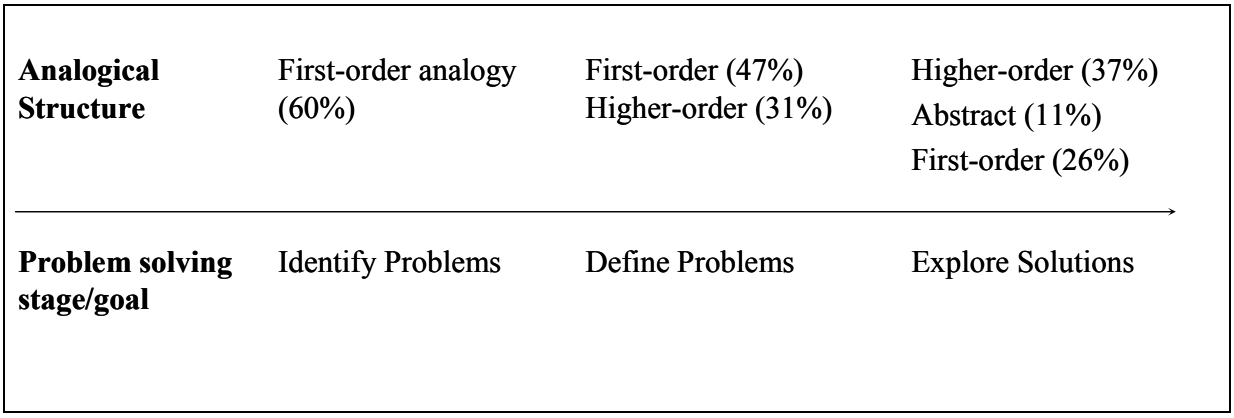

*Figure **5-2.***The trend of the complexity in using analogies

2. "Students vary the complexity of their analogies in different stages of problem solving." Students were prone to make lower-order analogies when identifying problems; they made lower- and higher-order analogies when

defining problems; they tended to make higher-order analogies when exploring possible solutions.

In the structure-mapping theory (Gentner, 1983), the difference between the first-order analogy and the higher-order analogy is the complexity of the arguments in the predicate. The first-order predicates take objects as arguments and the second- or higher-order predicates take propositions as arguments. For example, "***Have-high-demand*** *(consumers, cracker)*" is first-order predicate, which take consumers and crackers as an argument; "***Cause*** *[Have-high-demand (consumers, cracker), partner-with (Company E, co-packer)]*" is a second-order predicate, which takes the cause-effect proposition between the first-order predicates as arguments.

In this study (see Table 4-17), students tended to make more first-order analogies when they identified problems and defined problems. It means students look for simple similarities of arguments between objects when they make analogies to help identify problems. Does this imply that novices are prone to see the lower-order arguments when they diagnose a problem situation? For instance, when identifying a problem for the cracker case, they were likely to see the problem "*consumers have high demand for low-calories crackers*," but most of them didn't indicate the problem that "*consumers have high demand for low-calories crackers due to the trend of eating healthy food*".

However, novices do not always see the lower-order structure of analogies when they solve problems. In this study, when their goal is to explore possible solutions, they are more likely to make higher-order analogies. It means that they focus more on the complexity of the propositions in order to justify the solutions they suggested. For example, "*In-order-to [Do-Research (Company E, new package size), Invest-new-idea*

(Company E, new package size)]" is a higher-order analogy. In order to generate a solution for Verdelli, this subject had to justify his recommendation. He took the propositions of "implement A in order to get B done" between the first-order predicates as an argument to explain that Company E has to conduct more research about a new packaging, in order to invest a new idea of packaging.

It seems that students tended to use stories in simple orders for simple tasks but they tend to use stories in complex orders for complex tasks. **They used stories in appropriate depth for different levels of problem tasks they encountered**.

Summary and Discussion of Finding Three

Based on the summary of Findings One and Two, the relation between analogical structure and analogical function is found in Figure **5-3** and Finding Three is made below. See Table 4-17 for more information.

Analogical Structure	superficial (100%)	first-order (80%)	higher-order (67%)	Higher-order (62%)	Abstract (43%)	Higher-order (56%) Abstract(32%)
Analogical Function	object similarity	illustration	prompt	strategy	Strategy logistics	Prediction

*Figure **5-3**.* The relation between the complexity of using analogies and the function of using stories.

3. "The complexity of students' analogies changes as they change their problem solving goals and seek for stories with different functions."

Depending on the tasks students facing, they define their problem-solving goals, which help them look for stories with appropriate functions to facilitate solving problems. The setting of problem-solving goals affects how learners use the stories for different functions and how they think and make analogies with different kinds of structures.

While the goal is to identify problems, students seek stories providing similar illustrations, and most analogies are made in first-order structure. While the goal is to define problems, students look for stories that provide illustrations, strategies, and predictions, and most analogies are made in first-order and higher-order structures. While the goal is to explore solutions, students search for stories that provide strategies, strategy logistics, and predictions, and most analogies are made in higher-order structures.

Regardless of the problem-solving goals defined by the student, a relation was detected between the analogical function and analogical structures. The complexity of an analogy increases from superficial, to first-order, to higher-order, to deep level as the function of an analogy changes from providing object similarity, illustration, prompting, strategy, providing strategy logistics, and prediction (See Table 4-17).

The possible explanation for this phenomenon is described next. In order to use a story for a higher level of function such as generating solutions, the student has to integrate information and to reason a story in a more structural way. When the student uses the story for higher-level functions (such as strategy providing, strategy explanation

and implementation, and prediction providing), it requires the student to focus more on the structural relation and even the abstract relation between objects. On the contrary, when the student uses the story for lower-level functions (such as object similarity and illustration), students are most likely to see the descriptive features.

The finding indicates that there is no single right index method (surface, deep, or other kinds) because people use the appropriate depth of story functionally or structurally for different levels of problem-solving tasks.

Limitations of the Study

There were several constraints faced by the researcher when this study was conducted. They are discussed below.

First, due to the class size constraint, the researcher had to collect data from six different classes. Though the qualification criteria were set up to reduce the differences among subjects, the students' motivation for taking this class changed as they registered for the class in different semesters, which affected how seriously they took their assignment (participation in this study was considered as part of their assignment). Also, their motivation for participating in this experiment varied depending on the incentives they received from the class instructors.

Second, the nature of a task affects students' performance. An open-ended question allows students to answer questions in open ways. If students are not motivated enough to finish this test, they can just simply skip questions or leave them for blank. A goal-based scenarios (GBSs) is a-learning-by-doing simulation which use case-based reasoning (CBR) theory to explain the memory and learning (Schank, Berman & Macpherson, 1999). GBS emphasizes that the goal or mission to solve a problem should be motivational for the student to pursue. In this study, learning cannot be prompted by doing due to the paper and pencil test. The verbal and writing abilities are also possible factors which affect students' task performances.

Third, because of time constraints and implementation difficulties, the IDEAL problem-solving model was not completed due to missing the last two parts, "Act on and

Look back." In the real world, implementation and assessment of a proposed solution are very important. People improve their problem-solving skills by making mistakes and learning lessons from their past experiences. CBR also emphasizes reinterpreting and reindexing an old experience based on what one learns from new experiences. Therefore, providing strategies to help student assess their case application is important.

Fourth, since students were given the post-test only design, their ability to use stories as analogical sources and prior knowledge of solving real case problems are unknown. Though students were randomly assigned into three groups to make sure those with different levels were equally distributed, in reality, it was still difficult to achieve such an equilibrium because of students' different class sections, major backgrounds, and related experiences. However, it was shown that the skewness of the analogical problem-solving ability is very close to zero (-0.073), which means perfect normal distribution. It indicated that randomization is not a major issue.

The last limitation is associated with the qualitative design. Participants volunteered to attend the think-aloud activity and the major reason of their participations was that they could not make it to the experimental study. Also, their verbal ability affected their performances of thinking and talking aloud. Though training was conducted, some participants seemed to need more time and practice than others to get used to thinking aloud.

Implications for Instructional Design

Though the empirical hypotheses were retained, past research supports using case-based reasoning (CBR) to solve real-world problems (J. Hernandez-Serrano, 2001; J. Hernandez-Serrano *et al.*, 2002; Jonassen & Hernandez-Serrano, 2002; Swap *et al.*, 2001). From the perspective of instructional design, the purpose of this section is to suggest how to integrate the findings from this study to support students interpreting new problem situations and applying appropriate stories to solve the problem by scaffolding them with appropriate learning strategies and environments. The discussion is based on examining the findings, reviewing more educational suggestions from the view of CBR, and exploring the index systems used in the ASK System (Ferguson et al., 1992).

From the findings of the quantitative data, the results show that the students didn't use the indexes provided because no significant differences are found among the three groups.

From the qualitative data, Finding One shows that students tend to search stories with appropriate functions to satisfy their problem solving goals in different stages of problem-solving processes. Finding Two shows that students make analogies with different complexities of analogical structures through the problem-solving processes. Finally, Finding Three shows that the complexity of students' analogies change as they change their problem solving goals and seek for stories with different functions. In other words, when students use a story for higher level of functions (such as strategy providing, strategy explanation and implementation, and prediction providing), it requires them to

focus more on the complex structures, even abstract structures; when students use a story for lower-level functions (such as object similarity hinting or illustration providing), they are most likely to focus on simple or lower-order structures between objects.

The findings indicate that students look at stories in multiple ways depending on the complexity of problem-solving tasks they received. In this study, the stories within each case library are indexed with a single indexing method, which may be useless for students when they move through the problem-solving processes and encounter different problem-solving tasks. An instructional designer must be aware that stories are viewed and used differently depending on the problem tasks. Therefore, providing multiple story indexes for each story in a case base should be considered for the instructional design purpose.

For educational purposes, CBR suggests focuses on three cognitive components: **cases, case indexes, and the case processor** (Kolodner et al., 2004). A case processor helps learners interpret and index their experiences, find appropriate old cases in their memories, apply lessons learned from an old case to a new situation, and reindex or reinterpret old cases in light of new findings (Koloener et al., 2004). Case-based learning aids are proposed by Kolodner (2004) to support students in learning as a case processor.

How to integrating the findings in this study and provide a case processor to help students interpret cases and index cases? ASK System (Ferguson *et al.*, 1992) is an example of taking one story and providing lots of different links to related stories. ASK System was built upon a theory of memory organization and memory conversation in mind, but the researchers didn't necessarily test the underlying theories. The findings

concluded from this study suggest an theoretical basis for indexing stories in multiple ways.

Therefore, for story indexes to be useful, the instructional designer needs to help learners achieve their problem-solving goals, and the indexes should be aligned with the problem-solving tasks.

Suggestions for the instructional design are listed below:

- A single indexing method cannot cover everyone's indexing vocabulary or structures. A case library has to allow the students to browse related stories by providing multiple indexes; the multiple indexes should be built upon the abstract task knowledge, which can serve as the common ground between the students and the teachers
- Though students are considered to be novices in their fields, the way they search stories and use the case library lead us to think that there is no right index for each person given different knowledge levels and problem tasks difficulties. A good index (surface, deep, or others) for a person means that the depth of the index is at the right level for the problem-solving tasks. The most important thing for an instructional designer to consider is how to get the right index for the right student at the right time.

Conclusions and Suggestions for Future Work

Based on the suggestions for the instructional design described in the previous section, how will I redesign this study in the future? It will be similar to ASK System and will be combined with the rule of thumb idea used in Owensby & Kolodner (2002)

A brief introduction of ASK System is described next in order to facilitate understanding of the following suggestions for instructional design.

ASK System argues that memory organization determines conversational behavior and, therefore, conversational coherence (Ferguson *et al.*, 1992). The ideal context for someone to listen to a story is when he is engrossed in a task and he listens to a story offering appropriate advice (Adams *et al.*, 1988). The Aesopic dialog used in ASK Systems (Ferguson *et al.*, 1992) has the student asking questions and the teacher answering by telling stories around the performance of a target task; this is assumed to be an ideal way to listen to a story. They argued that the mental context induced in the student when they formulate questions and understand prior stories is appropriate for understanding and indexing subsequent stories. Therefore, the memory organization that students use to understand previous stories or problem situations determines the conversational coherence; concurrently, the conversational input or output determine where to go next in memory (Ferguson et al., 1992).

ASK System is a story-based teacher that allows students to ask questions and provides related stories through students asking specific questions.

The Aesopic conversation of the same task between the student and teacher provides a context that allows the student to translate his questions into the zooming or browsing choices, which are used to design the two levels of indexes: zooming and browsing interfaces. The function of the first level of the index (the zooming interface) is to bring the student's goals into alignment with those of the system. The function of the second level of the index (the browsing interface) is to connect stories to stories that answer likely follow-up questions by the students (see Figure **5-4**).

How to rebuild this study?

How does ASK System design reflect the findings in this study and give suggestions for future work? The design procedure is explained in the following paragraphs.

There are two stages, the case interpretation and case application stages, in ASK System (see Figure **5-4**). At the case interpretation stage, students are displayed a big layout of the new problem case. Student can click on the nodes in the layout to see background information. If we use the fresh-cut fruit case as an example, the nodes include Verdelli, Giant, fruit suppliers, consumers, retailers, partners, and others. Then, the student can ask questions to help them divide what they need to know about a new case into manageable chunks. Hints and examples for each chunk are provided to scaffold students (Kolodner et al., 2004).

After interpreting the new problem case, the student will create his own rule of thumb (e.g., Rule of thumb: "monitoring temperature at the retail level".) to best catch the

important features in the problem case. Templates of other rules of thumb are provided. The idea of using a "*rule of thumb*" (Kolodner et al., 2004; Owensby & Kolodner, 2002) can help students to create his own index framework; the idea of comparing with other rules of thumb helps the student see the same case from others' index frameworks.

Then students can click the links between the nodes, and the system will lead students to the case application stage, which consists of two levels of indexes. The first level of the index system is the zooming interface to help the student narrow down his focus by asking questions about the relations between the nodes. For example, one of the relations between Verdelli and Giant can be: "The food processor (Verdelli) cut fresh fruits for the retailer (Giant)". The questions that the student might ask is: How does Giant know if Verdelli has enough technical skills to cut fresh-cut fruits? Does Verdelli have effective distribution lines to deliver freshness to Giant? After Verdelli delivers the fresh fruit to Giant, does Giant have the equipment to maintain its shelf-life? Under each question, related stories are picked out and listed below.

The student can click any of the stories and review it; this leads the student into the second level of the index system. The selected story becomes a center clip displayed on a new screen. Several questioning nodes around the center story clip with links connected with the center story (see Figure **5-5)**. Each questioning node is tagged with a question that is related to the center story, and a sub-question "Do I need to revise my rule of thumb?" is asked in each questioning node. By doing that, the student has to ask himself every time after he reviews the related story by thinking whether the rule of thumb he created can address the problems or overcome them. The browsing links are intended to be related to other cases, which are relevant to the tasks of solving the

problem cases (Ferguson et al., 1992). In this case, the learning issues defined for the fresh-cut fruit cases (see Appendix 2), the categories of analogical functions gathered in this study (illustration, solutions, predictions or warning, and strategy logistic), or the belief-based index (theme, goal, plan, result, lesson) probably can be used as questioning nodes; related questions could then be linked to the center story. For example, if a student chooses to ask the question "Does Verdelli have effective distribution lines to deliver freshness to Giant?" in the first level of the index (see Figure 5-4), one of the stories that is provided would be the "General Foods story," which becomes the center story clip in the second level of the index. One of the questioning nodes can be "Prediction," and links to that node will ask predictive prospects that might arise with the situation. Therefore, the student can ask questions like: "What are the potential problems that I have and is it similar to this story?" or "What are the possible results that I may make and is it similar to this story? One of the questioning nodes can be "identify market opportunity," and it is the learning issues identified in the fresh-cut fruit case in Appendix 2. Questions linked to the story can include "What is the market opportunity that I am facing and is it similar to General Foods' opportunity?" Under each questioning node, related stories are connected, too. The questioning nodes served as multiple indexes to help students solve different depths of problem tasks.

The extent to which an old situation is interpreted and elaborated upon will affect further reasoning (Kolodner, 1997). Through asking questions in the case application stage, students can browse stories from multiple perspectives and they are able to form their own index framework, reindex their interpretation for the previous case, and even reuse the case appropriately in the future.

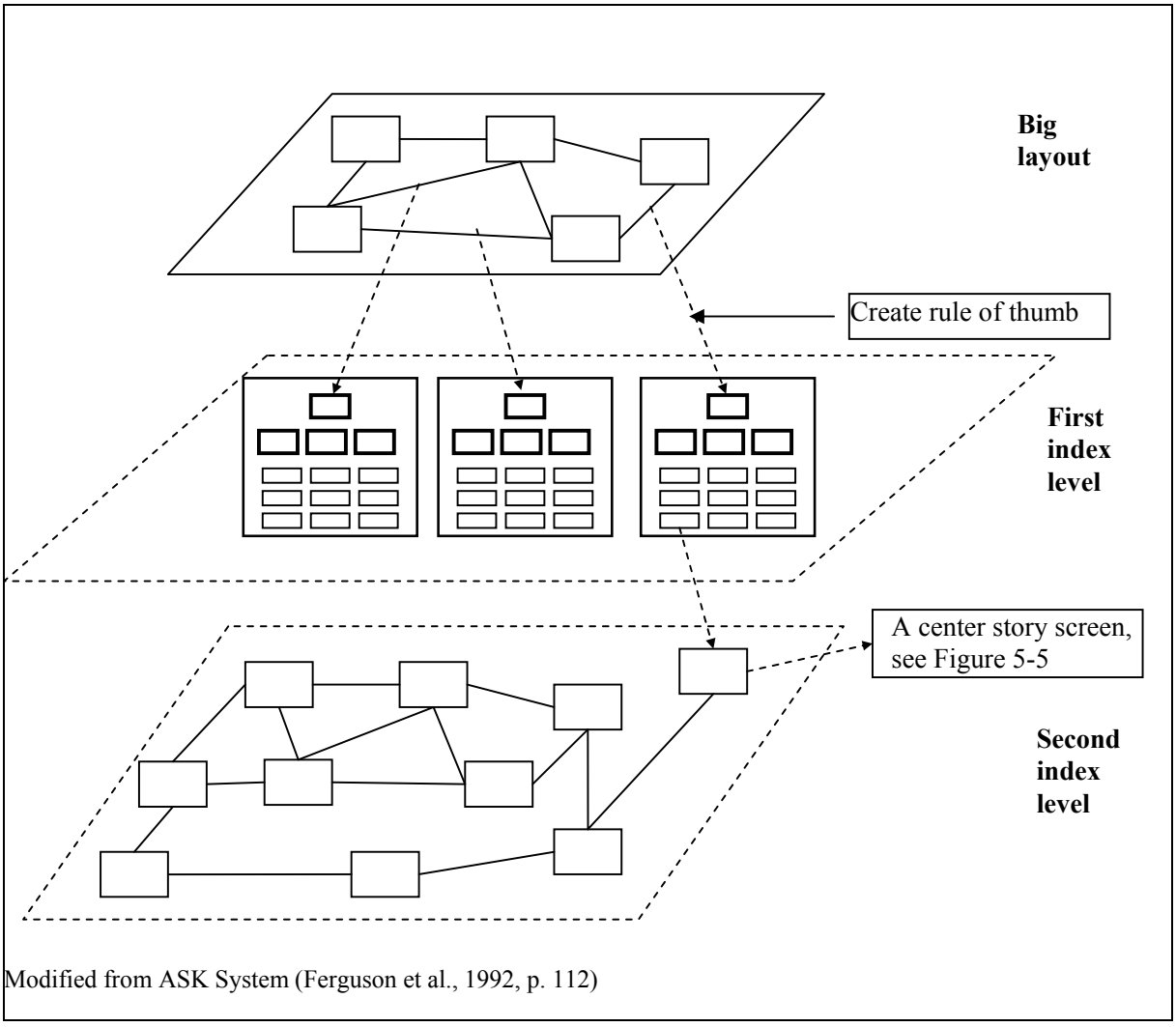

*Figure **5-4**.* A multiple index system.

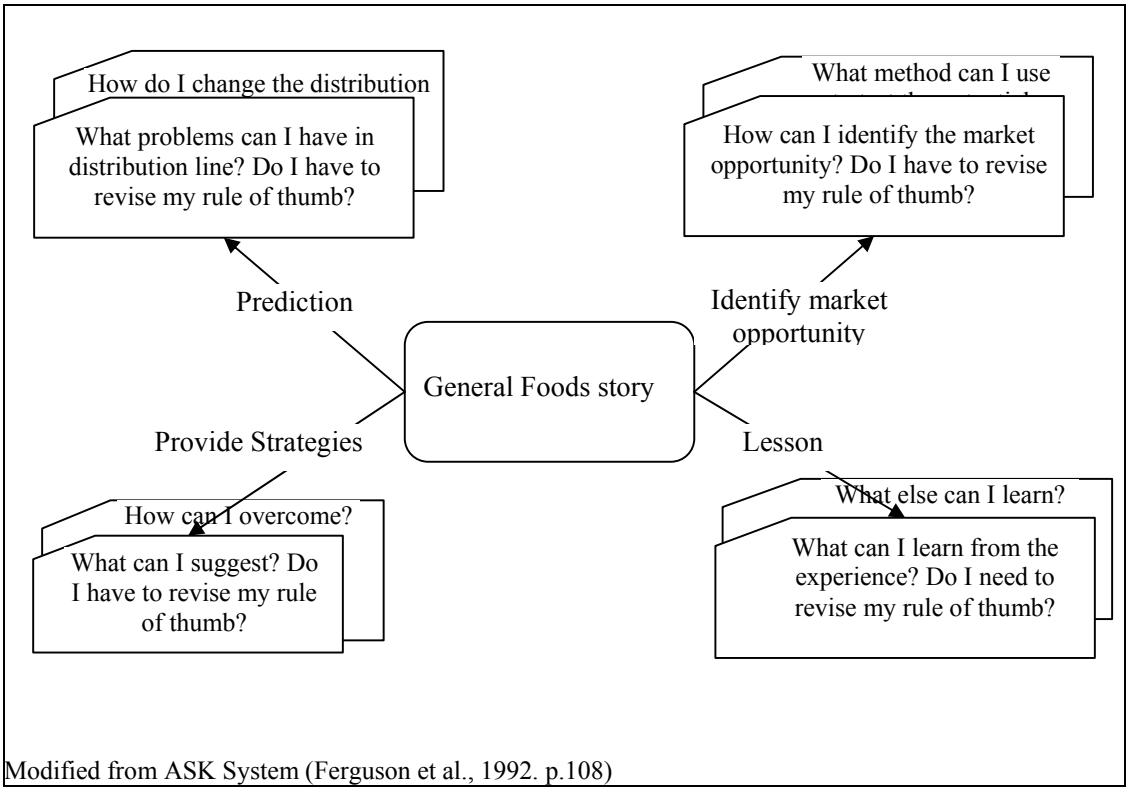

*Figure **5-5**.* A screen of a center story clip.

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Appendix A

Definitions of Key Terms

For this study,

- A story is defined based on Edelson's criteria (1993):
    1. It must have characters, real or fictitious;
    2. It must have an identifiable incident;
    3. It must deal in specifics not structured in abstraction; and
    4. It must be told or observed but not directly experienced.
- A **case** also refers to a story in a case-based reasoning system (Kolodner, 1997). In Kolodner (1996), a definition of a case always includes:
    1. A situation description;
    2. A description of some problem or question or failed expectation that arose in that situation;
    3. A description of the way that the problem or question was addressed or the failed expectation was explained; and
    4. A description of the consequences, results, or outcomes.
- A Case Library is a systematic collection and organization of a number of experts' experiences presented in the form of stories to the learner as the learner interacting with a task environment (Edelson, 1993).
- **Case-based Reasoning (CBR)** is reasoning based on previous cases or experiences (Kolodner, 1996).

- In a CBR system, **indexing** is the assigning of important values to dimensions of a representation, labeling cases with their important or defining sets of features, choosing a case that matches those features, and setting up a memory and its retrieval process so that the right cases are retrieved at the right time (Kolodner, 1996). **Indexing** is the process of assigning labels to stories based on specific rules or interpretations when putting stories into the case library (Kolodner, 1993).
- An expert is a person who falls into at least one of the following three categories:
    1. .25+ years of experience in the food industry working in a number positions that reflect increasing levels of responsibility (ideally starting in a staff-level position, to managing important food product development projects, to having obtained a position with executive-level decision-making power such as vice president, CEO, etc.);
    2. 15+ years of experience specifically working in some specialized aspect of the food product development process (specialists in packaging, flavor, formulation, regulatory issues, etc.); or
    3. 15+ years in a faculty position at a major university, developing and teaching food systems courses, conducting research and offering consulting services for the food industry, and in general being active in the academic development of the field.

(ps. The stories used in this study come from the same story database as those used in Hernandez-Serrano's study (2001, p. 154). Therefore, the definition of an expert is cited from his study.)

- A **novice learner** is an undergraduate student who majored in a relevant food systems field (food science, food marketing or management, agricultural economics, marketing management, consumer behavior, etc.)

Appendix B

Identification of Learning Issues, Related Skills, and Related Stories within the Fresh-Cut Fruit Case

For the learning issue of "Identify market opportunity", the associated skills needed in this case include:

1.1.3/1.1.4	Evaluate line expansion/Evaluate line extension
1.1.2.2.1.1.1	Analyze market trends within the current market system
1.1.A.1.1.1.A.1/2	Analyze quantitative/qualitative market data

Story Titles:

- Just "bottled water"
- The dog litter product
- Changing business for changing times—Friendly's restaurants
- Indulging phenomena

For the learning issue of "Generate product idea and concept", the associated skills needed in this case include:

2.1.2.1/2	Gather qualitative/ quantitative data on retail product concepts

Story Title:

- Just "bottled water"

For the learning issue of "Evaluate preliminary plans for the purpose of deciding to develop the product", the associated skills needed in this case include:

3.3.2 Evaluate existing in-house/external distribution logistics

Story Title:

- General Foods' ready-to-eat meals

For the learning issue of "Perform research and development", the associated skills needed in this case include:

2.1.1.1.2.5 Define packages

4.1.1.1.3.1.1.3 Shelf-life tests

4.1.1.1.3.1.1.4 Safety tests

Story Titles:

- Packaging for convenience
- Learning from competitors: Keeping the carrots from "blushing"
- Extraordinary means for dealing with extraordinary problems: Monitoring temperature at the retail level
- Different production lines for different products—Different strokes for different folks

Appendix C

Indexing Strategies Used for This Study

For this study,

Surface Indexing Strategy is the indexing of stories in the surface features that have no inferential or meaningful interpretation and are not predictive (Kolodner, 1996).

What indexes were up for surface features?

Basically, the stories collected in the case library are about food product development. The most obvious features are the company name, the product name, the product category, and the product development process.

Thematic indexing strategy is the indexing of stories in the deep features that are predictive of something important and abstract enough to make a case useful for future situations. Schank (1990) indicated that indices organized around themes were called Thematic Organization packages (TOPs). Such high-level indices come from juxtapositions of plans, goals, and themes. The thematic indices used in this study are the Belief-based Indices in Schank (1990). The structure of Belief-based Indices includes Theme, Goal, Plan, Result, and Lesson.

Themes are the general topics that tend to generate goals related to those topics; **goals** have obvious intended results that relate to the overarching theme; **plans** are the approaches used to achieve the goal; **results** are the outcomes of using the plans; and

lessons are the new belief or point of view, namely, what is to be learned from the stories (Schank, 1990).

How do I index stories based on Theme-goal-plan-result-lesson?

Based on the hierarchy skill analysis map, each story is assigned more than one skill related to food product development by an expert panel composed of two professors and a doctoral student. Then, each skill is ranked based on whether the story is directly, closely, or marginally related to the main theme of the story. Thus, the expert panel decides the theme, goal, plans, results, or lessons from these skill components.

Appendix D

Training Plans

Training I:

Audiences: All participants

Trainers: Either trainer A with teaching experience in case-based instruction or trainer B with experience in assisting case-based instruction conducted the training.

Materials: A short case and two stories

Time:

- 10 minutes: Students read the short case and two relevant stories.
- 15 minutes: The trainer used the one relevant story and ask students to compare it with the short case.
- 15 minutes: A practice activity was administered to all participants so that they may practice what they learned from the training.

Procedure:

1.	**Understand the problem statement in the short case** The trainers asked students to read the short case first and ask students, 'Can you tell me what is going on in this case?' or 'Can you tell me what the main character is trying to do here'? Then he wrote down the key phrases provided by the students.
2.	**Understand the problem statement in analogous story A** The trainers asked students to read the two relevant stories and ask students the same questions in step 1. Then, he wrote down the key phrases provided by the students.
3.	**Make an analogy between the short case and story A** The trainers asked students to find or compare the similarities between the short

	case and story A. He can ask, 'Can you connect story A to the short case?' or 'Do you find any similar scenarios (problems, background information, characters, skills, actions, or results) between the short case and story A?'
4.	**Practice activity** 1. Use the same short case and story B. 2. Students wrote down the major things happening in the short case. 3. Students wrote down the major things happening in story B. 4. Students wrote down the similarities between the short case and story B.
5	1. Get the assigned group number and information about the next study. 2. Leave quietly.

Training II:

Audiences: Those who participate in the think-aloud protocol

Trainer: The researcher

Time: 10 minutes

How:

1. The trainer gave oral instructions for the think-aloud exercise described next.
2. Then the subject practiced a warm-up task to think aloud.
3. Once the think-aloud task was done and the subject is ready to go to the treatment, the researcher taught the basic function of the case library.
4. Tell the subject what the indexes at the top of each story are used for.

Instruction (adopted from Ericsson & Simonp, 1993, p. 378)

In this experiment we are interested in what you think about when you find answers or solutions to some questions that I am going to ask you to answer. In order to

do this I am going to ask you to THINK ALOUD as your work on the problem given. What I mean by think aloud is that I want you to tell me EVERYTHING you are thinking from the time you first see the question until you give an answer. I would like you to talk aloud CONSTANTLY from the time I present each problem until you have given your final answer to the question.

I don't want you to try to plan out what you say or try to explain to me what you are saying. Just act as if you are along in the room speaking to yourself. If you are silent for any long period of time I will remind you to keep talking aloud. Do you understand what I want you to do?

Warm-up tasks:

Good. Before we turn to the real experiment, we will start with a couple of practice problems. I want you to talk aloud from the time when I present you with the problem statement until you give me your answer.

Problem Statement

Pasta Roma, a regional pasta importer and manufacturer, decided to develop a frozen garlic-flavored ravioli product. After conducting a number of focus group sessions and blind in-home tests, it was determined that the product could be a success. Participants almost uniformly reacted extremely well to taste ("great garlic flavor"), appearance ("looks delicious"), price ("affordable"), flat box package ("let me see the product"), cooking requirements ("really convenient"), and many other product attributes. To further highlight the appearance of the product, the company decided to use a few graphics on the box rather than a "window" through which the product could be seen. With production and distribution systems in place, Pasta Roma rolled out the product. The product was stacked in the freezer area of the supermarkets. Pasta Roma managers were sure they had a winner. However, almost immediately retailers were complaining and the product was not selling.

1. Select the most appropriate solution to the problem.

a. Conduct more focus group sessions to determine the problem.
b. With R&D's help convert the product to a refrigerated type.
c. Redo the graphics emphasizing freshness.
d. Close the "window" and rely only on graphics.

e. Redesign the package into a stand-up design.

2. Why do you think the company had this problem?

a. They did not approach retailers during the process.
b. They relied entirely on focus group (qualitative) data.
c. They failed to conduct BASES or similar research.
d. They did not have a good media selection strategy.
e. They did not realize this was just a niche product.

Appendix E

Definition of Problem-solving Components

(In this study, categories VI and V are not adopted.)

I. Identify Problem

Definition	• The first step taken by the inventors of the objects was the identification of the problems that the objects were designed to solve (Bransford & Stein, 1984)
Components	• Be able to identify **problems** • Be able to identify **unsatisfied situations** • Be able to identify **opportunities**

II. Define and Represent Problem

Definition	• Represent the problem in order to obtain a clear picture of the problem prior to any solution attempts (FCTL, 2003). • People can agree about the existence of a problem, yet disagree about the reasons for it. As a result, different definitions may lead to different solutions (Gnam *et al.*, 1999).
Components	• Be able to pose questions • Linguistic understanding/comprehension • Be able to identify irrelevant/less important information • Be able to identify multiple strategies • Be able to identify assumptions based on the tentative strategies • Be able to identify obstacles • Be able to modeling problems

- **Posing questions**

Definition	• The questions that need to be asked/answered in order to solve the defined problems (Nitko, 2001) • The questions that need to be asked/answered in order to get a better understanding/comprehension of the defined problems
Components	• Propose questions based on given information • Propose questions for lack of enough information to solve the problem • Propose questions for lack of enough information to gain better understanding/comprehension of the defined problems

- **Linguistic understanding**

Definition	• Explain the meaning of the linguistic features of the key phrases or common vocabulary that they need to know to comprehend the context of the problem in their own words (Nitko, 2001)
Components	In their own words, • Explain the meaning of the key phrase/ common vocabulary • Explain the meaning of key concepts • Explain the relationships between concepts

- **Identify Irrelevant / less important information**

Definition	• The information provided in a problem statement is irrelevant to the problem solution
Components	• Identify irrelevant information to the solution • Identify less important information to the solution • Discriminate between relevant and irrelevant information to the solution • Identify important and not important information to the solution

- **Identify multiple strategies**

Definition	• Students will be able to solve the defined problem in two or more ways (Nitko, 2001)
Components	• Define the problem • Provide more than one strategy for solving the defined problem • Define the logicality and feasibility of the strategies • Strategies are elaborated upon based on provided information or proposed assumptions • Do they make the strategies carefully or think them through thoroughly?

- **Identify assumptions**

Definition	• The assumptions they make to come up with solutions for the current and future problem (Nitko, 2001)
Components	• The logicality between the assumptions and the solution/strategies • Do they make the assumptions creatively? • Do they think the assumptions clearly?

- **Identify obstacles**

Definition	• Identify the obstacles to solving the defined problems (Nitko, 2001)
Components	• Be able to identify the obstacles • Identify additional information they need to overcome the obstacles (identify missing information) • Explain why it is difficult to complete the task

- **Modeling problem**

Definition	• Draw a diagram or picture showing the problem situation (Nitko, 2001)
Components	• Problem situation includes: Identify the problem→ Comprehend the problem→ Pose questions→Define problem→ Make assumptions→ Identify obstacles, irrelevant information→ Come up with strategies→ Develop the correct solution

III. <u>Exploring Possible Solution Strategies</u>

Definition	• Generate and analyze alternative strategies that might deal with the problem (FCTL, 2003).
Components	• Justify strategies (there may be one or more than one strategy to achieve the best solution) • Justify solutions • Integrating data • Using analogies

- Justify strategies & integrate data

Definition	• Be able to explain, summarize, and conclude multiple strategies by integrating related information and data
Components	• Integrate data to come up with one or more strategies • Integrate data using some of the information in two or more of the interpretive materials • Justify why these strategies are correct

- Justify solutions & integrate data

Definition	• Be able to justify and recommend one best solution or no solution by analyzing problem situation and constraints and

	integrating related information and data
Components	• Analyze problem situations, constraints, resources • Integrate data to come up with the best solution using some of the information in two or more of the interpretive materials • Justify your belief that the solution is correct

- Using analogies

Definition	• Be able to recall similar stories, compare and adapt or adopt experiences or lessons learned from the stories
Components	• Retrieve: search for stories with the most similar problem situation • Adapt: transfer the solution for the most similar problem to one that fits the new circumstance

IV. <u>Action</u>

- Select the best strategy and use it to attempt to solve the problem (FCTL, 2003).
- Acting on a plan is how students test the adequacy of their problem definition and strategy selection. Only now can they see whether their solutions are effective (Gnam et al., 1999).

V. <u>Look</u>

- Evaluate the value of the strategy in meeting the demands of the problem (FCTL, 2003).
- Looking back at the effects of their plan is how students ultimately evaluate their thinking. By monitoring their performance for success and failure, and revisiting their plan in light of new knowledge, true learning occurs and the quality of their solution will increase (Gnam et al., 1999).

Appendix F

The Problem-solving Rubric for the Fresh-cut Fruit Case

Q1:

Element: **Use Analogies – Giant's Problems and Opportunities**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	**Retrieve**: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of the problem situation description in a story: ❑ Problem situation description - Strategy/ solution/ plan - Characteristics - Constraints - Results	□ At least 2 stories are connected to Giant's problem/opportunities ---------- □ The similar story attributes are connected to Giant's problem/opportunities with clear and logical explanations
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to Giant's problem/opportunities ---------- □ The similar story attributes are connected to Giant's problem/opportunities with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to Giant's problem/opportunities ---------- □ The similar story attributes connected to Giant's problem/ opportunities are off the mark.
❑ 0		□ No response

Element: **Identify and Define Giant's Problem**				
Rating (select one)		**Components**	**Description**	
Prob	**Opp**		**Problems**	**Opportunities**
❑ 3	❑ 3	Problem /Unsatisfied situation[1] Opportunities Clarity Thoroughness	State the problem/unsatisfied situation □ on point □ clearly and thoroughly	State the opportunities □ on point □ clearly and thoroughly
❑ 2	❑ 2		State the problem/unsatisfied situation □ superficially □ vaguely or incompletely	State the opportunities □ superficially □ vaguely or incompletely
❑ 1	❑ 1		State the problem/unsatisfied situation □ off the mark completely	State the opportunities □ off the mark completely
❑ 0	❑ 0		□ No response	□ No response

[1] An unsatisfied situation is one that I may find to be a problem but others may not find it to be a problem. Examples: (1) Spiro does not have a problem working in his office, which he views as having a few piles of books and papers collected; Daisy finds Spiro's office an impossible work environment; (2) in the example with the student visiting the ER and presenting yellow eyes, I may not find a yellow tint to my eyes to be a problem (just wear sunglasses until it clears up), but Daisy is very concerned that her eyes are yellowish.

Q2:

Element: **Use Analogies – Verdelli's Problems and Opportunities**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	**Retrieve**: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of the problem situation description in a story: □ Problem situation description - Strategy/solution/ plan - Characteristics - Constraints - Results	□ At least 2 stories are connected to Verdelli's problem/opportunities ---------- □ The similar story attributes are connected to Verdelli's problem/opportunities with clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to Verdelli's problem/opportunities ---------- □ The similar story attributes are connected to Verdelli's problem/opportunities with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connect to Verdelli's problem/opportunities ---------- □ The similar story attributes connected to Verdelli's problem/ opportunities are off the mark.
❑ 0		□ No response

Element: **Identify and Define Verdelli's Problem**				
Rating (select one)		**Components**	**Description**	
Prob	**Opp**		**Problems**	**Opportunities**
❑ 3	❑ 3	Problem/Unsatisfied situation Opportunities Clarity Thoroughness	State the problem/unsatisfied situation □ on point □ clearly and thoroughly	State the opportunities □ on point □ clearly and thoroughly
❑ 2	❑ 2		State the problem/unsatisfied situation □ superficially □ vaguely or incompletely	State the opportunities □ superficially □ vaguely or incompletely
❑ 1	❑ 1		State the problem/unsatisfied situation □ off the mark completely	State the opportunities □ off the mark completely
❑ 0	❑ 0		□ No response	□ No response

Q3:

Element: **Use Analogies – Posing Questions from Verdelle's Perspective**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to Verdelli's questions ---------- □ The similar story attributes are connected to Verdelli's questions with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to Verdelli's questions ---------- □ The similar story attributes are connected to Verdelli's questions with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to Verdelli's questions ---------- □ The similar story attributes connected to Verdelli's questions are off the mark.
❑ 0		□ No response

Element: **Pose Questions from Verdelle's Perspective**		
Rating (select one)	**Components**	**Description**
❑ 3	Propose questions based on information given Propose questions for lack of enough information - solving the problem - developing a better understanding about the problem(s) defined	□ Questions are proposed with a view toward building on the information set given □ Questions are proposed on point (i.e., looking for clarification for the purpose of solving the problem, understanding the defined problems) **NB: Checking at least one box is sufficient to receive full points**
❑ 2		Questions are proposed at a superficial level about □ solving the problem □ understanding the defined problems
❑ 1		□ Questions are irrelevant to solve the problem or understanding the defined problem
❑ 0		□ No question is proposed

Q4:

Element: **Use Analogies—QA and Safety Issues**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to the quality assurance and safety issues ---------- □ The similar story attributes are connected to the quality assurance and safety issues with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to the quality assurance and safety issues ---------- □ The similar story attributes are connected to the quality assurance and safety issues with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to the quality assurance and safety issues ---------- □ The similar story attributes connected to the quality assurance and safety issues are off the mark.
❑ 0		□ No response

Element: **Linguistic Understanding - Quality Assurance**		
Rating (select one)	**Components**	**Description**
❑ 3	Key phrases or common vocabulary Key concepts **Quality assurance** **Food safety issues**	□ Explains the key concepts clearly and completely
❑ 2		□ Explains the key concepts vaguely or incompletely
❑ 1		□ Fails to explain the concepts
❑ 0		□ No response

Q5:

Element: **Use Analogies – Packaging Concerns for Giant**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to the packaging concern ---------- □ The similar story attributes are connected to the packaging concern with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to the packaging concern ---------- □ The similar story attributes are connected to the packaging concern with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to the packaging concern ---------- □ The similar story attributes connected to the packaging concern are off the mark.
❑ 0		□ No response

Element: **Linguistic Understanding—Packaging Concerns for Giant**		
Rating (select one)	**Components**	**Description**
❑ 3	Key phrases or common vocabulary Key concepts **Package (for retailer convenience)**	□ Explains Giant's packaging concern clearly and completely
❑ 2		□ Explains Giant's packaging concern vaguely or incompletely
❑ 1		□ Fails to explain Giant's packaging concern
❑ 0		□ No response

Q6:

Element: **Use Analogies—Cutting and Packaging Concern for Verdelli**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to the **c**utting and packaging concern ---------- □ The similar story attributes are connected to the **c**utting and packaging concern with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to the **c**utting and packaging concern ---------- □ The similar story attributes are connected to the **c**utting and packaging concern with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to the **c**utting and packaging concern ---------- □ The similar story attributes connected to the **c**utting and packaging concern are off the mark.
❑ 0		□ No response

Element: **Linguistic Understanding—Cutting and Packaging Concern for Verdelli**		
Rating (select one)	**Components**	**Description**
❑ 3	Key phrases or common vocabulary Key concepts **Processing (cutting)** **Package (for retailer convenience & quality and shelf life)**	□ Explains the **c**utting and packaging concern clearly and completely
❑ 2		□ Explains the **c**utting and packaging concern vaguely or incompletely
❑ 1		□ Fails to explain the **c**utting and packaging concern
❑ 0		□ No response

Q7:

Element: **Use Analogies – Verdelli's Marketing Concerns**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to Verdelli's marketing concerns ---------- □ The similar story attributes are connected to Verdelli's marketing concerns with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to the **c**utting and packaging concern ---------- □ The similar story attributes are connected to Verdelli's marketing concerns with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to Verdelli's marketing concerns ---------- □ The similar story attributes connected to Verdelli's marketing concerns are off the mark.
❑ 0		□ No response

Element: **Linguistic Understanding- Verdelli's Marketing Concerns**		
Rating (select one)	**Components**	**Description**
❑ 3 ❑	Key phrases or common vocabulary Key concepts **Marketing concern**	□ Explains the marketing concerns clearly and completely
❑ 2		□ Explains the marketing concerns vaguely or incompletely
❑ 1		□ Fails to explain the marketing concerns
❑ 0		□ No response

Q8:

Element: **Use Analogies – Irrelevant /Less Important Information**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to the exclusion of irrelevant information ---------- □ The similar story attributes are connected to the exclusion of irrelevant information with clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to the exclusion of irrelevant information ---------- □ The similar story attributes are connected to the exclusion of irrelevant information with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to the exclusion of irrelevant information ---------- □ The similar story attributes connected to the exclusion of irrelevant information are off the mark.
❑ 0		□ No response

Element: **Identify Irrelevant/Less Important Information**		
Rating (select one)	**Components**	**Description**
❑ 3	Irrelevant information for arriving at a solution Less important information for arriving at a solution	□ Clearly and completely identifies irrelevant information/less important information for arriving at a solution
❑ 2		□ Vaguely or incompletely identifies irrelevant information/less important information for arriving at a solution
❑ 1		□ Fails to identify irrelevant/less important information for arriving at a solution
❑ 0		□ No response

Q9:

Element: **Use Analogies – Obstacles**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to Verdelli's obstacles ---------- □ The similar story attributes are connected to Verdelli's obstacles with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to Verdelli's obstacles ---------- □ The similar story attributes are connected to Verdelli's obstacles with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to Verdelli's obstacles ---------- □ The similar story attributes connected to Verdelli's obstacles are off the mark.
❑ 0		□ No response

Element: **Identify Obstacles**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Be able to identify the obstacles as Verdelli cuts and packages melons and explain why it is difficult to complete the task ---------- Identify additional information Verdelli needs to overcome the obstacles (identify missing information)	□ Identifies the obstacles with clear explanation regarding why cutting and packaging melons are difficult tasks to complete ---------- □ Identifies additional/ missing information with clear explanation in order to overcome the obstacles
❑ 2 ---------- ❑ 2		□ Identifies the obstacles with superficial explanation regarding why it is difficult to complete the task ---------- □ Identifies additional/missing information with minimal explanation in order to overcome the obstacles
❑ 1 ---------- ❑ 1		□ Identifies irrelevant obstacles without explanation regarding why it is difficult to complete the task ---------- □ Fails to identify additional/missing information in order to overcome the obstacles
❑ 0		□ No response

Q10:

Element: **Use Analogies – Multiple Strategies**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to the suggested strategies ---------- □ The similar story attributes are connected to the suggested strategies with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to the suggested strategies ---------- □ The similar story attributes are connected to the suggested strategies with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to the suggested strategies ---------- □ The similar story attributes connected to the suggested strategies are off the mark.
❑ 0		□ No response

Element: **Identify Multiple Strategies- for Verdelli to Address Shelf-life**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	More than one strategy/approach for Verdelli to address re shelf-life The feasibility of the strategies Strategies are elaborated upon based on information provided or assumptions proposed Do they propose strategies **carefully** (i.e., use the information provided and any other expertise they have on marketing & product development) or **superficially** (i.e., without using any information at their disposal)?	□ More than one **careful** strategy/approach is addressed to solve the problem ---------- □ The strategies/approaches are **careful** and elaborated upon based on information provided or assumptions proposed
❑ 2 ---------- ❑ 2		□ One **careful** strategy/approach is addressed to solve the problem ---------- □ This **careful** strategy/approach is elaborated upon based on the information provided or the assumptions proposed
❑ 1 ---------- ❑ 1		□ **Superficial** strategies/approaches are addressed to solve the problem ---------- □ The **superficial** strategies/approaches are not elaborated upon based on the information provided or the assumptions proposed
❑ 0		□ No response

Q11:

Element: **Use Analogies – Assumptions**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to the assumptions ---------- □ The similar story attributes are connected to the assumptions with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to the assumptions ---------- □ The similar story attributes are connected to the assumptions with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to the assumptions ---------- □ The similar story attributes connected to the assumptions are off the mark.
❑ 0		□ No response

Element: **Identify Assumptions**		
Rating (select one)	**Components**	**Description**
❑ 3	The rationality between the assumptions and the solution/ strategies Do they think through the assumptions clearly?	□ The rationality between the assumptions and the strategies is reasonable and on point
❑ 2		□ The rationality between the assumptions and the strategies is vague with a weak relationship
❑ 1		□ There is no rationality between the assumptions and the strategies
❑ 0		□ No response

Q12:

Element: **Using Analogies – Justify Solutions & Integrate Data**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to the recommended solutions ---------- □ The similar story attributes are connected to the recommended solutions with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to the recommended solutions ---------- □ The similar story attributes are connected the recommended solutions with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to the recommended solutions ---------- □ The similar story attributes connected to the recommended solutions are off the mark.
❑ 0		□ No response

Element: **Justify Solutions & Integrate Data**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Integrate data to come up with the best solution/recommendation - Integrate data: using some of the information in two or more of the interpretive materials ---------- Justify why the solution/ recommendation is correct	□ The recommendation proposed is justified by <u>combining at least two elements</u> of the following: the assumptions in **Q11**, the strategies proposed in **Q10**, & the questions proposed in **Q3** ---------- □ The recommendation addresses explicitly why the solution can work
❑ 2 ---------- ❑ 2		□ The recommendation proposed is justified by <u>drawing on only one of the following</u>: the assumptions in **Q11**, the strategies proposed in **Q10**, & the questions proposed in **Q3** ---------- □ The recommendation addresses minimally why the solution can work
❑ 1 ---------- ❑ 1		□ No information is integrated to come up with the solution ---------- □ The solution is developed but without any explanation about how it works
❑ 0		❑ No response

Q13:

Element: **Use Analogies – Alternative Strategies**		
Rating (select one)	**Components**	**Description**
❑ 3 ---------- ❑ 3	Retrieve: search for stories with the most similar problem attributes Adapt: transfer the attributes of the most similar story into one that fits the new circumstance. Attributes of a story: □ Story theme/background/Goal □ Problem situation description - Strategy/solution/plan - Characteristics - Constraints - Results □ Lessons	□ At least 2 stories are connected to Plan B ---------- □ The similar story attributes are connected to Plan B with a clear and logical explanation
❑ 2 ---------- ❑ 2		□ At least 1 story is connected to Plan B ---------- □ The similar story attributes are connected to Plan B with minimal explanation
❑ 1 ---------- ❑ 1		□ This story is not connected to Plan B ---------- □ The similar story attributes connected to Plan B are off the mark.
❑ 0		□ No response

Element: **Produce Alternate Strategies**		
Rating (select one)	**Components**	**Description**
❑ 3	The feasibility of the strategies Strategies are elaborated upon based on information provided or assumptions proposed Do they propose strategies **carefully** (i.e., use the information provided and any other expertise they have on marketing & product development) or **superficially** (i.e., without using any information at their disposal)?	□ The alternate strategy/approach is **careful** and elaborated upon based on information provided or assumptions proposed to substitute the recommendation
❑ 2		□ The alternate strategy/approach is **superficially** made to substitute the recommendation
❑ 1		□ The alternate strategy/approach cannot substitute the recommendation
❑ 0		□ No response

Appendix G

Instrument

Identifying and Recognizing Problems

- **Construct of identifying the problem** (in Q1 and Q2)

Q1. Are there problems or opportunities facing Giant Foods in providing fresh-cut melons to customers at Giant Food Supermarkets? What are they? What stories remind you of the problem/ opportunities that Giant is facing?

Which stories come to mind? (Check the ones come to mind) How do they connect to the fresh-cut melon problem/ opportunities? Please explain it.	Giant's Problems?	Giant's Opportunities?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I ---------- Explain it here:		

Q2. Are there problems or opportunities facing Verdelli Foods in providing fresh-cut melons to customers at Giant Food Supermarkets? What are they? What stories remind you of Verdelli's problem/ opportunities?

Which stories come to mind? (Check the ones come to mind) How does it connect to the fresh-cut melon problem/ opportunities? Please explain it.	Verdelli's problems?	Verdelli's opportunities
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I ---------- Explain it here:		

Defining and Representing Problems

- **Posing questions**

Q3. Image yourself as Dan Verdelli, what kind of questions you will ask yourself to help you define the scopes of the problems facing Verdelli? Please list your questions. What stories remind you of the questions that Dan Verdelli has to ask himself when he deals with the problems?

Which stories come to mind? (Check the ones come to mind) How do they connect to Dan Verdelli's questions? Please explain it.	Questions that Dan Verdelli will ask
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:	

- **Linguistic understanding**

Q4. What are the quality assurance (QA) and safety issues to be addressed?

Which stories come to mind? (Check the ones come to mind) How do they connect to the QA and safety issues here? Please explain it.	What are the quality assurance (QA) and safety issues to be addressed?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:	

Q5. Why is the packaging of this product an important concern for Giant Foods?

Which stories come to mind? (Check the ones come to mind) How do they connect to the Giant Foods' packaging concerns? Please explain it.	Why is the packaging of this product an important concern for Giant Foods?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I ---------- Explain it here:	

Q6. Why is the cutting and packaging of this product an important concern for Verdelli?

Which stories come to mind? (Check the ones come to mind) How do they connect to Verdelli's cutting and packaging concerns? Please explain it.	Why is the cutting and packaging of this product an important concern for Verdelli?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I ---------- Explain it here:	

Q7. After processing this product, what marketing concerns is Verdelli facing?

Which stories come to mind? (Check the ones come to mind) How do they connect to Verdelli's marketing concerns? Please explain it.	After processing this product, what marketing concerns is Verdelli facing?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:	

- **Identifying irrelevancies**

Q8. What is the irrelevant/less important information to consider as when you attempt to develop solutions for Verdelli?

Which stories come to mind? (Check the ones come to mind) How do they connect to your exclusion while coming up with solutions for Verdelli? Please explain it.	What is the irrelevant/less important information while you try to come up with solutions for Verdelli?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:	

- **Identifying obstacles**

Q9. Why is it difficult for Verdelli to cut and package the fresh-cut melons for Giant? What are the obstacles? What additional information does Verdelli need to overcome these obstacles?

Which stories come to mind? (Check the ones come to mind) How do they connect to the obstacles that Verdelli need to overcome? Please explain it.	What are the obstacles and why is it difficult for Verdelli to cut and package the fresh-cut melons for Giant?	What additional information does Verdelli need to overcome these obstacles?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:		

- **Describing multiple strategies**

Q10. What strategies/approaches can you suggest to Verdelli for dealing with the constraint on the limited shelf-life of the fresh-cut melons?

Which stories come to mind? (Check the ones come to mind) How do they connect to the strategies you suggest to Verdelli? Please explain it.	What strategies/approaches can you suggest to Verdelli to address how to increase the shelf-life of the fresh-cut melons?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:	

- **Identifying assumptions**

Q11. What are the assumptions that you make to answer Q10?

Which stories come to mind? (Check the ones come to mind) How do they connect to the assumptions that you make to answer Q10? Please explain it.	What are the assumptions that you make to answer Q10?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:	

<u>Exploring Possible Solution Strategies</u>

- **Justifying solutions & integrate data**

Q12. There are several possible solutions to the problem of the fresh-cut melon idea. Verdelli may want to conduct more research and study, wait for several years, launch the product immediately by cloning the process and operation used by Giant produce employees, or consider other solutions.
What is your recommendation to Verdelli? Please justify this recommendation by identifying your rationale/reasoning and the information you used to reach this recommendation.

Which stories come to mind? (Check the ones come to mind) How do they connect to your recommendation to Verdelli for solutions? Please explain it.	What is your recommendation to Verdelli for possible solutions to the problem of the fresh-cut melon idea? Please justify this recommendation by identifying your rationale/reasoning and the information you used to reach this recommendation.
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:	

- **Producing alternate strategies**

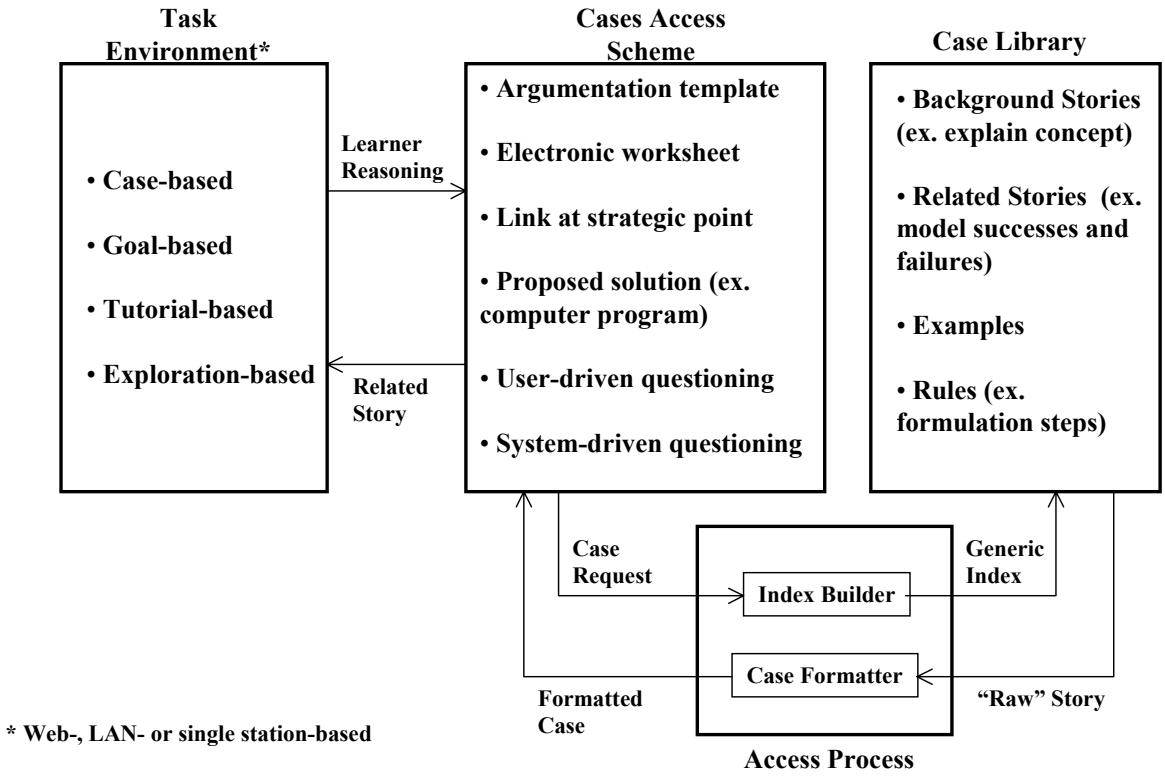
Q13. What should be Verdelli's Plan B?

Which stories come to mind? (Check the ones come to mind) How do they connect toVerdeli's Plan B? Please explain it.	What should be Verdelli's Plan B?
□ Story A □ Story B □ Story C □ Story D □ Story E □ Story F □ Story G □ Story H □ Story I --- Explain it here:	

Appendix H

Case Library Concept

Case Library Concept



Adopted from Hernandez-Serrano (2001, p. 156)

Appendix I

Training for the 2nd Reader to Review the Coding of Qualitative Data

1. Understand Basic Rules of Structure-mapping Theory

Object: b_1, b_2 (base domain); t_1, t_2 (target domain)

Predict: the predicates express propositions about the objects, such as **A**(attribute), **R**(relation)

Attributes: are predicates that take one argument, e.g., Large (x)

Relations: are predicates that take two or more arguments, e.g., Collide (x,y)

First-order analogy: the predicates take objects as arguments, e.g., Collide (x,y), Strike (y,z)

Second or higher-order analogy: the predicates take two or more than two propositions as arguments, e.g., Cause [Collide (x,y), Strike (y,z)]

How to describe the relation:

- $R\,[A^1\,(b^1, b^2), A^2\,(b^3, b^4)\,]$
- $R^1\{\,R^2\,[A^1\,(b^1, b^2), A^2\,(b^3, b^4)\,],\;\; A^3\,(b^3, b^4)\}$

2. **Explain Definition of Analogical Structures**

Analogical Structure		**Definition**	**Example**
Anomaly		•$R_1 \neq R_2$ and $(b_1,b_2) \neq (t_1, t_2)$ •$A_1 \neq A_2$ and $(b_1) \neq (t_1)$	• Attracts (sun, planet) ≠ More-massive-than (earth, moon) • Yellow (sun) ≠ Hot (fire)
Non-Structure Mapping (Superficial)		•$R_1 \neq R_2$ but $(b_1,b_2) \leftrightarrow (b_1,b_2)$* •$A_1 \neq A_2$ but $(b_1) \leftrightarrow (b_1)$	• Attracts(sun,planet) ≠ More-massive-than (sun, planet) • Yellow (sun) ≠ Big (sun)
Structure Mapping	First-order	•$R_1(b_1,b_2) \leftrightarrow R_2(t_1, t_2)$ •$A_1(b_1) \leftrightarrow A_2(t_1)$	•Attracts(sun, planet) ↔ Attracts (nucleus, electron) • Yellow (sun) ↔ Yellow (banana)
	Higher-order	•$R'[R_1(b_1,b_2) , R_2(b_3, b_4)] \leftrightarrow R'[R_1(t_1,t_2) , R_2(t_3, t_4)]$ *R_1 or R_2 can be replaced by A_1 or A_2	• Cause [Attracts (sun, planet), revolves around (planet, sun)] ↔ Cause [Attracts (nucleus, electron), revolves around (electron, nucleus)] •Cause{AND[Puncture(vessel), Contain(vessel, water)], Flow-From (water, vessel)}
Deep Level		• Deep features connections are predictive of something important and abstract enough to make a rule to apply for future situation. • When the comparison **is more like a proverb** to a situation (this proverb may predict unexpected problems, give warning avoid mistakes, or hint solutions) than a regular analogy between base and target, it is concerned as abstract mapping.	• The atom is a central force system. • Different products need different production lines to avoid dangerous products.

* "A ↔B" means A map to B; "A ≠ B" means A does not map to B

3. Explain Definition of Analogical Function

- **Solution:** A story provides a direct solution or approach to a specific question or problem.
- **Explain Solution:** A story provides hints about why this solution works or suggests this solution.
- **Implementation of Solution**: A story provides hints about how to implement this solution.
- **Alternative:** A story provides indirect solutions or approaches to a specific question or problem.
- **Illustration:** Illustrative analogies are designed as a comparison of one idea with another. They appear to be metaphorical in nature rather than directed at problem solving. Their purpose is merely to facilitate understanding rather than advance solution development (Bearman, 2002).
- **Inspiration**: A story prompts or inspires learners to think of next stages under a given situation.
- **Promote Questioning/ Inquiry:** A story prompts learners to propose new questions or to challenge some ideas under a given situation.
- **Prediction—Predict Problems & Provide Solutions:** A story provides warnings about potential problems and provides solutions or suggestions.
- **Prediction—Predict Problems & Avoid Mistakes:** A story provides warnings about potential problems and may cause learners to avoid repeating mistakes.
- **Prediction—Predict Result & Avoid Mistakes:** A story predicts possible results and may help learners to avoid the same results.

4. Randomly Select Data:

Two subjects were randomly selected from each question for the second reader to review. (There is a total of 15 questions * 6 students = 90). Subjects in Q10&Q11, Q12&Q13 have to be the same because they are related questions.

Randomly select result:

Q1-1	Q1-2	Q2-1	Q2-2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
H, C	J, H	C, L	H, L	J, L	H, D	D, F	C, H	J, H	C, J	H, F	C, J	C, J	D, L	D, L

Appendix J

A Instructional Sheet for the Treatment

1. Login to the system by using your PSU ID and password.
2. Open Internet Explorer and go to this website:

http://www.personal.psu.edu/wxh167/caselibrary/group3/group3_home.htm

3. Make sure you are in the correct group, **Group 3**.
4. After you read the instructions, please click on "**Fresh-cut Fruit Case**" at the top.
5. Read the Fresh-cut fruit Case at the left.
6. Read all stories at the right by clicking on image icons.
7. The **Red Texts (theme, goal, plan, result, and lesson) in the tables at the top of each story** are labels used to help you organize each story. **Themes** are the general topics that tend to generate goals related to those topics; **Goals** have the obvious intended results that relate to the overarching theme; **Plans** are the approaches used to achieve the goal; **Results** are outcomes of using the plans; and **Lessons** are the new belief or point of view, namely, what is to be learned from the stories.
8. Once you finish reading, raise your hand to get the test sheets.
9. You are allowed to browse the website when taking the test.
10. The total time for reading and writing the test is 1 hour and 45 minutes.
11. If you need more time, please raise your hand.
12. Leave your test sheets on the desk when you leave.
13. Raise your hand if you have any questions.

VITAE

Wen-Lan Daisy Hsieh

EDUCATION

Ed. D.	Instructional Systems The Pennsylvania State University	2000-2005
B.BA	Business Administration National Sun Yat-Sen University, Taiwan	1992-1996

EMPLOYMENT

Research Assistant	Department of Agricultural Economics The Pennsylvania State University	2001-2004
Instructional Designer	Softassist Inc. Philadelphia, PA	2002-2003
Intern	Schreyer Institute for Teaching Excellence The Pennsylvania State University	summer 2002
Investment Consultant	Dashin Securities Com., LTD. Kaohsiung, Taiwan	1997–1999
Secretary of the President	Cape Wine & Spirit Co., LTD Kaohsiung, Taiwan	1996–1997

TEACHING

Co-Instructor	An online course INSYS 448: Using the Internet in the Classroom The Pennsylvania State University	2002

AWARD

Alumni Society Research Initiation Grant 2003-2004
The Pennsylvania State University
The effects and process of using different story-indexing strategies within a case library on college students' abilities for solving ill-structured problems.

PUBLICATION

Hsieh, W., Smith, B. K., & Stefanou, S. E. (2004). It is more about telling interesting stories: Use explicit hints in storytelling to help college students solve ill-defined problems. *Proceedings of International Conference AECT 2004.* Chicago, IL.

PAPER

Hsieh, W., Smith, B. K., & Stefanou, S. E. (2004). It is more about telling interesting stories: Use explicit hints in storytelling to help college students solve ill-defined problems. Paper presented at AECT 2004 Chicago, IL

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